The preventable burden of musculoskeletal conditions in Australian musicians

A study of university music students and professional musicians

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ABSTRACT

Background: The prevalence of musculoskeletal symptoms (MSSs) among musicians is reportedly high, and may have a profound impact upon those affected. Most studies have been conducted on university classical music students and professional orchestral musicians, leaving other sub-groups, such as military band musicians and opera singers, under-investigated. Even for these most commonly researched groups, there have been relatively few studies investigating the impact of MSSs, or their preventability in terms of psychosocial and organisational factors potentially associated with MSS outcomes.

The central research question in this thesis was: "is there a preventable burden of musculoskeletal conditions among Australian university music students and professional musicians?".

Methods: Data were obtained from two sources: the National Data Set for Compensation-based Statistics, and a targeted questionnaire survey developed specifically for this project. Questionnaire development was informed by a systematic search and narrative review of the types of outcomes and data collection tools used to assess musicians' MSS outcomes. The questionnaire was distributed to university music students and professional musicians, as well as a reference group of university science students and non-music university staff. The utility of the questionnaire measures was examined using Rasch analysis. Data were analysed using standard statistical methods.

Results: Musculoskeletal disorders accounted for the majority of workers' compensation claims (WCCs) made by musicians (70%), and the majority of costs (78%). Of the musicians surveyed, 90% reported MSSs in the last 12 months, and 57% reported experiencing MSSs in the last 12 months that impaired musical activities. Musculoskeletal symptoms were most common in the upper limb and spinal regions.

There was no significant difference in MSS prevalence overall between musicians and the reference groups, however music students reported a higher prevalence of wrist/hand MSSs specifically. Symptomatic music students also reported higher ratings of the emotional impact of MSSs than did science students. A higher proportion of symptomatic female professional musicians reported moderate-severe pain than their university staff counterparts.

The majority (82%) of musculoskeletal WCCs made by musicians were attributed to body stressing. All symptomatic musicians surveyed provided at least one perceived cause (of up to three reported) of their MSSs that was likely modifiable or preventable. The most commonly reported such perceived causes were behavioural factors (94%).

Psychological distress was identified as the most important modifiable personal factor to address, as it was associated with most MSS outcomes. The evidence for other factors was less consistent, however social support, musical activity time, sitting time, and perceived work effort were associated with specific MSS outcomes.

Conclusion: Evidence from this research indicates that there is a preventable burden of musicians' musculoskeletal conditions. To reduce this burden, interventions should be developed that are directed at psychological distress. The effectiveness of these interventions should be examined with particular reference to MSSs in the upper limb and spinal regions, and to the consequences of having MSSs. If found to be safe and effective, appropriate interventions could be implemented nationally, to reduce the burden of musicians' musculoskeletal conditions.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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PRESENTATION OF WORK ARISING FROM THE THESIS[a]

Publications in peer-reviewed journals

1. Stanhope J. Brief Pain Inventory review. Occup Med (Lond). 2016; 66(6):496-497. DOI: 10.1093/occmed/kqw041. (Appendix 2.6)

2. Stanhope J. Patient Health Questionnaire-4. Occup Med (Lond). 2016; 66(9):760-761. DOI: 10.1093/occmed/kqw165. (Appendix 2.7)

3. Stanhope J. Effort-Reward Imbalance Questionnaire. Occup Med (Lond). 2017; 67(4):314-315. DOI: 10.1093/occmed/kqx023. (Appendix 2.8)

4. Stanhope J, Weinstein P, Tooher R, Pisaniello D. A comparative study of musculoskeletal symptoms and work- or study-related impact for professional and pre-professional musicians. Occup Environ Med. 2018; 75(Suppl 2):A262. DOI: 10.1136/oemed-2018-ICOHabstracts.749 (abstract). (Appendix 2.18)

5. Stanhope J, Tooher R, Pisaniello D, Weinstein, P. Have we thoroughly addressed musicians' musculoskeletal symptoms? A systematic mapping review. Int J Occup Med Environ Health. 2019; 32(3). DOI: 10.13075/ijomeh.1896.01340. (Appendix 2.2)

6. Stanhope J, Pisaniello D, Tooher R, Weinstein, P. How do we assess musicians' musculoskeletal symptoms?: A review of outcomes and tools used. Ind Health. Advance online publication. DOI: 10.2486/indhealth.2018-0065. (Appendix 2.5)

7. Stanhope J, Weinstein P, Pisaniello D. What can musicians' claims data reveal about their musculoskeletal conditions?. Arch Environ Occup Health. Advance online publication. DOI: 10.1080/19338244.2019.1605968. (Appendix 2.17)

Manuscripts under review

8. Stanhope J, Weinstein P. Should musicians play in pain? (Appendix 2.1)

9. Stanhope J, Weinstein P. Why do we need to investigate non-classical musicians to reduce the burden of musicians' musculoskeletal symptoms? (Appendix 2.3)

10. Stanhope J, Alagumalai S, Weinstein P, Pisaniello, D. The application of Rasch analysis to occupational health measures: an example using a modified version of the Michigan Organizational Assessment Questionnaire - Job Satisfaction Subscale (Appendix 2.12)

Technical report

1. Stanhope J. The preventable burden of musculoskeletal conditions in Australian musicians. A report prepared for SafeWork SA; 2019.

[a]Manuscripts in preparation are included in Appendix 2. Chapters 4, 5, 7, 8 and 9 will be converted to manuscripts in the coming months.

Presentations

1. Stanhope, J. Musculoskeletal disorders in under-investigated occupational groups: a case study in the music industry. Oral presentation at The University of Adelaide School of Population Health Seminar Series: September 17, 2015; Adelaide, Australia.

2. Stanhope, J. Musculoskeletal disorders in under-investigated occupational groups: a case study in the music industry. Oral presentation at the Human Factors & Ergonomics Society of Australia's 10 minute theses presentation evening: April 13, 2016; Adelaide, Australia.

3. Stanhope J, Weinstein P, Tooher R, Pisaniello D. The prevalence of musculoskeletal symptoms in university music students compared with non-music students. Poster presentation at the 10th Annual Florey Postgraduate Research Conference: September 29, 2016; Adelaide, Australia.

4. Stanhope J, Weinstein P, Tooher R, Pisaniello D. A comparison of the prevalence of upper limb musculoskeletal symptoms between music and non-music students. Oral presentation at the State Population Health Conference: October 22, 2016; Adelaide, Australia.

5. Stanhope J, Weinstein P, Tooher R, Pisaniello D. Musicians' musculoskeletal symptoms: an under-recognised public health problem. Oral presentation at the 15th World Congress on Public Health: April 3-7, 2017; Melbourne, Australia.

6. Stanhope J, Weinstein P, Tooher R, Pisaniello D. The prevalence of musculoskeletal symptoms in university music students compared with non-music students: preliminary findings. Digital poster presentation at the 15th World Congress on Public Health: April 3-7, 2017; Melbourne, Australia.

7. Stanhope J, Weinstein P, Tooher R, Pisaniello D. A comparative study of musculoskeletal symptoms and work- or study-related impact for professional and pre-professional musicians. Oral presentation at the 32nd International Congress on Occupational Health: April 29 – May 4, 2018; Dublin, Ireland.

ABBREVIATIONS

AIC: Akaike Information Criterion

ANZSCO: Australian and New Zealand Standard Classification of Occupations

AOR: Adjusted odds ratio

CI: Confidence interval

CTT: Classical test theory

DIF: Differential item functioning

ERI: Effort-reward imbalance

GFC: Global Financial Crisis

MOAQ-JSS: Michigan Organizational Assessment Questionnaire-Job Satisfaction Scale

MRMD: Music-related musculoskeletal disorder

MSD: Musculoskeletal disorder

MSS: Musculoskeletal symptom

NDS-3: National Data-Set for Compensation-based Statistics, third edition

NMQ: Nordic Musculoskeletal Questionnaire

NRS: Numeric rating scale

OHS: Occupational health and safety

PCM: Partial credit model

PHQ-4: Patient Health Questionnaire-4

PRMD: Playing-related musculoskeletal disorder

QPS_{Nordic}: General Nordic Questionnaire for Psychological and Social Factors at Work

QR: Quick response

RMM: Rasch measurement model

RSM: Rating scale model

VIF: Variance inflation factor

WCC: Workers' compensation claim

WLE: Weighted likelihood estimate

WRMSD: Work-related musculoskeletal disorder

YLD: Years lived with disability

INTRODUCTION AND THESIS OVERVIEW

INTRODUCTION

The research presented in this thesis sets out to determine whether there is a preventable burden of musculoskeletal conditions [b] among Australian university music students and professional musicians. The research is underpinned by a series of literature reviews that informed the specific research questions (through a gap analysis), and musculoskeletal symptom (MSS) outcomes investigated, including the data collection tools used. This research includes the first study of musicians' workers' compensation claims (WCCs) for musculoskeletal disorders (MSDs) internationally, as well as being the first to conduct a questionnaire survey of MSSs and their consequences across all types of university music students and professional musicians. Together the findings from these data sources were integrated to determine the burden of musculoskeletal conditions in Australian university music students and professional musicians, and whether this burden was preventable. These integrated findings led to evidence-based recommendations to reduce the burden of musculoskeletal conditions in Australian university music students and professional musicians.

Musculoskeletal disorders

Musculoskeletal disorders impact significantly on the global population, accounting for 17.1% of years lived with disability (YLD); making MSDs the third most common cause of YLD, after substance and mental disorders, and 'other'[c] non-communicable diseases.[1] When considering specific conditions, lower back pain was found to be the most common cause of YLD globally in 1990, 2010 and 2016, with neck pain and 'other' MSDs also ranking in the top 10 at all three time points.[1] Musculoskeletal disorders therefore continue to be an important cause of disability globally.

In Australia, lower back pain is also the leading cause of YLD, with 'other' MSDs ranked third, and neck pain sixth.[1] It is estimated that almost 6.9 million Australians (29.9%) have a long term[d] condition of the musculoskeletal system or connective tissue.[2] More effective strategies to address musculoskeletal conditions in Australia are therefore required to reduce the burden of these conditions.

Work-related musculoskeletal disorders

Musculoskeletal disorders are the most common type of work-related injury or illness in Australia, accounting for 55.2% of new work-related injuries or illnesses in the 2017-2018 financial year.[3] This finding is consistent with WCCs data where MSDs accounted for 61.9% of claims from 2009-2014.[4] Furthermore, 42% of the estimated A$61.8 billion (4.1% gross domestic product) that work-related injuries and illnesses were estimated to have cost in the 2012-2013 financial year were due to MSDs.[5] Given the high proportion of WCCs related to MSDs, their preventability, and the severity of their consequences, MSDs have been listed as a priority area in Safe Work Australia's Australian Work Health and Safety Strategy 2012-2022.[6]

'High claim' industries have traditionally received most of the attention for work health and safety research and implementation of intervention strategies, with the selection of target industries being driven by data.[7] Indeed, the Australian Work Health and Safety Strategy 2012-2022[6], which listed agriculture, road transport, manufacturing, construction, accommodation and food services, public administration and safety, and health care and social assistance as priority industries, based selection of these priority industries on their hazardous nature, or rates of injury and/or fatality. One of the limitations of this approach is that specific

[b] Musculoskeletal conditions include musculoskeletal symptoms and musculoskeletal disorders (including musculoskeletal diseases and injuries), as will be defined in Chapter 1.

[c] As per the classification used in the Global Burden of Diseases study[1]

[d] A condition which has or is expected to last for more than 6 months[2]

occupational groups, with unique exposures and intervention needs, may be missed where data are not available at a specific enough level. In addition, groups characterised by self-employment and/or transient work may be missed as these workers might not be eligible for workers' compensation and/or be less inclined to claim due to concerns regarding their future employability.[8] As a result, specific research is required into under-investigated groups whose MSD burden may otherwise not be captured using traditional monitoring strategies, such as WCCs data and the Australian Bureau of Statistics' Work-Related Injuries Survey.[e3]

There are a number of occupational groups whose musculoskeletal conditions remain under-investigated, particularly in terms of high-quality research. These occupational groups include some sub-groups of scientists[11], health professionals[12, 13], musicians[14], and those working in the catering[15], agricultural[16-19], and manufacturing[20] industries. Strategies to address musculoskeletal conditions in these occupational groups may differ from the strategies used with occupational groups that have received the bulk of previous research attention.

This thesis focuses on university music students (i.e. pre-professional musicians) and professional musicians. Musicians are a group with many of the features of vulnerable occupational groups, including being characterised by freelance/self-employed work[21], and being exposed to high physical[22] and psychosocial demands.[23] With 86% of Australian professional musicians[f] working in a freelance and/or self-employed capacity[21] only the minority have access to workers' compensation. Furthermore, musician-specific data are not available in the Australian Bureau of Statistics' Work-Related Injuries Survey.[3] Musicians therefore require specific research to determine whether they have a preventable burden of musculoskeletal conditions, and to guide the development of strategies to reduce the identified burden.

Music and musicians

Music is a social and cultural construct that has a long cross-cultural tradition.[24] The earliest musical instruments are thought to be flutes made from the ivory or bones of a range of animals, including mammoths and vultures, with specimens dating back 35 000 calendar years.[25] The evolutionary purpose of music for humans remains unclear[24, 26], however music still plays an important role in our society today.

Today, in Western society, a higher proportion of people 'consume' music than 'produce' it.[26] This observation is particularly true in Australia where only 4.6% of people aged 15 years or older in the 2017-2018 financial year reported singing or playing a musical instrument[27], while 38.2% of the same population attended a live music concert or performance, and 15.8% attended musicals or operas.[28] Together, these statistics highlight the importance of music in Australian society, and the need to protect the health of the minority of the population who produce music, particularly at a professional level.

Music has also played a role in health. Early proponents of music therapy included Pythagoras (the father of music therapy), Hippocrates, and Aristotle, with music therapy crossing geographical bounds.[29] There is supporting evidence for contemporary music therapy targeting a range of health conditions[30-35], including for pain.[30, 36] Despite the beneficial effects of music therapy, the potential adverse effects of producing music have been known for over 300 years, with Ramazzini (the father of occupational medicine) including a chapter on musicians in his De Morbis Artificum Diatriba.[37] Musicians today still experience a range of

[e]Data from the Work-Related Injuries Survey are only available at the three-digit level[9] of the Australian and New Zealand Standard Industrial Classification.[10]

[f]Professional musicians were defined as those who consider themselves to be engaging in music at a professional level[21]

health problems[38-47], including musculoskeletal conditions.[48-52] Musicians' musculoskeletal conditions should therefore be investigated in order to reduce the burden of these conditions.

Musicians

Musicians represent a diverse group of people who engage in a range of activities, including playing various musical instruments, singing, conducting, composing and arranging music, and/or teaching music. Playing an instrument or singing requires the integration of a range of skills, including visual and auditory perception, and motor control.[53] Musicians therefore require a well-functioning musculoskeletal system and minimal distractions (e.g. symptoms) in order to perform at the required level.

Musicians often have portfolio careers consisting of numerous jobs, including roles outside of the arts.[21, 54] The music industry is highly competitive[55], and musicians face constant criticism of their work.[56] Many professional musicians are in precarious employment, with 86% of Australian professional musicians working in a freelance and/or self-employed capacity in 2016[21], up from 67% in 2009.[54] The proportion of musicians in freelance or self-employed work is well above that of the general Australian workforce who are self-employed (8% in 2018)[57], or even in casual work (25% in 2018).[57]

The usual total weekly income (including non-work sources of income) for Australian professional musicians is relatively low, with the majority (56%) receiving less than A$599 per week according to the 2011 Census of Population and Housing.[g58] Musicians' incomes are therefore generally lower than those of other artists, and the general population[h] (Figure i). Musicians are also under-employed, with 46% working 15 hours or less[58], and 66% reporting that they would like to work more in the arts.[21] These reported psychosocial factors might place musicians at increased risk of adverse health events, including musculoskeletal conditions, and impact upon their prognosis.

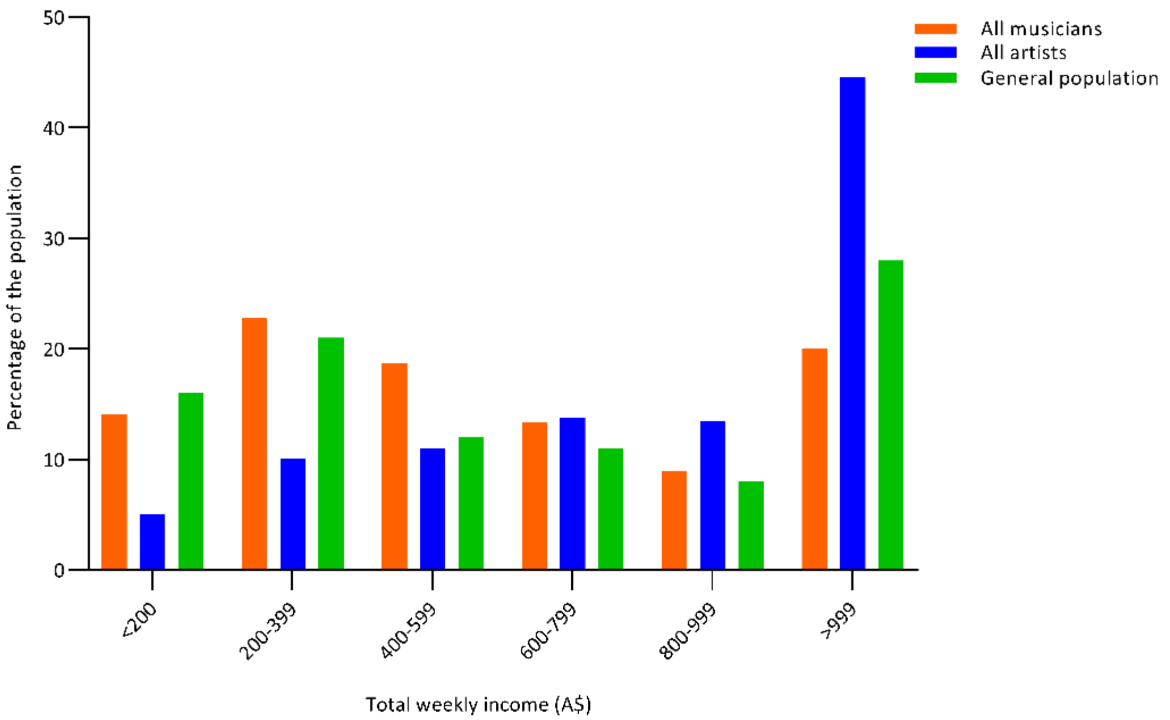

Figure i: Total weekly income of Australian musicians, all artists and the general population
Notes: Musicians included composers, musical directors, instrumentalists, singers, music teachers and musicians not classified elsewhere. Total population included anyone aged 15 years or over, irrespective of their work status. Data sources: Australian Bureau of Statistics' 2011 Census of Population and Housing[58, 59]

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[g]As of May 2019, the relevant statistics from the 2016 Census of Population and Housing had not been released.

[h]The population included any person aged 15 years or older, irrespective of work status[58]

Thesis objective, research questions and structure

The research presented in this thesis is underpinned by the central objective: to establish whether there is a preventable burden of musculoskeletal conditions in Australian university music students and professional musicians.[i] Musculoskeletal conditions encompass both MSSs and MSDs, as discussed further in Chapter 1.

The central research question of this thesis, "is there a preventable burden of musculoskeletal conditions in Australian university music students and professional musicians?", was divided into two main questions:

1. "Is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?" and, if so
2. "Is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?".

The thesis is broadly presented in four sections: Section A presents the preliminary material, Sections B and C answer Sub-questions 1 and 2, respectively, and Section D draws together the findings of the thesis in the context of the existing evidence base to produce recommendations for future research and practice (Figure ii). Throughout the thesis, blue boxes are used to highlight key points and provide summaries at the end of each chapter. The four main thesis sections are summarised below.

Section A reports the preliminary material, and comprises of Chapters 1 and 2. Chapter 1 reports the background for this thesis, drawing upon a series of literature reviews, which are presented in full in Appendix 2. Chapter 2 reports on the methodology and methods used in this research (WCCs data, and data from a targeted questionnaire survey). In addition, to examine the utility of the questionnaire measures, Rasch analysis was also conducted, as outlined in Chapter 2 (and reported in full in Appendix 2).

Section B serves to answer the question "is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?". Section B is presented across Chapters 3-5. Chapter 3 reports the analysis of WCCs data for employed professional musicians.[j] Specifically, the proportion of all claims attributed to MSDs, the nature and body location of these MSDs, and the time lost and cost of claimed MSDs are reported.

Chapters 4-5 draw upon data from a targeted questionnaire survey. Chapter 4 reports on the prevalence and profile (e.g. body region, consequences) of MSSs for Australian university music students and professional musicians, and includes a comparison between sub-groups of musicians (e.g. students compared with professionals). These findings inform the prioritisation of MSS outcomes (e.g. body regions) and sub-groups of musicians for future research and interventions.

Chapter 5 compares the prevalence and profile of MSSs for university music and science students, and professional musicians and non-music university staff. The purpose of the comparative study was to determine whether musicians have a different MSS prevalence and profile compared with other student/occupational groups, and these findings will contribute to the prioritisation of MSS outcomes for musicians (e.g. body regions where musicians have a higher prevalence of MSSs than the reference group).

[i]Professional musicians in this research refer to those who were employed to perform as singers, instrumentalists, conductors or drum majors, or to teach singing or instrumental music in the last 12 months, and musicians who were members of the Music Teachers' Association or Musicians' Union.

[j]Music teachers were excluded from this analysis as no specific data were available for this group

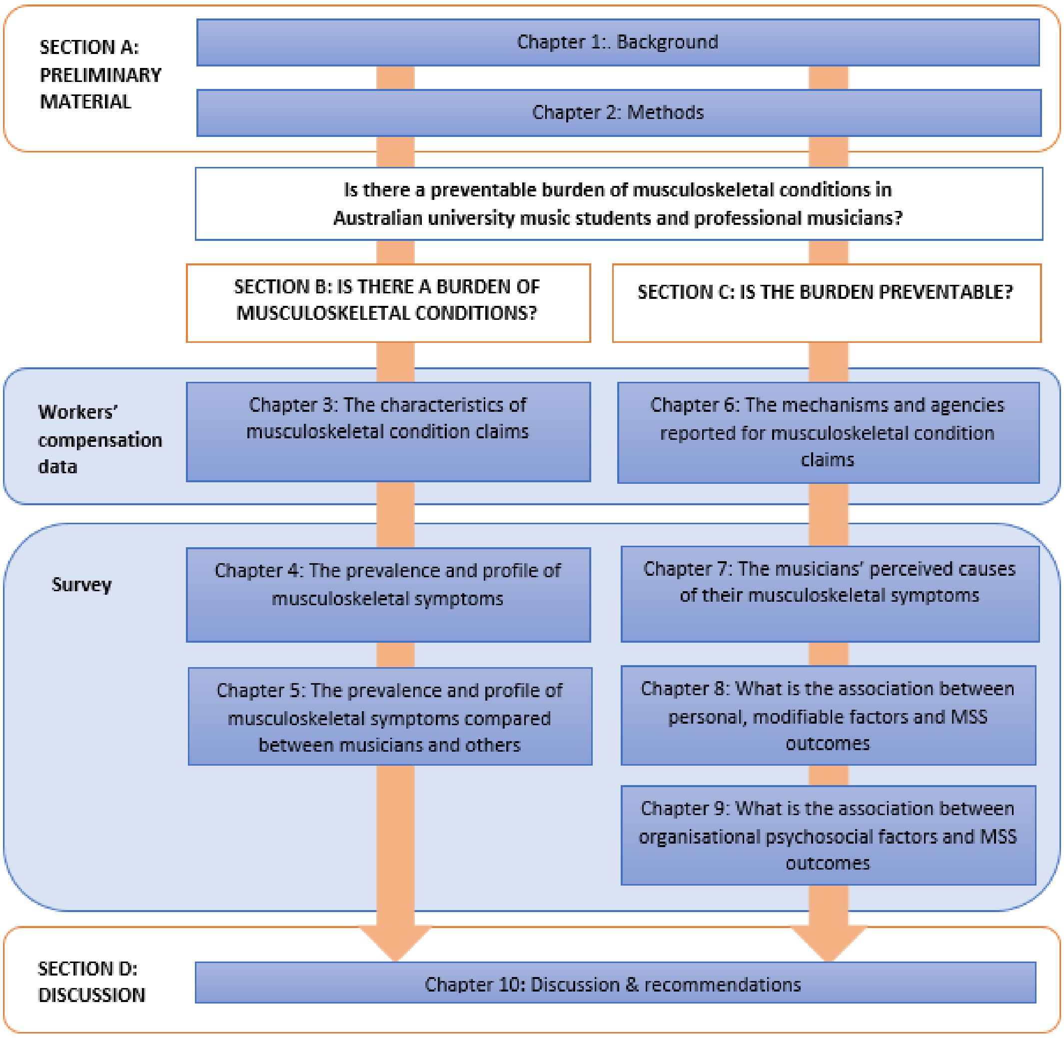

Figure ii: Thesis structure
Note: MSS: musculoskeletal symptom

Section C comprises of four chapters, and answers the question "is the burden of musculoskeletal conditions for Australian university music students and professional musicians preventable?". The reported mechanisms and agencies for claimed work-related MSDs from employed musicians[k], using data from WCCs is reported in Chapter 6. Chapter 7 reports on musicians' perceived 'causes' of their MSSs, using data from the questionnaire survey. Chapters 6 and 7 report descriptions of the possible risk factors for musicians' MSSs, providing insight into the perceived preventability of musculoskeletal conditions, and potential risk factors for MSSs to investigate in future research.

Chapters 8 and 9 explore the association between modifiable factors and MSS outcomes. Chapter 8 reports the analysis of the association between modifiable personal factors, and MSS outcomes, including the consequences of MSSs. The modifiable personal factors of interest were body mass index, typical daily sitting time, and time engaged in musical activity, as well as perceived levels of musical social support, musical career satisfaction, psychosocial stress, and psychological distress. Chapter 9 focuses on employed musicians (performers and teachers), investigating the association between psychosocial organisational factors, and the same MSS outcomes as Chapter 8. The psychosocial organisational factors investigated were perceived effort and reward (including the reward subscales: perceived job security, esteem and promotion opportunities), and elements of organisational safety climate (perceived

[k]Music teachers were excluded from this analysis as no specific data were available for this group

workplace communication of, prioritisation of, and the individuals' involvement in occupational health and safety within the organisation).

The findings of Sections B and C were integrated, along with the existing evidence base, in **Section D** - the discussion and recommendations (Chapter 10). Chapter 10 includes a discussion of the key findings of the research, in order to answer the central research question, and offers future directions, including recommendations.

The **Appendices** include elements of the research that are not central to the thesis. These elements are the supplementary material supporting the main chapters (Appendix 1), and manuscripts derived from the research (Appendix 2). Appendix 2 includes manuscripts of the literature reviews that have been integrated into Chapters 1 and 2, and a series of papers reporting Rasch analysis[l] for the measures used in this research. Within Appendices 1 and 2 the numbering follows the order in which these Appendices are referred to in text; but the grouping of material into either Appendix 1 or 2 follows the type of material (i.e. supplementary material, or a manuscript).

Together, the four main thesis sections (Sections A-D) provide an analysis of the burden of musculoskeletal conditions among Australian university music students and professional musicians, and whether the identified burden is preventable. The methodological contributions from this research are also discussed; namely a thorough review of the MSS outcomes and data collection tools, Rasch analysis of measures in the questionnaire, and insights into the applicability of an existing occupational stress model (the effort-reward imbalance (ERI) model) to musicians. This analysis addresses the leading cause of YLD and WCCs in Australia, in a population with several vulnerabilities: university music students and professional musicians.

[l] Rasch analysis is a modern psychometric method used to test the utility of measures (described further in Chapter 2)

SECTION A:
Preliminary material

Section A reports the preliminary material for this thesis and includes Chapters 1 and 2. Chapter 1 provides the background to the thesis, drawing upon a series of literature reviews. Chapter 2 presents the methods and methodology of the research, including the methods for the analysis of workers' compensation claims data, the development of the questionnaire (including a review of musculoskeletal symptom outcomes and data collection methods for musicians), and the administration and analysis of the data from the questionnaire survey. Chapter 2 also includes the methods for Rasch analysis, a modern psychometric method for testing the utility of measures, which had not previously been applied to any of the measures used in this research.

CHAPTER 1. BACKGROUND AND LITERATURE REVIEW

As outlined in the Introduction, musculoskeletal disorders (MSDs) are a leading cause of years lived with disability[1], and workers' compensation claims (WCCs)[4] in Australia. Musculoskeletal symptoms (MSSs) are common among musicians[48-52], and may affect various facets of their lives.[60-65] This thesis examines musculoskeletal conditions in Australian university music students and professional musicians, specifically asking the question "is there a preventable burden of musculoskeletal conditions in Australian university music students and professional musicians?".

In Chapter 1, the thesis background is presented. The background integrates five separate literature reviews:

1. A narrative review to answer the question "should musicians play in pain?" which draws upon contemporary pain science (Appendix 2.1);
2. A systematic mapping review of the literature (published 2007-2016) regarding musicians' MSSs (Appendix 2.2);
3. A narrative review comparing the characteristics of musicians' working in different ensemble types or genres, and how these characteristics may relate to MSS outcomes (Appendix 2.3);
4. A systematic review of the effect of public health interventions to prevent and/or manage musicians' MSSs and/or their consequences (including studies published up until July 2018; Appendix 2.4); and
5. A systematic search and narrative review of the MSS outcomes investigated and data collection tools used for musicians' MSS research (published 2007-2016; Appendix 2.5).

These reviews are reported in full in Appendix 2, with the key elements drawn together in the present chapter to provide a comprehensive, relevant background specific to the thesis. An update search of the literature was performed in April 2019 to identify any additional, relevant studies that were published following the initial searches (see Appendix 1.1 for the flow chart of study inclusion/ exclusion for the update search). Additional relevant studies were integrated into the background presented in this chapter.

Chapter 1 is divided into three main sections:

1. A literature review of musculoskeletal conditions generally (i.e. not specific to musicians), including a discussion of the musculoskeletal condition terminology used in this thesis, the mechanisms leading to MSSs, and risk factors for MSS outcomes reported in non-musical populations (Section 1.1, integrating Review 1);
2. A review of musicians' musculoskeletal conditions specifically, including a review of our current understanding of musicians' musculoskeletal conditions, and an identification of the evidence gaps (Section 1.2, integrating Reviews 2-5); and
3. The purpose and significance of the research presented in this thesis (Section 1.3).

1.1 Musculoskeletal conditions

In this section, the terminology regarding musculoskeletal conditions is outlined, followed by a discussion of the theory underpinning our understanding of these conditions. This discussion draws upon the literature regarding pain mechanisms, the risk factors for MSSs outcomes (e.g. the presence, characteristics, and consequences of MSSs), and the proposed theoretical frameworks regarding MSS outcomes. This background is necessary to establish why musicians may have a different MSS profile to other populations, and which factors may increase the risk of MSS outcomes for musicians, thus informing the research presented in this thesis.

1.1.1 Musculoskeletal terminology

Throughout this thesis the term 'musculoskeletal conditions' is used to encompass musculoskeletal symptoms, disorders, diseases, and injuries. The definitions of each of these terms are reported in Table 1.1. The thesis focuses on MSSs rather than MSDs, due to the poor correlation between MSSs and tissue damage[66] (discussed further in Section 1.1.2). Further, MSSs, by definition, are what the individual experiences, and therefore the aspect of the condition that is of most relevance to them. Work-related MSDs (WRMSDs; injuries and diseases) will however be reported in Chapters 3 and 6 where an analysis of WCCs data is reported.

Table 1.1: Musculoskeletal condition terminology and definitions used in this thesis

Musculoskeletal conditions encompass all musculoskeletal symptoms and disorders.
Musculoskeletal symptoms may include ache[67], discomfort[67], pain[67-69], stiffness[69], tingling[68], weakness[68], numbness[68], and lack of control[68] in soft tissue, peripheral joints and the axial spine.[69]
Musculoskeletal disorders are conditions that affect the musculoskeletal system; specifically the synovium, muscles, tendons, soft tissue, connective tissue, spinal vertebrae, intervertebral discs and/or joints.[70] Musculoskeletal disorders are further split into musculoskeletal diseases and injuries.
Musculoskeletal injuries are musculoskeletal disorders resulting from a single traumatic event with a short latency period.[71]
Musculoskeletal diseases are musculoskeletal disorders resulting from long-term or repeated exposure to an event or agent, or from uncertain or multiple causes.[71]
Work-related musculoskeletal disorders are musculoskeletal disorders resulting from employment, and include both musculoskeletal diseases and injuries.[72]
Music-related musculoskeletal disorders refer to "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed"[a]

Note: [a]modified from Zaza et al.'s[68] definition of playing-related musculoskeletal disorders to encompass playing an instrument, singing, being a drum major and conducting (see Appendix 2.5 for more information).

Based on a review of the MSS outcomes and data collection methods used in studies of musicians (Appendix 2.5), the term 'music-related musculoskeletal disorders' (MRMDs) was used in this research. Music-related musculoskeletal disorders were defined in this thesis as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed". This definition is based on Zaza et al.'s[68] definition of playing-related musculoskeletal disorders (PRMDs)[m]; expanded to incorporate non-instrumental musical activities (e.g. singing, conducting and being a drum major). Zaza et al.'s[68] definition of PRMDs was developed through focus groups with professional musicians and health professionals who treated musicians, and has been used frequently in the musicians' musculoskeletal condition literature (Appendix 2.5). The terms PRMDs/MRMDs are not analogous with WRMSDs; referring to MSSs that impair musical activity, rather than MSSs caused by musical activity. While PRMDs/MRMDs are not technically 'disorders', the term was used to maintain consistency with the existing literature (Appendix 2.5), and because the definition reflects the term 'disorder' from the musicians' perspective.

1.1.2 Musculoskeletal symptom mechanisms, risk factors, and theoretical frameworks

Musculoskeletal symptoms may include ache[67], discomfort[67], pain[67-69], stiffness[69], tingling[68], weakness[68], numbness[68], and lack of control.[68] Of these MSSs, pain is the most commonly reported MSSs for musicians[73, 74], and along with ache and discomfort has been used as a proxy indicator of MSDs.[67] As pain mechanisms are similar to other sensations, such as chronic itch[75-78], as well as chronic cough[75, 79] (which is likely to be the response to a sensation) it is anticipated that other MSSs would follow similar mechanisms to pain.

[m]Playing-related musculoskeletal disorders were defined by Zaza et al.[68] as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with your ability to play your instrument at the level to which you are accustomed"[68(p 2016)]

1.1.2.1 Pain mechanisms

Pain has been defined by the International Association for the Study of Pain[80] as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". The experience of pain is complex, and has inter- and intra-individual variability[81], that is driven by the context[81], the individual's psychological state[81, 82], and the cognitive and emotional aspects of pain[81, 82], as well as immunological[82], endocrinological[82] and neurophysiological factors.[81, 82] Pain is a conscious event, not a sensory signal.[66] Pain can occur without tissue damage, and tissue damage without pain.[83-86] For instance, abnormal anatomical findings on imaging scans may occur in asymptomatic individuals[84-86], while symptomatic individuals may have no detected abnormalities.[83] There is also evidence of a poor correlation between physical test findings and MSSs in musicians specifically.[87] Pain does not directly relate to tissue damage, nor anatomical abnormalities. In fact, pain may be evoked by a range of experiences, such as seeing someone else in pain[88, 89], or through anticipating pain.[81] Pain is therefore a complex experience that does not necessarily indicate tissue damage nor inflammation. Nonetheless, MSSs (including pain) can have a profound negative impact on musicians[60-65]; hence, the mechanisms underlying pain should be explored.

Types of pain

The three main types of pain are nociceptive, neuropathic and nociplastic/ algopathic/ nocipathic pain.[66] The pain types are not necessarily discrete, and may occur in combination.[66] A description of the mechanisms of each follows. However, the clinical patterns of these pain types is beyond the scope of this review, with interested readers referred to Hainline et al.[66] for a discussion of these.

Nociceptive pain involves activation of nociceptors, the peripheral nerve terminals that detect noxious stimuli, whether the stimuli be mechanical, thermal, or chemical.[90] Inflammatory pain is a special type of nociceptive pain, where physiological changes involved in inflammation trigger nociceptors.[90] Nociceptive pain is a type of protective mechanism, and nociceptors have been described as the 'first detection' system for body tissue.[66] These receptors may be triggered following an injury (e.g. sprained ankle) where the tissue damage is sudden, or via more ongoing, repetitive tissue load (e.g. tendinosis), however the experience of pain does not necessarily mean that the tissue is threatened. Furthermore, the association between the amount of nociceptor activation and the experience of pain is not necessarily linear.[66] The non-linear nature of the relationship is driven by modulation of pain or central sensitisation (discussed further in the following sections).

Neuropathic pain relates to a lesion in the somatosensory nervous system[80, 90, 91], and does not require nociceptive activation.[66] Lesions may occur as the result of trauma (including surgery) or disease (e.g. diabetes mellitus, or stroke) in the spinal cord, nerve roots or peripheral nerves.[92] Damage to peripheral nerves may also occur through inflammatory irritation or repetitive mechanical load[66]; hence some musical activities may lead to neuropathic pain.

The terms nociplastic, algopathic, and nocipathic pain (sometimes referred to as 'dysfunctional pain'[93]) describe pain that relates to altered nociception, without evidence of a threat or damage to tissue, nor any lesion of the somatosensory nervous system.[91] Specifically, nociplastic pain describes pain driven by altered nociceptive pathway function; nocipathic pain a pathological state of nociception; and algoplastic pathological pain a pain that has not been generated by injury.[66] Fibromyalgia, visceral pain disorders, and Complex Regional Pain Syndrome Type 1 are examples of conditions that appear to be driven by these pain types,[91] and it is thought that central sensitisation (hypersensitivity of the nociceptors in the central nervous system[90]) may be implicated.[91]

Pain processing and modulation

Pain modulation may explain why there is not a simple relationship between tissue damage (or potential damage) and the experience of pain. Modulation occurs through various processes in the peripheral and central nervous systems[66], and relevant neurological changes include both the anatomy and function of the nervous system[81] (see Bushnell et al.[81] for a comprehensive review). The brain regions involved in the processing of pain (or the stimuli resulting in pain) include the somatosensory[94], prefrontal[94], and anterior cingulate cortices[94], the insula[94], amygdala[95, 96], nucleus accumbens[95, 96], periaqueductal grey[97], thalamus[94], and the cerebellum.[94] These brain regions are also involved in a range of other processes including sensory processing[98-101], executive functioning (e.g. attention)[99, 101, 102], memory[99, 101, 103], emotion (including fear)[104-107], motivation[103, 104], motor control[98, 102, 104], and descending pain modulation.[108] The multiple functions of these brain regions may explain the role that contextual cues[109], non-nociceptive sensory input[109], and affective and cognitive factors[81] play in the modulation of pain. Furthermore, associations between changes in some of these brain regions, and emotional and cognitive representation of pain have been identified in those with chronic pain[110], providing further support for the important role that psychosocial factors may play in the pain experience, particularly the transition from acute to chronic pain.

Another process that may alter an individual's response to mechanical loading is the up-regulation of nociception.[66] This up-regulation is thought to occur with low-level inflammation whereby the threshold of mechanical nociception is reduced; hence mechanical demands which would previously not have triggered nociceptors now do so.[66] This threshold change may lead to an increase in the level of pain experienced with a previously unpainful trigger.[66] Low-level inflammation may be due to a load exceeding the tissue's capacity, but also other factors such as ongoing stress and sleep deprivation.[66] Another issue with ongoing, repetitive load that exceeds the tissue's capacity, is that a cycle of inflammation-repair-remodelling-inflammation is established.[66] The establishment of this cycle can alter the mechanical properties of tissues which may in turn alter nociceptive activation[66], and may therefore be of particular relevance to musicians.

1.1.2.2 Risk factors for musculoskeletal symptom outcomes

The pain mechanisms described above are consistent with epidemiological research regarding the risk factors for MSS outcomes. Epidemiological studies indicate a relationship between a wide range of biomechanical, behavioural, cognitive, and emotional factors, and the presence, intensity and/or consequences of MSSs (see Table 1.2 for examples). Furthermore, the transition from acute to chronic pain is associated with depression, fear-avoidance, catastrophisation, pain expectation, negative affect, trauma, emotional distress and helplessness-hopelessness[111], further supporting the important role that psychosocial factors may play in the experience of pain.

Table 1.2: Summary of factors associated with musculoskeletal symptom outcomes from recent systematic reviews in a range of populations

Physical characteristics
- Body mass index: high[112-118] & low[115, 116]
- Waist circumference: high[114]
- Body fat content: high[119]
- Perceived level of fitness: low[114]
- Level of aerobic fitness: high[114]
- Cardiorespiratory endurance: low[120]
- Range of motion: high[114, 121-123] & low[123-130]
- Muscle strength: high[114, 117] & low[113, 116, 117, 125, 131, 132]
- Muscle endurance: high[114, 122, 125] & low[112, 114, 116, 117, 122, 125, 128, 131]
- Muscle tightness: high[117, 125] & low[125]
- Muscle cross-sectional area/ size: small[132, 133]
- Perceived muscular tension[112, 128]
- Muscle power: high[122] & low[122]
- Functional stability: low[125]
- Poor movement patterns[114, 134, 135]
- Muscle activation patterns[121, 136]
- Baseball pitching characteristics[123]
- Golf swing characteristics[116]
- Level of mobility[113]
- Scapular protraction[127]
- High physical exposure[112]
- High traumatic exposure[111]
- Functional capacity tests[137]
- Impaired proprioception[138]
- Visual accommodation[127]
- Low vitamin D concentration[139, 140]
- Physical function[141]

Equipment/ environment
- Warmer climate[123]
- Unadjustable chairs[112, 128]
- Running shoe age[115]
- Bicycle set-up[136]
- Wearing graduated lenses[127]
- Computer work with poor ergonomic set-up[127]

Movements/ manual handing
- Repetitive movement[127, 128]
- Carrying a backpack[117]
- Heavy lifting[130]

Sporting/ physical activities
- Engaging in sport[117]
- Participation in competitive sport[117]
- Longer duration of sporting activity/ exercise[115, 117, 126]
- More frequent sporting activity[115, 117]
- Recent changes in running training[142]
- Running distance[115]
- Running speed[115]
- Training activities[115]
- Baseball pitch count: high & low[123]
- Stretching before and/or after physical activity[126, 143]
- Walking to school[117]
- Longer duration of walking [117]
- Less time engaged in sporting activity[116]
- Not engaging in physical activity[112, 117, 127]

Posture/ position
- Characteristics of posture[112, 117, 122, 125, 127, 129, 144, 145]
- Prolonged sitting[117, 127]
- Prolonged standing[146, 147]

Technology use
- Positioning for computer use[128]
- Longer computer use[117, 127]
- Longer use of mouse[127]
- Longer use of keyboard[127]
- Screen size of mobile handheld device[148, 149]
- Characteristics of mobile handheld device use[145, 148, 149]

Coping
- Sense of coherence[113]
- Poor coping strategies[130]
- Lower levels of resilience[150]
- Helplessness-hopelessness[111]

Psychological
- Psychological/ mood disorder[151, 152]
- Symptoms of psychological distress/ anxiety/ depression[111-113, 127, 130, 150-155]
- Higher levels of emotional distress[111, 150]
- Stress[113, 127, 151]
- Post-traumatic stress disorder[156]
- Negative affect[111, 127]
- Somatisation[130, 150, 153]

Work-/ study-related
- Job satisfaction/dissatisfaction[137, 151]
- Lower satisfaction with school[117]
- Unemployment/ unable to work[113]
- Retired[113]
- Tiredness at the end of the working day[127]
- Mental tiredness at the end of work day[127]
- High concentration tasks[127]
- High task difficulty[127]
- High perceived job demands[112]
- High perceived effort reward imbalance[112]
- Perceived quantitative demands[112]
- Low perceived empowering leadership[112]
- Lower level of education level[130, 157]
- Higher physical demands[141]
- Perceived work ability[137]
- Less work task variation[128]
- Lower supervisor support[127]
- Lower perceived co-worker support[112]

Support (outside of work/study)
- Lower perceived social support[113, 127, 130]
- Relationship status[113]
- Living alone[127]
- Emotional support[113]
- Instrumental support[113]
- Clinician-patient relationship[113]
- High perceived role conflict[112]
- Low perceived social climate[112]

Musculoskeletal symptom characteristics & beliefs
- Beliefs about back pain[158]
- Pain behaviour[137]
- Kinesiophobia/ fear-avoidance beliefs[111, 113, 137, 141, 150, 151, 155, 158, 159]
- Personal pain control beliefs[160]
- Catastrophising[111, 113, 150, 151, 155, 158, 159]
- Pain self-efficacy[113, 150, 159, 161]
- Lower levels of recovery expectations[137, 150, 153, 159]
- Expectancy of pain[111]
- Pain perceived to be chronic[160]
- Higher levels of concern regarding pain[160]
- Higher emotional pain representations[160]
- Non-adaptive pain thoughts[113]
- Pain intensity: high[113, 130] & low[141]
- Number of symptoms[160]
- Type of symptoms[157]
- Bilateral symptoms[157]
- Widespread pain[130]
- Higher pain frequency[157]
- Higher level of pain interference/ impairment[113, 130, 157]
- Lower functional status[141]
- Consequences of pain[160]
- Expectation of returning to work[141]
- Claiming workers' compensation or litigation[113, 141]
- Illness attitudes[153]
- Illness behaviours[153]
- Use of pain medication[113, 130]
- Shorter delay in referral[141]

Other
- Sleep problems[162]
- Smoking[117]
- Non-musculoskeletal comorbidities[115]
- Poor self-assessed health[112, 137, 141, 157]
- Health-related quality of life[137]
- Self-rated disability[137]

1.1.2.3 Theoretical frameworks for musculoskeletal symptom outcomes

The drivers of MSS outcomes included in theoretical frameworks that attempt to explain the development of MSSs and their consequences[163-176], are similar to those outlined above, based on pain science and epidemiological studies. Most of these proposed models for MSS outcomes include internal[164, 166-176] and external factors[164-166, 168-170, 172-176]; more specifically work-related factors[164-166, 168-170, 172-176], physical load[163, 165, 166, 168-176], and psychosocial factors.[163-166, 168-176] The models differ from one another in terms of the specificity of the factors proposed (e.g. genetic factors rather than individual factors), and the pathways connecting the factors included in the models. Some factors are proposed to have a direct[165, 166, 169, 170, 172, 173, 175] and/or indirect effect[165, 166, 169-173, 175] on the MSS outcomes, while others propose a moderating effect.[169, 170, 175] In addition, several models consider bidirectional relationships between factors and MSS outcomes, or feedback loops[169, 172-175], and some the transition from MSSs to the consequences of these symptoms.[163, 164, 167, 171-174] Regardless of the proposed relationships within these MSS frameworks, the role of both internal and external factors, including work-related, psychosocial and physical factors, remains consistent. The theoretical frameworks under-pinning this thesis will be described further in Section 1.3.

The consistency in the importance of individual and external factors, including psychosocial and physical factors, across MSS frameworks highlights the important role that these broad factors are thought to play in the development of MSSs, and their consequences. These factors are also consistent with the factors associated with MSS outcomes and mechanisms of contemporary pain science. The consistency in the inclusion of various internal and external factors, including psychosocial and physical factors in the MSS frameworks, epidemiological studies of MSS outcomes, and studies of pain science, provide strong evidence of their role in MSS development, prognosis, and consequences. These broad factors were therefore considered in this thesis.

1.2 Musicians’ musculoskeletal conditions

Our understanding of musicians and their musical activities, as well as pain mechanisms and risk factors for MSSs in non-musical populations indicates that musicians may be at increased risk of experiencing MSSs and their consequences. Musicians’ brains are reportedly different to those of non-musicians[53, 177-179], including in some of the specific brain regions involved in pain processing.[94] These differences include musicians having a larger somatosensory cortex[178] and cerebellum[179], as well as greater insula connectivity.[180] Furthermore, musicians’ sensory processes have been described as maladaptive, with ‘healthy’ musicians[n] exhibiting sensory processing similar to that of non-musicians with chronic pain.[181] These neurological differences may be involved in the experience of pain for musicians, and may explain why musicians are reported to have a higher prevalence of MSSs compared with reference groups.[63, 182-184]

Many factors modulate pain, including behavioural responses to pain (e.g. stress management[81], and fear-avoidance behaviour[185]), and psychosocial aspects (e.g. emotional state[186-189], and depression[190]). These factors may have particular relevance to musicians who have higher levels of psychological distress[191], lower levels of mental health[192], and poorer sleep[193] than the general population, and who may have been told to avoid playing while in pain[194, 195] (which may contribute to fear-avoidance behaviour; see Appendix 2.1 for a more comprehensive review). These characteristics may indicate that musicians are more susceptible to pain of greater intensity than their tissue damage indicates, or pain in the absence of any damage, than the general community is. The negative consequences of pain reported by musicians, including social isolation[194, 196, 197], a loss of self-worth[194] and identity[61,

[n]‘Healthy’ refers to musicians without chronic pain

[68, 194, 196], feelings of depression[196], stress[61], and financial strain[60] may further compound this problem; highlighting the need to comprehensively investigate musicians' MSSs.

In the following sections, the current evidence-base regarding musicians' MSSs is discussed. This review integrates four specific literature reviews, which are reported in full in Appendices 2.2-2.5. The section commences with an examination of the gaps in the current evidence-base in relation to musicians' MSSs, followed by a discussion regarding how MSSs may differ for various types of musicians (e.g. by genre). It concludes with a review of the prevalence of MSSs and their consequences for musicians, musicians' perceived causes of MSSs, the factors associated with MSS outcomes, and the safety and effectiveness of strategies to prevent and manage musicians' MSSs.

1.2.1 Gaps in the evidence regarding musicians' musculoskeletal conditions

Gaps in the evidence regarding musicians' musculoskeletal conditions were identified through a systematic mapping review. In doing so, original research questions were developed for the thesis.

The systematic mapping review involved a systematic search to identify all studies of musicians' MSSs published in English language, within peer-reviewed journals from 2007-2016 (see Appendix 2.2 for details). Included studies were categorised as studies that investigated the extent or severity of MSSs (e.g. prevalence, incidence, ratings of severity), risk factors and mechanisms, interventions and 'other' studies (based on van der Beek et al.'s[198] framework for preventing WRMSDs[o]). The 'other' studies category was included for studies that did not fit the three main categories (e.g. qualitative studies, studies of attitudes or beliefs regarding MSSs). An update systematic search using the same methods as those of the systematic mapping review (Appendix 2.2) was conducted in April 2019. The findings of this update search have been integrated into the discussion in the following sections. The systematic mapping review encompassed all types of musicians, including children and amateur musicians, however the discussion below reports only on university music students and professional musicians, unless otherwise indicated.

1.2.1.1 Summary of the evidence base

There were 125 unique primary studies (reported across 144 articles), identified in the systematic mapping review and update search, that investigated MSS outcomes in university music students and/or professional musicians. In addition, two systematic reviews were identified that focused on these populations; one[52] investigated the prevalence of MSSs and reported some differences between the groups of musicians, while the other[199] investigated risk factors for MSSs. While a relatively large number of studies regarding university music students' and/or professional musicians' MSSs were identified, these tend to focus on classical musicians, particularly professional orchestral musicians (Table 1.3). This finding indicates that there are under-investigated sub-groups of musicians, including non-classical music students, and professional opera, military band, and self-employed musicians, as well as instrumental and singing teachers. Further, there remain important MSS consequences that have received little attention, such as taking leave, the impact of MSSs on daily life, and the emotional impact of MSSs (as will be described further in Section 1.2.2.1). There were also relatively few intervention studies identified (Table 1.3; discussed in more detail in Section 1.2.2.3). Musicians' musculoskeletal conditions therefore remain an under-investigated public health problem that require further investigation in order to reduce the burden of musculoskeletal conditions more broadly.

[o]The framework specified incidence and severity, however most studies of the extent of musicians' musculoskeletal symptoms report prevalence; hence prevalence was also included in this category.

Table 1.3: The musical populations and study types investigated in studies of musicians' musculoskeletal symptom outcomes (published January 2007-April 2019)

	Extent/ severity	Associated factors/ mechanisms	Interventions	Other	Total
Professional	45, 63-65, 74, 87, 182, 200-242	45, 63-65, 87, 181, 182, 203, 206, 208, 211-222, 225-230, 232-235, 237, 238, 243	200, 226, 241, 244-250	62, 64, 65, 194, 197, 200, 205, 217, 229, 231, 251-259	45, 62-65, 74, 87, 181, 182, 194, 197, 200-259
Orchestral	45, 63-65, 74, 87, 200, 203, 204, 206, 208, 210-213, 215, 219, 220, 222, 224, 225, 227-229, 231-238	45, 63-65, 87, 203, 206, 208, 211-213, 215, 219, 220, 222, 225, 227-229, 232-235, 237, 238	200, 244-250	64, 65, 194, 200, 229, 231, 253-255, 258, 259	45, 63-65, 74, 87, 194, 200, 203, 204, 206, 208, 210-213, 215, 219, 220, 222, 224, 225, 227-229, 231-238, 244-250, 253-255, 258, 259
Military band	216, 217, 223, 226	216, 217, 226	226	217	216, 217, 223, 226
Blues	226				226
Ceremonial	226				226
Chorus	226				226
Concert	226				226
Cuban/ West Indian	182, 205	182		205	182, 205
Opera singers				257	257
Classical choristers	207				207
Teachers	201, 214, 230	214, 230		252	201, 214, 230, 252
Jazz				252	252
Professional or university students	73, 228, 239, 240, 242, 260-266	73, 228, 239, 240, 242, 261-263, 265-270	271-273	239, 260, 274, 275	73, 228, 239, 240, 242, 260-275
Orchestral			273		273
Classical	240				240
Jazz	240				240
Popular	240				240
Irish	73	73			73
University students	60, 183, 184, 192, 228, 239, 240, 242, 252, 276-303	183, 192, 228, 276, 277, 282, 284-290, 292-297, 299-301, 304-307	308-317	60, 252, 281, 283, 284, 288, 295, 296, 298, 299, 303, 318-324	60, 183, 184, 192, 228, 239, 240, 242, 252, 276-324
Orchestral	277	277			277
Symphony orchestra	293	293			293
Marching band	278, 289, 291	289			278, 289, 291
Classical	60, 183, 286, 287, 295, 298, 301	183, 287, 295, 301		60, 295, 298, 319, 323	60, 183, 286, 287, 295, 298, 301, 319, 323
Jazz	252, 279			252	252, 279
Rhythmic	286				286
Musical theatre	299	299		299	299

Note: The population type refers to the target population, which was not necessarily the same as those from whom data were collected (e.g. Rickert et al.[194, 254, 255, 320], Ackermann and Driscoll[325], Ajidahun and Phillips[326], and McKechnie and Jacobs[327])

1.2.1.2 Why research into different genres/ ensemble types matters

Although some of the elements of being a musician are similar across different musical genres and ensemble types, there are distinct differences in the education, prioritisation of specific skills, work environments and cultures between them, as summarised in Tables 1.4 and 1.5 (reported in full in Appendix 2.3). Therefore, the findings of existing studies that focus on university classical music students and professional orchestral musicians might not be generalisable to other types of musicians. In Australia, orchestral musicians are estimated to account for less than 10% of instrumental musicians[p], hence the potential generalisability of findings regarding orchestral musicians to other types of musicians must be considered.

Owing to the differences between orchestral and classical musicians, and other types of musicians, we are unlikely to be able to adequately identify nor address the burden of musculoskeletal conditions for Australian musicians without studies of the whole music industry, including analyses specific to and comparing sub-groups of musicians. This limitation of the existing evidence-base regarding musicians' musculoskeletal conditions will be addressed in the thesis.

1.2.1.3 Studies of Australian musicians

The findings of international studies of musicians' MSSs are not necessarily generalisable to Australian musicians. Differences that may limit generalisability include university health and safety training[328, 329], and differences in workers' compensation schemes[330, 331] and medical benefits.[331] Public health recommendations should be specific to the population, in this case Australian musicians. As there have not been international comparative studies of musicians' musculoskeletal conditions, the generalisability of findings internationally cannot be assumed. As such, studies specific to Australian musicians are required.

Regarding studies of Australian university music students or professional musicians, there were only seven unique studies investigating the extent of MSSs[45, 60, 200, 201, 225, 227, 228, 234, 281, 296], four investigating associated factors or mechanisms[45, 225, 227, 228, 234, 269, 296], three investigating interventions[200, 245, 246], and five investigating 'other' aspects of MSSs.[60, 194, 200, 254, 255, 281, 296, 320, 323] These Australian studies examined professional orchestral musicians[45, 200, 225, 227, 234, 245, 246], professional orchestral cellists[194, 228, 254, 255], pianists[201] and piano teachers[201], professional violinists and university violin students[269], and university woodwind[60, 323], flute[281], cello[q][228, 320], and piano students.[296] The recent evidence regarding Australian musicians' musculoskeletal conditions remains scant; hence, a more comprehensive study of the music industry as a whole is required.

Addressing the identified gaps would provide better insight into the burden of musicians' musculoskeletal conditions, which types of musicians are most affected, and how best to reduce the burden of musicians' musculoskeletal conditions. There are gaps in the current evidence base that indicate that further research regarding musicians' MSSs is warranted, including non-orchestral professional musicians and non-classical university music students, particularly among Australian musicians.

[p]In Australia, 6033 people indicated their primary employment was as an instrumental musician in the Census of Population and Housing[58], yet Ackermann et al.[224] reported that there were 580 musicians employed in professional orchestras in Australia.
[q]The focus of Rickert et al.'s[320] qualitative study was student cellists, although the views of professional cellists were also sought.

Table 1.4: Comparison of the characteristics of classical and non-classical musicians

	Classical musicians	Non-classical musicians
Types of musicians	• Vocalists, and violin, viola, cello, double bass, harp, flute, oboe, bassoon, clarinet, saxophone, trumpet, cornet, trombone, French horn, euphonium, tuba, percussion, piano, harpsichord, pipe-organ, and classical guitar players	• Jazz: Vocalists, and saxophone, trumpet, trombone, double bass, acoustic guitar, electric guitar, bass guitar, keyboard, piano, and percussion players, and sometimes other instruments including flute, clarinet, banjo, and electric organ players • Rock/ popular: Vocalists, and acoustic guitar, electric guitar, bass guitar, piano, keyboard and percussion (generally drum kit) players, and sometimes saxophone, trumpet, trombone, and double bass players • Folk: Depends on the type of folk music, but in Western folk music instruments may include tin whistles, fiddles, acoustic guitar, banjo, concertina, and bagpipe players and players of various percussion instruments
Training/ valued skills	• Start music at a younger age than non-classical musicians[332, 333] • Undertake formal training[333] • Focus on solo work[332, 333] • Value skills in technical proficiency[332, 333], sight reading[333], control/ quality of tone[333], notation-based skills[332], musical analysis[332], and musicality[332, 333]	• Start music at an older age than classical musicians[332, 333] • Jazz/ popular musicians learn by attending gigs[333], listening to music and memorising or transcribing it[333], networking with more experienced musicians[333], and jamming with friends.[333] • Folk musicians tend to be self-taught through listening and participation[334], learn through imitation as part of an oral-aural learning culture[334, 335], with little consideration of musical literacy[335], and posture.[335] • More recently, university programs for non-classical musicians have been introduced but with greater autonomy than for classical students.[333] • Value skills in memorisation[332, 333], improvisation[332, 333], and collaboration[333]
Repertoire	• Prescriptive, to emulate the composer's intention	• Greater emphasis on improvisation than classical music • Jazz: The prescribed tune (the 'head') on which improvised sections are based, are typically technically easier than classical works • Folk: ornamentation upon a tune, which is typically easier than classical works
Venues	• Often perform in concert halls and churches	• Large concert venues for groups with large fan bases (often professional contemporary groups) • Typically perform in pubs and clubs • Irish traditional musicians often play in pubs which can be cramped[334], with inappropriate seating (chairs with arm rests, lounges, benches bar tolls, beer kegs or instrument cases)[335]
Movement on stage	• Typically do not move around the stage, except in opera	• Contemporary musicians may move around the stage and dance while performing, which may include head-banging • Musical theatre performers are generally required to dance, as will be described further in Table 1.5

Table 1.5: Comparison of the characteristics of the main types of musical ensembles

Orchestral musicians	• Symphony/ philharmonic orchestras consist of a conductor, and violin, viola, cello, double bass, harp, flute, oboe, bassoon, clarinet, trumpet, cornet, trombone, French horn, euphonium, tuba, and percussion players, and sometimes other instrumentalists including saxophone, cornet, piano, harpsichord and pipe-organ players. Soloists may include any type of instrument, as well as vocalists. • Chamber orchestras consist of violin, viola, cello, and double bass players, and sometimes other instrumentalists, typically flute, oboe, trumpet, and harpsichord players. • Most symphony/ philharmonic musicians typically sit (except for the conductor and percussionists) • Most chamber orchestra musicians typically stand (except for cellos) • Bowed strings tend to share the same parts, so it may be easier for these musicians to take leave or 'fudge' sections that may aggravate musculoskeletal symptoms, compared with winds and percussionists • Pit orchestras (for musical theatre and opera performances) play within the space largely beneath the stage, where they may face cramped conditions[336, 337], poor lighting[337], dangerous access to the pit[337], cables (e.g. for lighting)[337], and objects falling from the stage into the pit.[337] • Musicians in pit orchestras for musicals, particularly woodwinds, are often required to play multiple instruments. Multi-instrumentalists may have to swap quickly between instruments may lead to instruments being hung around the neck while playing other instruments, and limits free-space around the musician • Orchestral musicians do not have 'under-studies' (or similar) ready to fill in for performances • Stage crews are typically responsible for setting up and packing up equipment for rehearsals and performers
Military band musicians	• Military band musicians are typically involved in marching while playing, particularly for ceremonial parades, and also play in the concert band. Military band musicians may also perform in smaller groups such as big/stage bands, or contemporary rock groups[338] • Concert bands typically include a conductor, and flute, clarinet, oboe, bassoon, saxophone, trumpet, trombone, French horn, euphonium, tuba, and percussion players, and sometimes include other instrumentalists such as cornet, double bass and piano players. • Marching bands typically include a drum major, and piccolo, clarinet, oboe, saxophone, cornet, trombone, French horn, euphonium, tuba/ sousaphone, and percussion players. • Big/ stage bands include saxophone, trumpet, trombone, electric guitar, bass guitar, piano, and percussion players, and sometimes the saxophone player will 'double' on flute and/or clarinet • Musicians in military bands are often multi-instrumentalists • Lyres used instead of music stands (or the music is memorised) • Must wear standard uniforms, including footwear • Musicians are involved in setting up and packing up for performances, and this also involves loading equipment into trucks • Musicians undergo military training and testing (e.g. fitness, physical, and weapons training and testing) • Often have access to military healthcare (varies internationally and may differ between reservists and regular military personnel)
Opera and musical theatre (stage performers)	• Performances involve acting as well as singing, and may also involve acrobatics[339], dancing[339], stage combat[339], and puppetry[340] (typically musical theatre rather than opera) • Stages may be raked (angled down towards the audience) • Costumes, footwear, props and stage trucks may pose a risk to performers • 'Understudies' (or similar) are typically trained to take over from a lead cast member if they are unable to perform

1.2.2 What is known about musicians' musculoskeletal conditions?

In the following sections the current understanding of the extent and severity of musicians' MSSs are discussed, followed by a review of the evidence of the potential risk factors and interventions for musicians' MSSs. Studies were drawn from the systematic mapping review (Appendix 2.2) and the update search (Appendix 1.1), and were specific to university music students and professional musicians, unless indicated otherwise. Concerning the prevalence of MSS outcomes, only findings where the recall periods were clearly stated are reported.

1.2.2.1 Extent and severity of musicians' musculoskeletal symptoms

The extent and severity of musicians' MSSs was determined by the prevalence of both MSSs and the consequences of MSSs. Further, ratings of the intensity of MSSs and of the severity of the consequences of MSSs were considered. Prevalence was the focus rather than incidence, owing to the recurrent nature of MSSs[341], making prevalence a more appropriate measure of the extent of musicians' MSS outcomes.

Prevalence of musculoskeletal symptoms

The prevalence of MSSs among university instrumental music students and professional instrumental musicians was recently reported in Kok et al.'s[52] systematic review. In Kok et al.'s[52] review, MSSs were divided into 'playing-related' or 'non-playing-related'.[r] The point prevalence of non-playing-related musculoskeletal complaints was 57-68%, while the 12 month prevalence was 86-89%.[52] The playing-related musculoskeletal complaint prevalence estimates were broader: 9-68% for point prevalence, 41-93% for 12 month prevalence, and 62-93% for lifetime prevalence.[52] Kok et al.[52] reported issues with the lack of consistency regarding the MSS outcomes investigated, and concerns regarding the use of data collection methods that have not been validated. The wide prevalence estimates may be due to differences in the specific MSS outcomes, data collection methods used, or in the amount of the body considered.[s] Notwithstanding the variability in some prevalence estimates, MSSs appear to be an issue faced by the majority of musicians.

Regarding specific body regions, Kok et al.[52] noted difficulties in synthesising data due to a lack of consistency in the body regions reported. Nonetheless, they reported that the neck and shoulders generally had the highest prevalence of MSSs, while the elbows had the lowest.[52] As studies that focused on specific body regions (i.e. less than half the body) were excluded from Kok et al.'s[52] review, these findings should be interpreted with caution.

Kok et al.'s[52] systematic review provides strong evidence of a high prevalence of MSSs in some sub-groups of musicians (e.g. classical instrumentalists). As determined in the systematic mapping review (Appendix 2.2) there are few studies of non-classical musicians, including military band musicians, singers and music teachers; groups for which Kok et al.'s[52] findings might not be applicable. A broader investigation of the prevalence of MSSs in the music industry as a whole should therefore be conducted. Furthermore, the lack of consistency in the body regions investigated has meant that there is little evidence of the body regions with the highest prevalence[52]; required for prioritising interventions.

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[r] Kok et al.'s[52] classification of MSSs as 'playing-related' or 'non-playing related' appears to be based on the term used by the study authors, rather than on adherence to a specific definition or type of definition (e.g. MSSs perceived to be due to playing, that impaired playing, or had a temporal relationship to playing; see Appendix 2.5 for a review of 'music-related' MSS terminology).

[s] Kok et al.'s[52] review only included studies where prevalence referred to at least the upper limb, neck and back regions

To overcome some of the limitations of the evidence base identified by Kok et al.[52], a comprehensive review of the MSS outcomes and data collection tools used with musicians was indicated, as will be discussed further in Chapter 2 (and reported in full in Appendix 2.5). In conducting such a review, the data collection methods used in the research presented in this thesis could be selected in order to maximise consistency with the existing evidence base, thus allowing for direct comparison, and potentially future synthesis of these findings with the existing literature.

Comparative studies of the prevalence of musculoskeletal symptoms

Musicians have been described as a 'high risk' population for MSSs[342-344]; however there is little evidence to support this statement. As reported earlier, the majority of musicians experience MSSs[48-52], but this is also true of the general population[345]; hence comparative studies are required.

Only six studies (reported across eight articles[63, 182-184, 202, 207, 287, 298]) comparing the MSS prevalence and profile of university music students and professional musicians with other groups were identified in the systematic mapping review (Appendix 2.2) and the update search (Appendix 1.1). One of these studies[202] investigated ankle sprains and recurrent ankle lesions as the musculoskeletal outcomes of interest, while the other five studies[63, 182-184, 207, 287, 298] investigated MSSs more generally, and are therefore the focus of this section. These five studies compared MSS outcomes between professional choristers with the general population[207], university music students with health[184] or medical students[183, 287, 298], and professional steel drum players[182] and professional orchestral musicians with the general working population.[63] The evidence from these comparative studies suggests that musicians have a higher prevalence of MSSs compared with reference groups overall (i.e. in any body region)[182, 183], and specifically the spine and upper limb regions.[63, 183, 184] There was some variation in findings depending on the recall period used[63, 183], and between genders in gender-specific analyses.[63] Conversely, Vaiano et al.[207] found that professional choristers had a lower prevalence of MSSs in the spine and upper limb regions, as well as in the head region, compared with the general population. Vaiano et al.[207] did not report the recall period, nor was it clear in the questionnaire used.[t]

With the exception of one aspect of Kok et al.'s[298] comparative study, none of the comparative studies adjusted for potential confounders. Paarup et al.[63] did however stratify their analysis by gender. Further limitations of these comparative studies included not using validated questionnaires[183, 184, 207, 287, 298], and the use of inappropriate reference groups.[183, 184, 287, 298] By comparing university music students with health[184] or medical students[183, 287, 298], we cannot ascertain whether musicians have a higher prevalence than other students, or whether health/medical studies have a lower prevalence than 'typical' students, as health/medical may have different health behaviours, owing to their (likely) greater knowledge of the prevention and management of musculoskeletal conditions.

The existing evidence is inadequate to determine whether musicians have a higher prevalence of MSSs compared with other groups. Studies making such comparisons are required and should have appropriate reference groups, use validated questionnaires, and account for potential confounders in the analysis.

[t]The questionnaire was reported as an appendix in Vaiano et al.'s[207] study

The prevalence of the consequences of musculoskeletal symptoms
The focus of this thesis is on the burden of MSSs, rather than simply the presence of MSSs; hence, the *consequences* of MSSs are arguably the most important type of MSS outcome in this research. Despite the relative importance of MSS consequences, only 22 recent studies of university music students and professional musicians have reported the prevalence of MSS consequences, with clearly reported recall periods (e.g. lifetime prevalence), published since 2007. The prevalence of MSS consequences (among the whole sample, not just those with MSSs) for MSSs overall (i.e. in any body region) are reported in Table 1.6. These findings indicate that impaired musical activities, having time off from playing, and seeking treatment because of MSSs are relatively common experiences among university music students and professional musicians. The most commonly consulted health professionals were medical professionals, physiotherapists, and chiropractors.[63, 65] In addition to the outcomes reported in Table 1.6, 45% of university music students reported having experienced their current MSSs that impaired their musical activity for at least three months[286], indicating an ongoing burden of MSSs.

The prevalence of consequences of MSSs have only been compared between university music students and a reference group in one study[287, 298], with no such comparison between professional musicians and relevant reference groups. Kok et al.[287, 298] compared the MSSs consequences of university music and medical students. Music students with MSSs rated the consequences (i.e. impact on daily life) and emotional impact of their MSSs significantly higher than symptomatic medical students.[298] When considering MSSs in the neck and/or upper limb regions specifically, musicians also reported higher ratings of functional impairment compared with the medical students, both at the time of data collection and in the 12 months prior.[287]

Regarding treatment behaviour, a higher proportion of university music students with MSSs in the neck and/or upper limb sought medical care, specifically from specialists, physiotherapist or alternative medicine therapists compared with medical students, but not general practitioners, compared with symptomatic medical students.[287] This finding may be due to medical students being less likely to seek treatment compared with ‘typical’ university students, rather than music students differing from ‘typical’ university students, given that medical students would be expected to possess a greater knowledge of MSS prevention and management, than non-medical students did. As such, the consequences of MSSs should be compared between musicians and appropriate reference groups in future research.

Although the consequences of MSSs for musicians have been investigated in a number of studies, these studies have focused on university classical music students and professional orchestral musicians. Furthermore, only one study[287, 298] has compared the consequences of MSSs between musicians and a reference group. Research into the MSS consequences across the music industry are required, and the prevalence of these consequences should be compared with appropriate reference groups to determine whether musicians do have a higher burden of MSSs than other groups.

Table 1.6: Prevalence (percentage) of university music students and professional musicians who report consequences of musculoskeletal symptoms overall (i.e. in any body region)

	Lifetime	Career	18 month	12 month	4 week	7 day	Point
Impact on musical activity							
Unable to play at usual level	62-77[60, 218]	62[a286]		46[218]	51[295]	37-68[b218, 296]	38[60]
Affected performance	40[65]						
Significantly influenced performing ability		66[208]					
Missed a performance	"nearly 17%"[239]						
Interfered with playing, rehearsals, or performances	84[c224]						
Absent from orchestra	20[65]						
Cannot give classes	1[65]						
Change in technique	13[65]						
Affect playing time	43[65]						
Decrease playing	21[65]						
Cannot play	17[65]						
Warm-up	17[65]						
Extended time off from playing	6[290]						
Time off from playing				64[346]			
Work/ study							
Making a workers' compensation claim		3[64]					
Sick leave/ time off			8[224, 225, 234]	23[64]			
Management strategies							
Taken medication	21[65]						
Taken non-steroidal anti-inflammatory drugs							3[276]
Taken paracetamol							3[276]
Taken other pain medications							6[276]
Perform stretches	31[65]						
Change posture	32[65]						
Professional care		85[64]					
Consulted a medical professional	35[65]						
Consulted a physiotherapist	35[65]						
Consulted an occupational therapist	1[65]						
Consulted a chiropractor	32[65]						
Consulted an alternative medicine therapist	8[65]						
Did Alexander technique	9[65]						
Did Feldenkrais	1[65]						

Notes: The denominator for the reported percentages referred to all musicians (both symptomatic and asymptomatic). Findings related to consequences in specific body regions were not reported in the table. [a]it is unclear how 'career' was defined, as the participants were students. [b]reported as point prevalence but referred to the last 7 days. [c]reported as career prevalence, but the questionnaire[347] asks about musculoskeletal symptoms during their lifetimes.

Musculoskeletal symptoms with a specific perceived cause

Examining the prevalence of MSSs attributed by musicians to specific factors may provide valuable insight into beliefs that can be addressed through public health and/or clinical interventions, and guide future research into the association between the proposed factors and MSS outcomes. Recent studies of university music students and professional musicians indicate that the most commonly reported perceived causes of MSSs overall (i.e. in any body region) were long playing sessions, excessive muscle tension, muscle fatigue, poor posture, and insufficient rest (Table 1.7). Two of these studies investigated university piano students[252, 296], one investigated military brass band musicians[217], and three[64, 65, 224] investigated professional orchestral musicians. The perceived causes of MSSs may differ between groups of musicians, given the differences in characteristics (summarised in Tables 1.4 and 1.5, and reported in full in Appendix 2.3). For instance, a qualitative study[257] of opera musicians reported issues with raked stages and ill-fitting costumes leading to MSSs, that might not apply other types of musicians. A broader investigation into the perceived causes of MSSs for musicians as a whole is therefore required to ensure that unique issues in sub-groups of musicians are not overlooked.

While it was not clear in all studies of the perceived causes of MSSs, it appears that with the exception of one study[296], data regarding musicians' perceived risk factors/ causes for MSSs were collected by providing a list of potential risk factors/ causes and asking musicians' to endorse the factors they believe led to their MSSs.[64, 65, 217, 224, 252] These researcher-driven methods may be inadequate in determining the full range of perceived causes, particularly as the lists do not appear to have been based upon qualitative studies conducted with musicians.

Bragge et al.[296] utilised a different approach asking their participants to list their perceived risk factors (a musician-driven method) for playing-related musculoskeletal disorders (PRMDs) using Zaza et al.'s[68] definition[u]. Bragge et al.[296] only reported the percentage of pianists who attributed their PRMDs in the last 7 days to changes in playing routine, but also reported the top five perceived risk factors.[296] These factors were "muscle tension", "practice time", "technique", "posture", and "stress".[296] There has not been a comprehensive examination of musicians' perceived causes of their MSSs, using musician-driven data collection methods (i.e. open response, rather than endorsing causes from a list) - approaches that would overcome the potential biases in the recent evidence.

Although a number of studies have investigated perceived causes of musicians' MSSs, these studies have mainly looked at orchestral musicians, leaving other types of musicians under-investigated. Owing to different exposures across sub-groups of musicians, the perceived causes may also differ; hence, the perceived causes of MSSs from a broad range of musicians should be considered, using musician-driven data collection methods (e.g. open-response).

[u]"pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with your ability to play your instrument at the level to which you are accustomed"[68 (p 2016)]

Table 1.7: Percentage of symptomatic university music students and professional musicians who attributed their musculoskeletal symptoms to specified risk factors

	Percentage musicians with musculoskeletal symptoms	Musculoskeletal symptom type: recall period
Playing-related factors		
Long sessions of playing	77.8	Playing-related symptoms: last 12 months[64]
Long practice sessions	82.0	Pain or injuries[a]: lifetime[224]
Particular repertoire or a difficult piece	62.6	Playing-related symptoms: last 12 months[64]
Repertoire scheduling	71.7	Pain or injuries[a]: lifetime[224]
Increased difficulty	13.1	Musculoskeletal problems: lifetime[65]
Sudden increase or decrease in playing hours	42.8	Playing-related symptoms: last 12 months[64]
Increase in rehearsal time	37.7	Musculoskeletal problems: lifetime[65]
Sudden increase in playing[b]	75.5	Pain or injuries[a]: lifetime[224]
Increase in playing[b]	55.7	Musculoskeletal problems: lifetime[65]
Change in practice routine	35.6	Playing-related musculoskeletal disorders[c]: last 7 days[296]
Musculoskeletal factors		
Too much/ excess muscle tension	82.4	Pain or injuries[a]: lifetime[224]
	62.6	Playing-related symptoms: last 12 months[64]
Playing when physically exhausted	50.2	Playing-related symptoms: last 12 months[64]
Muscle fatigue	76.8	Pain or injuries[a]: lifetime[224]
Lack of endurance or strength	40.7	Playing-related symptoms: last 12 months[64]
Lack of fitness	67.0	Pain or injuries[a]: lifetime[224]
Lack of flexibility	65.7	Pain or injuries[a]: lifetime[224]
Poor/ bad posture	54.1	Musculoskeletal problems: lifetime[65]
	77.9	Pain or injuries[a]: lifetime[224]
	35.0	Playing-related symptoms: last 12 months[64]
Insufficient warm-up	66.7	Pain or injuries[a]: lifetime[224]
	32.1	Playing-related symptoms: last 12 months[64]
Insufficient rest	80.5	Pain or injuries[a]: lifetime[224]
Too few breaks during playing	31.3	Playing-related symptoms: last 12 months[64]
Poor technique/ technical flaws	57.5	Pain or injuries[a]: lifetime[224]
	7.41	Playing-related symptoms: last 12 months[64]
Mouthpiece pressure	57.6	Lip pain: lifetime[217]
Poor injury management	62.8	Pain or injuries[a]: lifetime[224]
Work environment factors		
Chairs of improper or invariable height	32.5	Playing-related symptoms: last 12 months[64]
Cramped playing conditions	32.5	Playing-related symptoms: last 12 months[64]
Carrying instrument or other equipment	28.4	Playing-related symptoms: last 12 months[64]
Temperature	20.6	Playing-related symptoms: last 12 months[64]
Lighting	14.0	Playing-related symptoms: last 12 months[64]
Variations in the functioning and/or malfunction of the instrument	14.4	Playing-related symptoms: last 12 months[64]
Instrument set-up	58.7	Pain or injuries[a]: lifetime[224]
Touring	37.2	Pain or injuries[a]: lifetime[224]
Psychosocial factors		
Emotional problems	13.1	Musculoskeletal problems: lifetime[65]
Stress and/or anxiety	65.4	Playing-related symptoms: last 12 months[64]
Stress	69.6	Pain or injuries[a]: lifetime[224]
Depression	14.8	Playing-related symptoms: last 12 months[64]
Performance anxiety	62.0	Pain or injuries[a]: lifetime[224]
Time pressure/ practicing with a deadline	51.0	Playing-related symptoms: last 12 months[64]
Feelings of inadequacy	25.5	Playing-related symptoms: last 12 months[64]
Job dissatisfaction	21.4	Playing-related symptoms: last 12 months[64]
Lack of support from management/ conductor	19.8	Playing-related symptoms: last 12 months[64]
Conductor approach	49.3	Pain or injuries[a]: lifetime[224]
Lack of social support	9.5	Playing-related symptoms: last 12 months[64]

Notes: Only studies that clearly reported the recall period for the musculoskeletal symptom outcome were included. Where studies did not use the symptomatic sample as the denominator, the percentages were recalculated based on the prevalence of musculoskeletal symptoms and the percentage who attributed their musculoskeletal symptoms to the proposed factors. Wood[252] reported that 41.2% of the whole sample attributed injuries during their lifetimes to practice or performance, but did not report the percentage of the sample who reported injuries. [a]Ackermann et al.[224] appears to refer to those who had pain or injury that impaired playing, therefore that value was used as denominator. [b]It is unclear what the increase refers to (e.g. time, intensity). [c]Zaza et al.'s[68] definition: "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with your ability to play your instrument at the level to which you are accustomed"[68 (p 2016)].

1.2.2.2. Risk factors for musculoskeletal symptom outcomes

The association between potential risk factors and MSS outcomes for university instrumental music students and professional instrumentalists was investigated in a recent systematic review.[199] Baadjou et al.[199] stated that "no conclusion can be drawn regarding risk factors for musculoskeletal disorders in (pre-) professional instrumental musicians".[199(p 621)] Yet, Baadjou et al.[199] reported that there was consistent evidence supporting an association between female gender, playing a string instrument, previous musculoskeletal injury, high levels of stress and performance anxiety, and MSS outcomes. They identified no such association with exercise, cigarette smoking, orchestra category/status, support or control at work.[199] These findings were however drawn from a small number of heterogeneous studies, of low methodological quality, excluded studies of military band musicians and singers, and did not include any studies of music teachers. Only two studies[214, 226] of groups of musicians who were not included in Baadjou et al.'s[199] review have investigated the association between potential risk factors and MSS outcomes using multivariable analyses. The addition of these two studies[214, 226] would not have altered the findings of Baadjou et al.'s[199] review. As identified in the systematic mapping review (Appendix 2.2), studies that have investigated the association between potential risk factors and MSS outcomes have focused on non-modifiable factors, such as age, gender, and instrument played. The evidence from both pain mechanisms and risk factors for MSS outcomes in other populations indicates that there is a range of potential risk factors for musicians' MSSs that have not yet been investigated, or have not adequately been investigated. Further, the bias towards orchestral/ classical musicians indicates that further research in this area is warranted, that includes non-orchestral/ non-classical musicians.

There have been relatively few studies comparing the MSS outcomes of different groups of musicians (Appendix 2.2). Different types (e.g. genres) of musicians have been compared in eight studies[201, 225, 226, 228, 240, 261, 262, 286, 296] (published since 2007). These studies compared musicians of different genres[240, 261, 286, 296] (two investigated bassists[240, 261] and another of pianists[296] specifically); professional and university student cellists[228]; performing pianists and piano teachers[201]; percussion students, orchestral percussionists, solo percussionists and percussion teachers[262]; pit, stage or pit and stage orchestras[225]; and the performance groups (chorus, concert, blues, and ceremonial) within military bands.[226] Only four of these studies[226, 228, 240, 286] identified differences between the musician groups for at least one MSS outcome. For cellists, the 18 month prevalence of pain or injury was significantly higher among professionals compared with students.[228] Bassists[v] who played classical music had a lower 3 month prevalence of left shoulder pain experienced 'often' or 'always', compared with those who only played non-classical music.[240] Conversely, Árnason et al.[286] reported that classical music students had a higher lifetime prevalence of PRMDs[w] compared with rhythmic students. For military band musicians, Grier et al.[226] reported that ceremonial musicians had a higher prevalence of foot MSSs that were perceived to be due to band activities and that impaired daily activities, compared with blues, chorus and concert military band musicians. These findings suggest that there are few differences between sub-groups of musicians in the prevalence of MSS outcomes; however, these studies focused on smaller groups of musicians (e.g. specific instruments) rather than the music industry as a whole, and focused on MSSs rather than the consequences of MSSs.

[v]Double bassists and bass guitarists

[w]Playing-related musculoskeletal disorders were defined as "any pain, weakness, numbness, or other physical symptom that interferes with one's ability to play a musical instrument in the manner one is accustomed to"[286(p 74)] citing Brusky[348]

Although there is evidence to suggest an association between female gender, playing a string instrument, previous musculoskeletal injury, high levels of stress and performance anxiety and MSS outcomes[199], there are many potentially modifiable factors that have not been considered (Appendix 2.2). Furthermore, few studies have compared sub-groups of musicians, with many comparisons being restricted to particular instruments. Future studies should determine which sub-groups of musicians have the highest MSS prevalence and burden, and target research into modifiable risk factors and interventions towards these groups. This targeted approach would provide the greatest opportunity to reduce the burden of MSSs.

1.2.2.3 The effect of interventions to prevent and/or manage musculoskeletal symptoms

In addition to risk factors (Section 1.2.2.2), the 'preventability' of musicians' MSS outcomes can also be examined by investigating the effectiveness of strategies to prevent and manage MSSs. The beneficial and adverse effects of public health strategies to prevent and manage MSSs in any type of musician were explored in a systematic review conducted in June 2018 (Appendix 2.4). A total of 14 studies were included; 10 of which investigated exercise programs[244-246, 250, 313, 349-351], and one each a combined exercise/ education program[352], education program[308], the use of 174 cm piano keyboards (rather than 188 cm)[309], and improved footwear.[226] An update systematic search (April 2019) identified a further four studies, that investigated an exercise program[241], education program[314], and combined exercise and education program[273], while another study compared a biopsychosocial and exercise program.[315]

The evidence for the effectiveness of exercise programs[241, 244-246, 250, 273, 313, 349-352] (including the combined education and exercise programs) was inconsistent, with the studies reporting a beneficial effect generally being at higher risk of methodological bias than those that did not find such an effect. There was no significant difference in MSS outcomes between musicians in the biopsychosocial and exercise programs[315], while the education programs[308, 314] and new footwear[226] were not found to be beneficial. The use of a 174 cm piano keyboard reduced the intensity of MSSs, in the short-term, compared with the 188 cm keyboard.[309] Few studies reported whether adverse events occurred. It was concluded that there was insufficient evidence to support the implementation of any of these public health interventions for musicians' MSSs.

Individualised interventions have also been tested with musicians (Appendix 2.2), however the effectiveness and safety of these interventions would not be anticipated to be different to that of non-musicians; hence, these studies provide little guidance as to how to reduce the burden of musicians' MSSs specifically, from a public health perspective.

While there is some support for further investigations into the use of smaller piano keyboards over a longer study duration, there is little evidence to support recommendations regarding how best to safely and effectively prevent and manage musicians' MSSs. In order to develop strategies that are likely to be effective in reducing the burden of musicians' MSSs the priority sub-groups of musicians, the priority MSS outcomes, and the modifiable factors for these MSS outcomes, within the priority sub-groups should be established.

1.3 The purpose of this research

As highlighted in the previous sections, musicians may be at particular risk of experiencing adverse MSS outcomes, however the current evidence base is insufficient to determine whether this is the case in Australian university music students and professional musicians specifically, and whether these findings are relevant to the sub-groups of musicians within these populations. This thesis therefore intends to address the knowledge gap identified.

The central research question for this thesis "is there a preventable burden of musculoskeletal conditions for Australian university music students and professional musicians?" was divided into two sub-questions, which were addressed, in turn, by answering a series of sub-questions (Figure 1.1). In the following sections, the development of these questions is discussed.

Is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?

- What proportion of workers' compensation claims, and their costs, are due to musculoskeletal disorders?
- What is the prevalence and profile of musculoskeletal symptoms? How does this compare between sub-groups of musicians? and between musicians and other populations?
- What is the impact of musculoskeletal symptoms? (e.g. daily activities, work/study, treatment)? How does this compare between sub-groups of musicians? and between musicians and other populations?

Is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?

- What are the reported mechanisms and agencies for musculoskeletal disorder claims?
- What do musicians believe caused their musculoskeletal symptoms?
- What is the association between personal modifiable factors and musculoskeletal symptom outcomes?
- What is the association between organisational psychosocial factors and musculoskeletal symptom outcomes?

Figure 1.1: Sub-questions for the thesis

Note: The musculoskeletal symptom outcomes include the presence of musculoskeletal symptoms, their location, intensity and chronicity, as well as the consequences of musculoskeletal symptoms relating to the musical activities, work or study, daily life, emotional impact, treatment seeking, and self-management strategies used.

The research reported in this thesis is placed within van der Beek et al.'s[198] research framework for developing and implementing WRMSDs (Figure 1.2). This research framework was proposed given the lack of success of many WRMSD prevention interventions.[198] The framework was developed for WRMSDs specifically, but will be used in this research for MSSs more broadly. The paper describing the framework focused on the incidence of WRMSDs for the sake of simplicity,[198] however here it is used to explore the extent of MSSs focusing on the prevalence of MSSs and the impact of MSSs. Given the recurrent nature of MSSs[341] this approach was appropriate for the research. As shown in Figure 1.2, this research focuses on Steps 1 and 2 of the framework; that is, establishing the extent of MSSs (e.g. prevalence and impact) and the modifiable factors associated with MSS outcomes. These two steps were focused on because the systematic mapping review (Appendix 2.2) revealed that the extent of and risk factors for MSSs were not well established beyond university classical music students and professional orchestral musicians. Even for university classical music students and professional orchestral musicians, the investigations of risk factors had focused on non-modifiable factors (Appendix 2.2), and a recent systematic review[199] was unable to draw conclusions regarding the risk factors for MSS outcomes in university music students and professional musicians. Furthermore, the interventions developed to prevent and manage musicians' MSS outcomes have been largely ineffective (Appendix 2.4). The extent of the MSS burden for university music students and professional musicians and the factors associated with MSS outcomes should therefore be investigated across the Australian music industry.

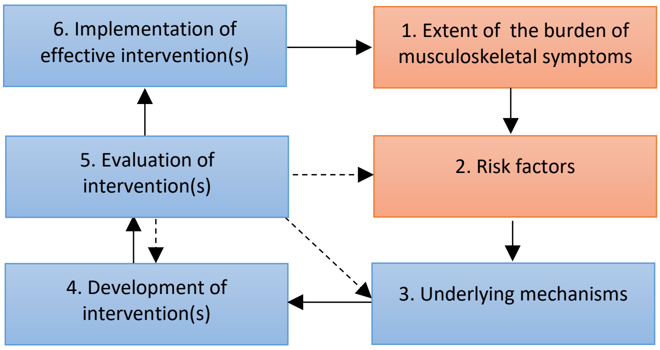

Figure 1.2: Adaptation of van der Beek et al.'s[198] research framework for developing and implementing interventions to prevent work-related musculoskeletal disorders

Notes: The framework indicates that ideally the steps would be followed sequentially, however if the evaluation of the intervention is unsuccessful then further research into the risk factors, underlying mechanisms and/or the development of the intervention itself should be repeated. The Step 1 has been modified from the incidence of musculoskeletal disorders to the extent (e.g. prevalence, incidence, impact) of musculoskeletal symptoms - the focus of this research. The orange boxes indicate the steps that will be covered in this research.

1.3.1 The extent of musicians' musculoskeletal conditions

The question "is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?" fits within the first step of van der Beek et al.'s[198] framework as it investigates the extent of the problem.

Although the prevalence of MSSs has been established for university classical music students and professional orchestral musicians, the outcomes have focused on the presence of MSSs and whether they impair musical activity, rather than other consequences such as the impact on daily life (Table 1.6). Given these gaps, the research reported in this thesis investigates the music industry as a whole; that is, it includes military band musicians, opera singers, and other types of musicians. The research also provides a more comprehensive investigation of the consequences of MSSs, including WCCs, than has previously been undertaken.

Two data sources were used to answer the question: WCCs data, and a targeted questionnaire survey. The WCCs data focus on the proportion and cost of musicians' WCCs attributed to WRMSDs. The survey focused on establishing the prevalence and profile of MSSs (including consequences of MSSs) among musicians, including a comparison between sub-groups of musicians (Figure 1.3), and a comparison between musician and reference groups. This dual approach (e.g. data from WCCs and a targeted questionnaire survey) is anticipated to provide more generalisable data on important MSS outcomes in order to inform further research into risk factors and interventions, as per van der Beek et al.'s[198] framework.

The MSS outcomes from the survey data were: the presence of MSSs and MRMDs (including specific body regions), the presence of current chronic MSSs and MRMDs, the intensity of pain, severity of MRMDs, level of impact of MSSs on daily life, level of emotional impact of MSSs, changes to and leave from work/study due to MSSs, claiming workers' compensation due to MSSs, discussing MSSs with other musicians, consulting a health professional for MSSs, and engaging in self-management strategies for MSSs. The details of these MSS outcomes will be discussed in more detail in Chapter 2.

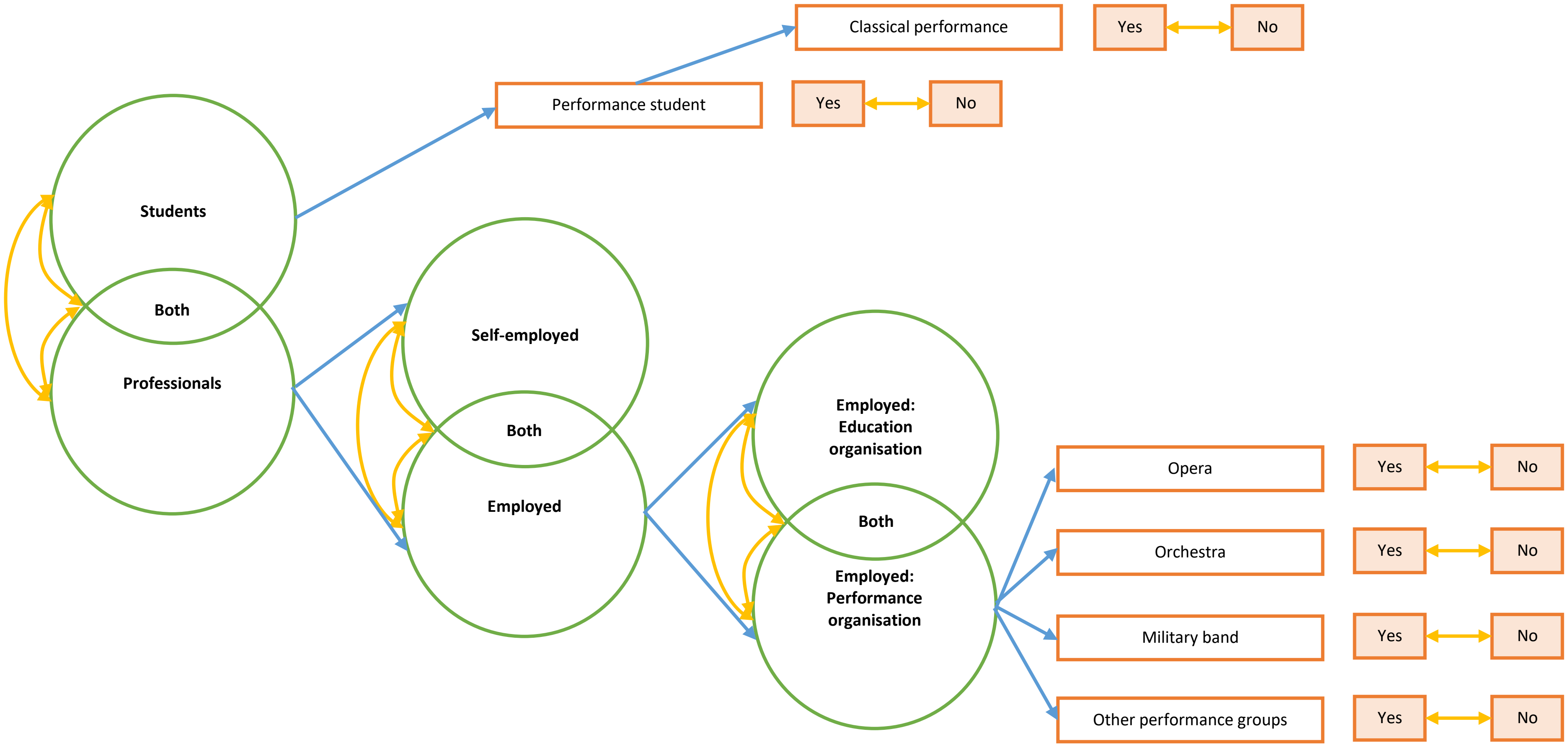

Figure 1.3: Schematic diagram of the comparisons between musician sub-groups
Notes: Blue arrows indicate sub-groups. Yellow arrows indicate comparisons. Orange rectangles represent discrete groups, and green circles indicate overlapping groups

1.3.2 The preventability of the burden of musicians' musculoskeletal conditions

Assuming a burden of musculoskeletal conditions, the question "is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?" was posed, broadly following van der Beek et al.'s[198] framework.

The assessment of the preventability of musicians' musculoskeletal conditions was also informed using musicians' WCCs data and data from a questionnaire survey. Musicians' WCCs data were used to explore the reported mechanisms and agencies of musicians' WRMSDs; thus informing future research into the prevention of musicians' WRMSDs. Similarly, musicians' perceptions of the causes of their MSSs were explored in the survey for this same purpose. Finally, the associations between modifiable factors (personal and organisational) and MSS outcomes were explored. The focus of this research was on modifiable factors, as these had been largely overlooked in the existing evidence (Appendix 2.2), and would provide the most useful findings for interventions to be developed.

The modifiable factors of interest in this study are broadly underpinned by the biopsychosocial model[353], which acknowledges the potential role biological, psychological and social factors in disease, as well as the proposed theoretical frameworks specific to MSSs and/or MSDs.[163-175] As discussed in Section 1.1.2.4, these MSS/MSD frameworks tend to include both internal and external factors, with physical and psychosocial factors featuring in many of the frameworks, in addition to work-related factors. There have been recent calls to consider not only MSS but the MSS consequences when determining the association between potential risk factors and MSS outcomes as the factors may differ depending on the specific outcome investigated[163]; hence this research will investigate a range of MSS consequences. The modifiable personal, and psychosocial organisational factors investigated in this research are described in the following sections, along with a discussion regarding the effort-reward imbalance (ERI) model that underpins the investigation into psychosocial organisational factors.

1.3.2.1 Modifiable personal factors

Based on the evidence regarding musicians' MSSs, pain mechanisms, and knowledge of the modifiable factors associated with MSS outcomes (reviewed in Sections 1.1 and 1.2 above) the following personal modifiable factors were included for investigation in this thesis: body mass index, typical daily sitting time, time engaged in musical activity, and levels of psychosocial stress, psychological distress, social support from other musicians, and musical career satisfaction.

1.3.2.2 Psychosocial organisational factors

For musicians who were employed as musicians, elements of safety climate within the organisation[x] (the organisations' communication and prioritisation of occupational health and safety (OHS), and the individuals' involvement in OHS at work) were investigated as correlates of MSS outcomes. In addition, ERI was investigated, also as a correlate of MSS outcomes. The ERI model[354] is one of two prevailing, complementary models for understanding occupational stress; the other being the job-demand-control (JDC) model.[355] Evidence for musculoskeletal conditions suggests that the ERI model may be more relevant for while collar workers than the JDC model[356]; hence the ERI has been used to underpin the part of this work investigating the association between psychosocial organisational factors and MSS outcomes.

The ERI model considers three factors: effort, reward and overcommitment, with effort and reward considered organisational factors, and overcommitment a personal factor.[357, 358] The model proposes that:

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[x]Organisation factors were specific to their 'main musical employer'

- ERI is a more important factor in determining the risk of adverse health outcomes than the individual components (i.e. effort and reward);
- overcommitment is associated with poorer health outcomes; and
- those with both an ERI and overcommitment are at the highest risk of experiencing adverse health outcomes.[357]

An examination of the ERI model for musicians' MSS outcomes will contribute to our understanding of the psychosocial organisational factors that may play a role in MSS development and experience (e.g. consequences) for musicians. The research presented in this thesis does not consider the overcommitment aspect of the model because overcommitment is not an important factor for MSSs.[359]

In summary, the overall objective of this research was to fill identified research gaps by establishing whether there was a burden of MSSs for university music students and professional musicians[y], and to determine whether the identified burden could be prevented.

1.3.3 The potential significance of this research

As per the outline presented in the Introduction (Figure ii), once the two fundamental questions have been answered, the outcomes of this research should contribute to our understanding of one of the leading causes of years lived with disability[1] in a vulnerable population – musicians. This research examines the burden of musculoskeletal conditions for Australian university music students and professional musicians. The research draws upon WCCs data and data from a targeted questionnaire survey in order to determine whether there is a preventable burden of musculoskeletal conditions for this vulnerable population.

The research presented in this thesis fills a number of gaps identified in the systematic mapping review (Appendix 2.2). These gaps include:

- Analysing musicians' WCCs data (Chapters 3 & 6);
- Using participant-driven methods to determine the perceived causes of MSSs for musicians (beyond pianists[296]; Chapter 7);
- Comparing MSS outcomes between:
    - university music students and professional musicians (beyond investigating single instruments[228, 262]),
    - performance and non-performance university music students,
    - self-employed and employed professional musicians,
    - musicians employed as performers and teachers (beyond investigating single instruments[201, 262]), and
    - musicians employed by orchestral, opera, military band and 'other'[z] performance groups (Chapter 4).
- Comparing the MSS outcomes between musicians and appropriate reference groups, with consideration for potential confounders (Chapter 5);
- Investigating the relationship between music-specific social support, elements of safety climate (communication, involvement and prioritisation), and effort and reward, with MSS outcomes (Chapters 8-9); and
- Using measures tested with modern psychometric methods (Rasch analysis, described in Chapter 2) in any investigation of the association between potential risk factors and musicians' MSS outcomes.

[y]For the purpose of the present study (in the absence of a 'gold standard' definition for 'professional musicians')[21], anyone employed as a performing musician, or instrumental or singing teacher as a professional musician, as well as any member of the Musicians' Union and Music Teachers' Association (to include freelance and self-employed musicians) was considered a professional musician.

[z]Any performance organisation that was not classified as orchestral, opera, or military band

The present research also includes one of few studies to compare classical and non-classical performance students, and includes a broad range of musicians (e.g. all genres and ensemble types were eligible), thus providing comprehensive analysis of the burden of MSSs in the music industry.

Through answering the above questions, the following can be elucidated:

- Whether musicians' musculoskeletal conditions are a health condition requiring intervention;
- Which sub-groups of musicians should be prioritised for such interventions;
- Which MSS outcomes are the most important to understand further, and attempt to change through interventions;
- Which factors musicians perceive caused their MSSs that may be investigated as potential risk factors in future studies; and
- Which modifiable personal and psychosocial organisational factors should be modified to reduce the burden of MSSs.

This research provides new insights into the burden of musicians' MSSs, and, if such a burden can be reduced, guides the development of new strategies to improve musicians' health and wellbeing. Recommendations to this end are presented in Chapter 10.

CHAPTER 2: METHODOLOGY AND METHODS

Chapter 2 outlines the methodology and methods used in the present research. This chapter includes two main sections. The first section describes the methodology and methods for a statistical review of workers' compensation claims (WCCs) data from the SafeWork Australia's National Data Set for Compensation-based Statistics (third edition, NDS-3).[360] The second section describes the methodology and methods for a targeted questionnaire survey of musicians and reference groups. The findings from the WCCs data and the survey questionnaire data analyses were integrated to answer the questions posed in this thesis (Figure 2.1), and to provide recommendations to reduce the burden of musculoskeletal conditions for Australian university music students and professional musicians (Chapter 10).

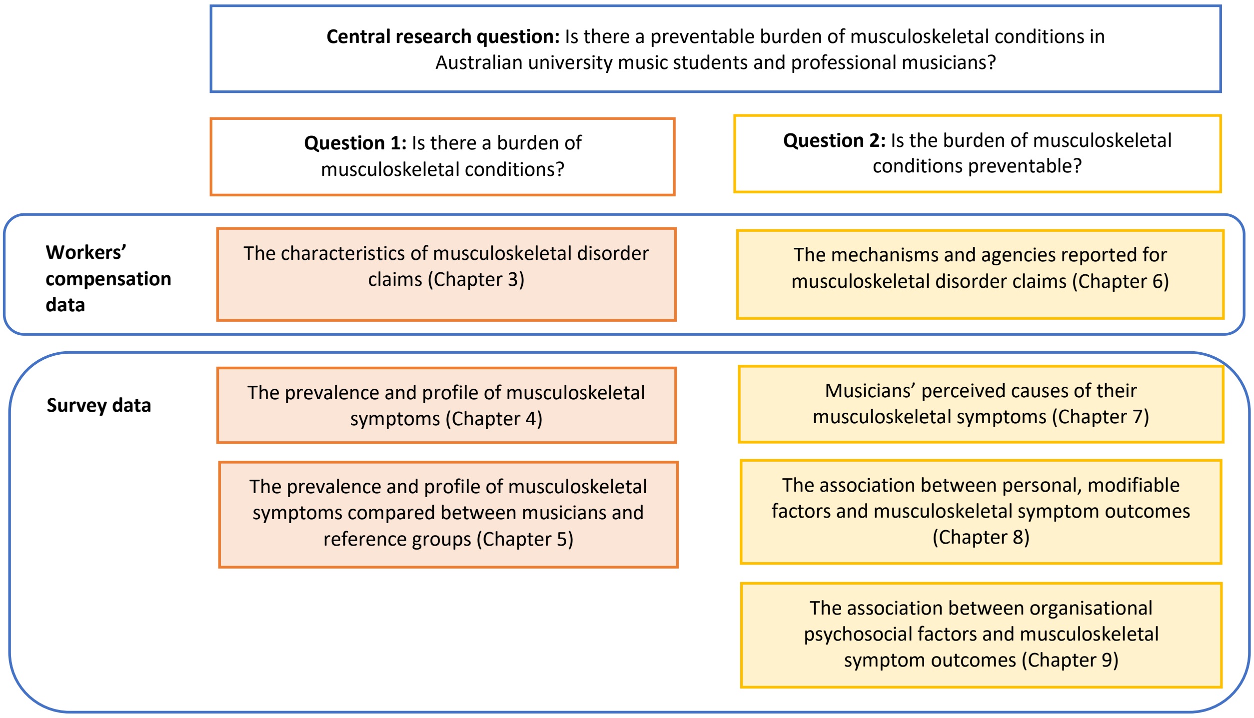


Figure 2.1 Relationship between data sources for the research and the thesis chapters

The University of Adelaide Human Research Ethics Committee (H-2015-279) and the Australian Defence Organisation Joint Health Command Low-Risk Ethical Review Panel (LREP 16-006) granted approval for this research (Appendix 1.2).

2.1 Statistical review of the National Data-Set for Compensational-based Statistics– 3

A statistical review of Safe Work Australia's NDS-3[360] was conducted to determine the proportion of musicians'[aa] WCCs and costs due to work-related musculoskeletal disorders (WRMSDs), and the characteristics of the claimed WRMSDs (Chapter 3), and to describe the mechanism and agency of these disorders (Chapter 6).

2.1.1 Data set and study population

Individual level data for music professionals (Australian and New Zealand Standard Classification of Occupations (ANZSCO)[361] unit group 2112) from the NDS-3[360] were obtained for the financial years 2004/2005-2015/2016. Music professionals (unit group 2112 according to the ANZSCO[361]) included instrumentalists, singers, music directors and composers. Music teachers were not included within this study as they were classified as "private tutors and

[aa]The statistical review of the NDS-3[360] only considered employed professional musicians. No specific data were available for music teachers.

teachers", along with other types of private tutors, including art, dance and drama[361], such that music teacher-specific data were not available. Data were obtained on all claims, not just musculoskeletal disorders (MSDs), so that the proportion of claims due to MSDs could be determined.

2.1.2 Variables

Variables obtained for this research were age, gender, month and year of reported incident, financial year the claim was lodged, and the nature, body region, agency, and mechanism of the condition, as well as the time lost and claim costs (see the NDS-3 documentation[362] for details). Data regarding the type of musician (e.g. opera, orchestral) were not available.

All musicians' WCCs were included, regardless of whether they were considered 'serious' or not. Serious WCCs are defined as "an accepted workers' compensation claim for an incapacity that results in a total absence from work of one working week or more".[72] As musicians do not typically work full time[21] Safe Work Australia's[72] definition of a serious claim was not appropriate for use with this population.

Within the NDS-3, MSDs refer to conditions that affect the musculoskeletal system; specifically the synovium, muscles, tendons, soft tissue, connective tissue, spinal vertebrae, intervertebral discs and joints.[70] Musculoskeletal disorders are further split into injuries and diseases depending on the onset of symptoms; that is, injuries refer to MSDs resulting from a single traumatic event with a short latency period, while diseases refer to MSDs resulting from long-term or repeated exposure to an event or agent, or from uncertain or multiple causes.[71] Classifications of the injury/disease were taken from the Type of Occurrence Classification System (third edition)[71], which is based upon the International Classification of Diseases and Related Health Problems, 10th Revision, Australian modification, with aggregated classifications.[362] For the purpose of this research, musculoskeletal injuries included fractures, and traumatic joint/ ligament and muscle/ tendon injury classifications, and musculoskeletal diseases refer to musculoskeletal and connective tissue diseases.

2.1.3 Analysis

Data were largely reported descriptively, and based on the number of claims. The incidence of WRMSDs was not investigated, as no valid denominator was available for musicians. Although the 2011 Census of Population and Housing[58] reported that there were 7 960 professional musicians in Australia, this number includes Defence and self-employed musicians, who are not eligible for workers' compensation. In Australia, 86% of Australian professional musicians worked in a freelance or self-employed capacity in 2016[21], up from 67% in 2009[54]; hence the number of musicians eligible for workers' compensation is likely smaller than the 7 960 reported. Furthermore, in the Census of Population and Housing[58], individuals were asked to report only the job in which they usually worked the most hours. However, on average, professional musicians only work 19 hours per week as a musician, with a further 26 hours per week on average devoted to non-musical work.[21] As such, the Census of Population and Housing[58] data cannot validly be used to estimate the number of people employed as musicians in Australia, who were eligible for workers' compensation; nor can the average number of hours working in an employed capacity be derived.

This is the first study to analyse musicians' WCCs data anywhere in the world. Despite the limitations of such an analysis (e.g. lack of a valid denominator), it provides a unique opportunity to examine the burden of musicians' musculoskeletal conditions. These new data, integrated with the survey data, will be able to inform whether Australian musicians have a preventable burden of musculoskeletal conditions.

2.2 Questionnaire survey

Section 2.2 describes the methods and methodology related to the questionnaire survey. This section is divided into three key parts: 1. the development of the questionnaire, and data collection (including a comprehensive review of the musculoskeletal symptom (MSS) outcomes and data collection tools used with musicians, reported in full in Appendix 2.5); 2. Rasch analysis (to examine the utility of the measures used); and 3. The main analysis to answer the questions posed in this thesis. The structured, systematic approach used in formulating the research protocol provides a methodological contribution to public health research, culminating in a range of research recommendations (Chapter 10) to overcome some of the issues identified in the current evidence base, as outlined in Chapter 1.

A cross-sectional questionnaire survey of university music students and professional musicians, as well as university science students and non-music staff, was conducted in order to determine: 1. the burden of musicians' MSSs, 2. musicians' perceived causes of their MSSs, and 3. the association between selected modifiable factors and MSS outcomes in musicians. The specific questions are outlined in Table 2.1. Data from the reference groups (university science students, and non-music staff) were only collected to answer Question 1.2.

Table 2.1: Sub-questions answered with data from the survey

	The burden of musicians' musculoskeletal symptoms		The preventability of the burden of musicians' musculoskeletal symptoms
1.1	What is the prevalence and profile of musculoskeletal symptom outcomes in university music students and professional musicians? (Chapter 4)	2.1	What are the perceived causes of university music students' and professional musicians' musculoskeletal symptoms? (Chapter 7)
1.2	Does the prevalence and profile of musculoskeletal symptom outcomes in university music students and professional musicians differ from that of respective reference groups? (Chapter 5)	2.2	What is the association between modifiable factors and musculoskeletal symptom outcomes in university music students and professional musicians? (Chapters 8-9)

A cross-sectional design was selected because it is appropriate and practical for investigating the prevalence of health outcomes, and the associations between a range of exposures and these outcomes.[363] Furthermore, there is evidence to suggest that similar findings are obtained from cross-sectional and more resource-intensive longitudinal studies regarding the association between psychosocial and MSS outcomes.[364] A cross-sectional design was therefore deemed appropriate for this research.

2.2.1 Questionnaire development and data collection

Two questionnaires were developed for this project, one for musicians (the Musicians' Musculoskeletal Health Questionnaire) and the other for the reference groups (the Musculoskeletal Health Questionnaire). The discussion below focuses on the questionnaire for musicians, as the questionnaire for the reference group was an abridged version of this.

2.2.1.1 Variables of interest

The questionnaire developed for this project was designed to collect data on the variables included in Table 2.2 to answer the research questions for Chapters 4, 5, 8 and 9. Questionnaire data were also used for Chapter 7. Chapter 7 reports a descriptive study of the perceived causes of musicians' MSSs, as will be outlined further in Section 2.2.3.3.

2.2.1.2 Selection and development of questionnaire items

The key considerations for the selection of the questionnaire items were the consistency with existing studies of musicians' MSSs, and the validity and reliability of the items. It was also important to ensure that the questionnaire would be short enough in order to maximise recruitment.[365]

Table 2.2: Variables related to Chapters 4, 5, 8 and 9, and the respective research questions being asked

	Chapter 4: Prevalence and profile of MSSs, & comparison between sub-groups of musicians	Chapter 5: Comparison of the prevalence and profile of MSSs between musician & reference groups	Chapter 8: Association between personal modifiable factors & MSS outcomes	Chapter 9: Association between organisational, psychosocial factors & MSS outcomes
Demographic information				
Age	CV	CV	CV	CV
Gender	CV	CV	CV	CV
Body mass index	CV	CV	**IV**	CV
Socioeconomic status	CV	CV	CV	CV
Typical daily sitting time	CV	CV	**IV**	CV
Number of employers (including self) in the last 12 months	CV	CV	CV	CV
Number of employers (including self) in the last 7 days	CV	CV	CV	CV
Total number of hours in paid work in the last 7 days	CV	CV	CV	CV
Musical factors				
Time engaged in musical activity in the last 7 days	CV	CV	**IV**	CV
Musical biomechanical exposures in the last 12 months	CV		CV	CV
Musical biomechanical exposures in the last 7 days	CV		CV	CV
Whether they had performed as a musician in the last 12 months	CV		CV	CV
Whether they had performed as a musician in the last 7 days	CV		CV	CV
Classification as a music student, professional musician or both	**IV**, CV[a]		CV	CV
Classification as a performance music student or non-performance music student	**IV**		CV	
Classification as a classical performance student or non-classical performance student	**IV**			
Classification as a self-employed, employed or 'both' musician	**IV**		CV	
Classification as being employed by an education or performance music organisation	**IV**			
Classification by the type of performance organisation they were employed by	**IV**			
Personal psychosocial factors				
Level of musical career satisfaction	CV		**IV**	CV
Level of musical social support	CV		**IV**	CV
Level of stress	CV		**IV**	CV
Level of psychological distress	CV		**IV**	CV
Organisational psychosocial factors[b]				
Effort-reward imbalance				**IV**
Perceived level of effort at work				**IV**
Perceived level of reward at work				**IV**
Perceived level of job security at work				**IV**
Perceived level of esteem at work				**IV**
Perceived level of promotion opportunities				**IV**
Perceived level of communication of occupational health and safety at work				**IV**
Perceived level of prioritisation of occupational health and safety at work				**IV**
Perceived level of involvement in occupational health and safety at work				**IV** *(continued)*

	Chapter 4: Prevalence and profile of MSSs, & comparison between sub-groups of musicians	Chapter 5: Comparison of the prevalence and profile of MSSs between musician & reference groups	Chapter 8: Association between personal modifiable factors & MSS outcomes	Chapter 9: Association between organisational, psychosocial factors & MSS outcomes
Musculoskeletal symptoms				
MSSs in the last 12 months, overall and by body region[c]	DV	DV	DV	DV
MSSs in the last 7 days, overall and by body region[c]	DV	DV	DV	DV
Number of body regions with MSSs in the last 12 months	DV	DV	DV	DV
Number of body regions with MSSs in the last 7 days	DV	DV	DV	DV
Current chronic MSSs[d]	DV	DV	DV	DV
MRMDs in the last 12 months, overall and by body region[c]	DV		DV	DV
MRMDs in the last 7 days, overall and by body region[c]	DV		DV	DV
Number of body regions with MRMDs in the last 12 months	DV		DV	DV
Number of body regions with MRMDs in the last 7 days	DV		DV	DV
Current chronic MRMDs[d]	DV		DV	DV
Intensity of pain in the last 7 days	DV	DV	DV	DV
Severity of MRMDs in the last 7 days	DV		DV	DV
Level of overall impact of MSSs in the last 7 days	DV	DV	DV	DV
Level of emotional impact of MSSs in the last 7 days	DV	DV	DV	DV
Level of concern regarding MSSs in the last 7 days	D			
Making changes to work/ study in the last 12 months due to MSSs[e]	DV	DV	DV	DV
Taking leave from work/ study in the last 12 months due to MSSs[e]	DV	DV	DV	DV
Claiming workers' compensation in the last 12 months due to MSSs[e]	D			
Talking to another musician in the last 12 months about their MSSs	DV		DV	DV
Consulting a health professional in the last 12 months about their MSSs	DV	DV	DV	DV
Consulting a conventional health professionals in the last 12 months about their MSSs, including specific types of conventional health professionals[f]	D			
Consulting an alternative health professional in the last 12 months about their MSSs, including specific types of alternative health professionals[g]	D			
Engaging in self-management in the last 12 months for MSSs, including specific types of strategies[h]	DV	DV	DV	DV
Currently undergoing treatment for MSSs	DV	DV	DV	DV

Notes: D: descriptive statistics only, IV: independent variable, DV: main dependent variable, CV: potential confounding variable, MSS: musculoskeletal symptoms, MRMD: music-related musculoskeletal disorders ("pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with your ability to do your musical activity at the level to which you are accustomed"). [a]classification as being a student or professional was considered a confounder for other sub-group analyses (e.g. comparing performance and non-performance students, comparing self-employed and employed professionals). [b]for their main musical employer only. [c]body regions were the head, orofacial, neck, shoulder, elbow, wrists/ hand, upper back, chest/ abdomen, lower back, hips/ thigh, knee, and ankle/foot regions, with 7 day outcomes also referring to the laterality of MSS. [d]chronic MSS/MRMD referred to MSS/MRMD that had been present on most days for over three months. [e]specifically for musical work/ study as well. [f]medical professionals, physiotherapists/ occupational therapists, psychologists/ counsellors. [g]personal trainers/ Pilates instructors/ yoga instructors, chiropractors/ osteopaths/ massage therapists/ Bowen therapists, naturopaths/ homeopaths, Alexander technique practitioners/ Feldenkrais practitioners/ body mapping teachers. [h]use specific self-management strategies was described only, and was not considered a dependent variable. Self-management strategies investigated were exercises/ stretches, heat/ice, medication use, and braces/strapping/ taping.

One of the key issues identified in the current literature regarding musicians' MSSs is the heterogeneity of both the specific MSS outcomes investigated, and the data collection methods used.[14, 50-52, 199, 366, 367] To help ensure that the results of this research could be compared and synthesised with the existing literature, a systematic search and narrative review of MSS outcomes and data collection tools used in studies of musicians (published 2007-2016) was conducted. The full review is reported in Appendix 2.5, while the summary of recommendations is reported in Table 2.3. These recommendations were used to guide the selection and development of the MSSs section of the questionnaire. It was intended that these study outcomes would wherever possible be consistent with the existing literature, allowing for synthesis and direct comparison.

Table 2.3: Recommendations regarding the selection of musculoskeletal symptom outcomes and data collection for studies of musicians

Questionnaire
To determine the presence of MSSs, the NMQ[67] is recommended.
To determine the presence of MSSs that impair musical activity, the NMQ[67] with Zaza et al.'s[68] definition for playing-related musculoskeletal disorders[a] incorporated is suggested.
Rating Scales
To determine pain intensity or the impact of MSSs, an NRS (11-point) is recommended.
To determine pain intensity, the anchors "no pain" to "pain as bad as you can imagine" should be used.
To determine pain intensity, multiple measures (e.g. worst, on average, least) should be considered, and if this is not possible, pain on average should be used (except in longitudinal studies).
Body regions
To determine the presence of MSSs in specific body regions, the body regions from the NMQ[67] are suggested, along with the NMQ body chart. For musicians, the addition of the head, orofacial and chest/ abdomen regions to the NMQ should be considered.
Recall periods
To determine the presence of MSSs, recall periods of 12 months and/or 7 days are recommended
To determine the intensity or the degree of impact of MSSs, a 7 day recall period is recommended

Notes: MSS: musculoskeletal symptom, NMQ: Nordic Musculoskeletal Questionnaire, NRS: numeric rating scale. [a]the term playing-related musculoskeletal disorder, and the corresponding definition, may be expanded to include other types of musical activities, such as singing, conducting and being a drum major.

The literature was also consulted to inform the other items (e.g. psychosocial measures) included in the questionnaire. The selection of items was based on the validity and reliability of the items/ scales, the applicability of the items to musicians, and the length of the scale (where applicable). In some instances, such as enquiring about the level of social support and career satisfaction specific to music, no existing measures were available; hence, more generic measures were modified for this purpose. The data collection tools used, and the necessary modifications, will be discussed further in Section 2.2.1.5.

2.2.1.3 Format and structure of the questionnaire

To improve participation in surveys, it has been recommended that close-ended items with responses offered horizontally are used where possible, that easier items are placed earlier in the questionnaire, and that questionnaires are pilot tested.[365] Each of these strategies was employed in the development of the questionnaire.

The questionnaire was available in paper and online formats (where organisational policy allowed[bb]), which has been found to improve response rates as it accounts for personal preferences.[368] Providing participants with a second copy of the questionnaire has also been found to be effective in increasing response rates.[365] Second copies were provided by sending recruitment emails to participants a few days after they were provided with the paper questionnaires, sending reminder emails to participants including a link to the questionnaire, and/or where possible attending two sequential rehearsals or classes to provide additional copies of the questionnaire to potential participants. Recruitment strategies varied depending on logistical constraints and organisational policy (see Section 2.2.2).

[bb]The Australian Defence Force does not allow their personnel to complete questionnaires on Survey Monkey; the platform used in this research

2.2.1.4 Pilot testing and amendments

Both the Musicians' Musculoskeletal Health Questionnaire and the Musculoskeletal Health Questionnaire were pilot tested with five musicians and five non-musicians, respectively. Each participant in the pilot testing stage was asked to complete both the online and paper version of the questionnaire, so that discrepancies between the two questionnaire formats could be identified. Participants involved in the pilot testing were informally interviewed to determine the face validity of the items, and their perceptions regarding the layout, flow and length of the questionnaire. Any difficulties they faced in completing the questionnaires were also discussed, as well as any suggestions they had for improvement. Changes were made to the draft questionnaires based on feedback from each participant, before testing the modified questionnaire with the next participant.

2.2.1.5 Questionnaire description

Musicians' Musculoskeletal Health Questionnaire

The finalised Musicians' Musculoskeletal Health Questionnaire (Appendix 1.2) was distributed to musicians, and was estimated to take 15-20 minutes to complete. The following sections focus on the items regarding the modifiable factors of interest, and the MSS outcomes. Table 2.4 reports on all questionnaire items, including those related to demographic variables. All psychosocial and MSS measures were tested for their utility with musicians using Rasch analysis. The methods of Rasch analysis and the scoring of these measures will be described in Section 2.2.3.2.

Personal factors

Participants were asked to report their weight and height so that their body mass index (BMI) could be calculated. Data regarding typical daily sitting time and musical activity time were collected using multiple-choice responses. Participants were asked to indicate whether their typical daily sitting time was <4 hours, 4-8 hours, 8-12 hours, or >12 hours. While direct observation is the gold standard for measuring sitting time[369], this and other objective measures of sitting time (e.g. accelerometers) were not practical for this study, particularly given that no previous study has investigated the relationship between sitting time and MSS outcomes in musicians (Appendix 2.2). Although self-report measures of sitting time tend to result in under-estimates of 2-4 hours per day, this is a systematic measurement error[369] and therefore unlikely to influence the findings of the present study.

There is no validated self-reported measure of musical activity available. As such, musical activity time referred to the last 7 days, and participants were asked to indicate whether they engaged in <5 hours, 5-10 hours, 10-15 hours, 15-20 hours, 20-25 hours, 25-30 hours, or 30 or more hours of musical activity during that time period. Multiple-choice response categories were used rather than open responses based upon feedback during the pilot testing of the questionnaire.

Participants were asked to complete a series of scales regarding psychological distress, psychosocial stress, musical social support, and musical career satisfaction. To measure psychological distress, the Patient Health Questionnaire-4 (PHQ-4), an ultra-brief screening tool for distress[370, 371], was used. The PHQ-4 combines the Patient Health Questionnaire-2 and Generalized Anxiety Disorder-2 Scale, resulting in a four-item measure.[370, 371] Respondents provided ratings to each of the four items on a 4-point scale (scores 0-3), and the scores are typically summed to produce a score of 0-12 (higher scores indicating a higher level of psychological distress).[370, 371] The selection of the PHQ-4 was based on the short nature of the scale, with evidence of its construct validity[370-373], factorial validity[370-374], internal consistency[370-375], sensitivity and specificity[375], and test-retest reliability.[372] The PHQ-4 has been reviewed more comprehensively in Appendix 2.6.

Table 2.4: Summary of the data collection methods for each variable in the Musicians' Musculoskeletal Health Questionnaire

	Data collection tool
Demographic information	
Age	Open response
Gender	Open response
Body mass index	Open response to their height and weight, which were used to calculate body mass index, using the formula weight (kilograms)/ height (metres)^2
Socioeconomic status	Open response for their residential postcode which was used to determine their socioeconomic status based on the Index of Relative Socioeconomic Advantage and Disadvantage[376], which was then classified by sample quartiles
Typical daily sitting time	Multiple choice categories <4 hours, 4-8 hours, 8-12 hours, >12 hours
Number of employers (including self) in the last 12 months	Open response
Number of employers (including self) in the last 7 days	Asked for details for their three main employers, then asked for the number of additional employers, which was used to determine the number of employers
Total number of hours in paid work in the last 7 days	Sum of the hours worked for their three main employers
Musical factors	
Time engaged in musical activity in the last 7 days	Multiple choice categories for <5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, over 35 hours
Musical biomechanical exposures in the last 12 months	Open response for their musical activities which were then categorised by biomechanical exposures[a]
Musical biomechanical exposures in the last 7 days	Open response within the time periods (0-2, 2-4, 4-6, 6-8, 8-10, 10-15, 15-20, 20-25, 25-30, and 30 or more hours) for their musical activities which were then categorised by biomechanical exposures[a]
Whether they had performed as a musician in the last 12 months	Binary response
Whether they had performed as a musician in the last 7 days	Binary response
Classification as a music student, professional musician or both	Based on the binary responses for whether they were currently studying music at university, and whether they had been employed as a musician in the last 12 months and/or were members of the Music Teachers' Associations or the Musicians' Union
Classification as a performance music student or non-performance music student	Open response for their major at university
Classification as a classical performance student or non-classical performance student	Open response for their major at university
Classification as a self-employed, employed or 'both' musician	Based on the multiple choice responses regarding musical employers in the last 12 months (which included a self-employed category)
Classification as being employed by an education or performance music organisation	Based on the multiple choice responses regarding musical employers in the last 12 months
Classification by the type of performance organisation they were employed by	Based on the multiple choice responses regarding musical employers in the last 12 months, with organisations classified as orchestral, opera/ musical theatre, military band, and 'other'
Personal psychosocial factors	
Level of musical career satisfaction	MOAQ-JSS[377] modified to ask about music work and/or study
Level of musical social support	Support from co-workers scale from the QPS_{Nordic}[378] modified to ask specifically about support from other musicians
Level of psychosocial stress	Littman et al.'s[379] two-item stress questionnaire
Level of psychological distress	PHQ – 4[370, 371]
Organisational psychosocial factors	
Effort-reward imbalance	Short version of the ERI Questionnaire[380]
Level of perceived effort at work	Short version of the ERI Questionnaire[380]
Level of perceived reward at work	Short version of the ERI Questionnaire[380]
Level of perceived job security at work	Short version of the ERI Questionnaire[380]
Level of perceived esteem at work	Short version of the ERI Questionnaire[380]
Level of perceived promotion opportunities	Short version of the ERI Questionnaire[380]
Level of communication of occupational health and safety at work	Safety Climate Assessment questionnaire[381] adapted for musculoskeletal disorders[382]
Level of prioritisation of occupational health and safety at work	Safety Climate Assessment questionnaire[381] adapted for musculoskeletal disorders[382]
Level of involvement in occupational health and safety at work	Safety Climate Assessment questionnaire[381] adapted for musculoskeletal disorders[382]

(continued)

	Data collection tool
Musculoskeletal symptom outcomes	
MSSs in the last 12 months, overall and by body region	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b]
MSSs in the last 7 days, overall and by body region	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b]
Number of body regions with MSSs in the last 12 months	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b]
Number of body regions with MSSs in the last 7 days	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b]
Current chronic MSSs	Binary response regarding whether they had experienced MSSs on most days for at least three months
MRMDs in the last 12 months, overall and by body region	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b] and asking about MRMDs rather than ache, pain or discomfort
MRMDs in the last 7 days, overall and by body region	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b] and asking about MRMDs rather than ache, pain or discomfort
Number of body regions with MRMDs in the last 12 months	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b] and asking about MRMDs rather than ache, pain or discomfort
Number of body regions with MRMDs in the last 7 days	NMQ[67] modified by adding the head, orofacial and chest/ abdominal regions[b] and asking about MRMDs rather than ache, pain or discomfort
Current chronic MRMDs	Binary response regarding whether they had experienced MRMDs on most days for at least three months
Intensity of pain in the last 7 days	11 point NRS from 0 "no pain" to 10 "pain as bad as you can imagine" for pain at its worst, at its least and on average, as per the Brief Pain Inventory-Intensity Scale[383]
Severity of MRMDs in the last 7 days	11 point NRS from 0 "does not interfere" to 10 "completely interferes", for MRMD at its worst, at its least and on average
Level of impact of MSSs on daily life in the last 7 days	11 point NRS from 0 "not affect at all" to 10 "severely affects my life"
Level of emotional impact of MSSs in the last 7 days	11 point NRS from 0 "not at all affected emotionally" to 10 "extremely affected emotionally"
Level of concern regarding MSSs in the last 7 days	11 point NRS from 0 "not at all concerned" to 10 "extremely concerned"
Making changes to work/ study in the last 12 months due to MSSs	Extended NMQ[384] modified by asking overall (i.e. for any body region), rather than specific body regions, and specifying whether the changes referred to musical or non-musical work
Taking leave from work/ study in the last 12 months due to MSSs	Extended NMQ[384] modified by asking overall (i.e. for any body region), rather than specific body regions, and specifying whether the changes referred to musical or non-musical work
Claiming workers' compensation in the last 12 months due to MSSs	Binary response
Talking to another musician in the last 12 months about their MSSs	Binary response
Consulting a health professional in the last 12 months about their MSSs	Binary response
Consulting a conventional health professionals in the last 12 months about their MSSs, including specific types of conventional health professionals	Binary response
Consulting an alternative health professional in the last 12 months about their MSSs, including specific types of alternative health professionals	Binary response
Engaging in self-management in the last 12 months for MSSs, including specific types of strategies	Binary response
Currently undergoing treatment for MSSs	Binary response

Notes: The full questionnaires are reported in Appendix 1.2. MOAQ-JSS: Michigan Organizational Assessment Questionnaire – Job Satisfaction Scale, QPS_{Nordic}: General Nordic Questionnaire for Psychological and Social Factors at work, PHQ-4: Patent Health Questionnaire-4, ERI: effort-reward imbalance, MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder, NMQ: Nordic Musculoskeletal Questionnaire, NRS: numeric rating scale. [a]Musical activities were classified into the following biomechanical exposures: wind instrument/ singing, singing, brass, woodwind, flute, reed, saxophone, and upper string, and musical activities characterised by at least one hand elevated to shoulder level, repetitive shoulder/ elbow movement, repetitive finger extension/ flexion, repetitive finger abduction/ adduction, and repetitive foot movement. [b]the body chart was amended accordingly (Figure 2.2)

Stress was measured using Littman et al.'s[379] two-item psychosocial stress questionnaire. The questionnaire has established validity and reliability, when used as individual items and as a combined score.[379] One item of this scale pertains to the level of stress experienced in the last 12 months, and the other the individual's perceived ability to handle stress. Responses were provided on 6-point rating scales.

Musical social support was measured using a modified version of the support from co-workers scale from the General Nordic Questionnaire for Psychological and Social Factors at Work (QPS_{Nordic}).[378] The QPS_{Nordic} has established validity and reliability across a range of populations.[385, 386] The scale was modified for this study so that it referred only to social support from other musicians (Appendices 1.2 and 2.11).

Similarly, the musical career satisfaction scale used in this study was a modification, in this case from the Michigan Organizational Assessment Questionnaire – Job Satisfaction Subscale (MOAQ-JSS).[377] The MOAQ-JSS is a short 3-item measure of job satisfaction, with responses given on 5-, 6-, or 7-point Likert scales.[387] Typically , the overall score is obtained by averaging the three item scores (with Item 2 reversed).[387] The sub-scale has acceptable construct validity, internal consistency, and test-retest reliability.[387] The wording of the MOAQ-JSS items was modified for the present study to obtain data regarding both musical work and study specifically. Responses in this study were provided on 5-point Likert scales (Appendices 1.2 and 2.12).

Psychosocial organisational factors

The short version of the Effort-Reward Imbalance (ERI) questionnaire[380] was used to measure perceived work effort and reward, as well as the three reward sub-scales - perceived job security, esteem and promotion opportunities. The short version of the ERI Questionnaire has been found to be valid and reliable for use with a range of occupational groups.[380, 388-390] A more comprehensive review of this questionnaire is reported in Appendix 2.7. Musicians were instructed to only provide responses regarding their main musical employer.

Perceptions regarding the organisations' communication and prioritisation of occupational health and safety (OHS), and the individuals' involvement in OHS within the workplace were measured using Whysall's[382] adaption for MSDs of the Safety Climate Assessment questionnaire.[381] The adapted questionnaire only has face validity, but has recently been used in studies of work-related MSDs[382, 391-393], including in Australia.[391, 392] As with the ERI, responses to these items referred only to the musicians' main musical employer.

Musculoskeletal symptom outcomes

As per the recommendation from the systematic search and narrative review (Table 2.3 and Appendix 2.5), the Nordic Musculoskeletal Questionnaire (NMQ; also called the Standardized Nordic Questionnaire)[67] was used to gather data regarding the presence of MSSs in the last 12 months and 7 days. The NMQ has been used with a range of populations[394], including musicians (Appendix 2.5), and is a valid and reliable questionnaire.[67, 395-398]

The NMQ[67] asks participants to indicate in which body regions they have experienced ache, pain or discomfort in the last 12 months and 7 days. The original NMQ has nine body regions: the neck, shoulder, elbow, wrist/ hand, upper back, lower back, hip/ thigh, knee, and ankle/ foot.[67] However, the head, jaw/mouth (i.e. orofacial), and chest/abdominal regions were added for this research as these are potentially important body regions to assess for MSSs in musicians. The body chart from the NMQ[67] was modified to accommodate the additional body regions, and included the anterior and posterior views of the body. Participants were instructed to respond to the modified NMQ items with reference to this body chart (Figure 2.2). Given the asymmetrical nature of some musicians' work, including in the lower limb, participants were asked to indicate the laterality of their MSSs in each body region for the last 7 days. In addition, those reporting MSSs in the last 7 days were asked whether they had experienced their MSSs on most days for more than three months, as an indicator of chronic MSSs.[399]

A further modification of the NMQ was used to collect data regarding music-related musculoskeletal disorders (MRMDs). Based on the review of MSS outcomes for musicians' research (Table 2.3 and Appendix 2.5), Zaza et al.'s[68] definition of playing-related musculoskeletal disorders was used as the basis of the definition used in this study. In order to encompass singing, conducting, and being a drum major, as well as playing a musical instrument, the definition for this research was expanded. The definition of MRMDs provided to participants was: "pain, weakness, lack of control, numbness, tingling or other symptoms that have interfered with your ability to do your musical activity at the level to which you are accustomed", where musical activity referred to playing a musical instrument, singing, conducting, or being a drum major. To collect data regarding MRMDs the NMQ was modified such that participants were asked to indicate the body regions in which they experienced "music-related musculoskeletal disorders" in the last 12 months and 7 days, rather than asking about ache, pain or discomfort. This substitution method has been used previously[295, 400] using Zaza et al.'s[68] definition for playing-related musculoskeletal disorders. As with the MSSs, participants who reported MRMDs in the last 7 days were asked whether they had had their MRMDs on most days for more than three months.

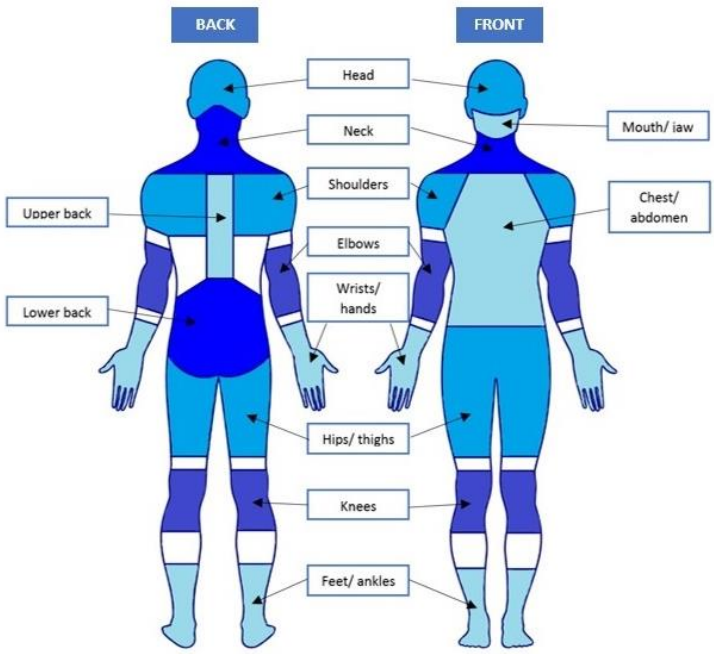


Figure 2.2: Body chart used to collect data on musculoskeletal symptom and music-related musculoskeletal disorder location in the last 12 months and 7 days as part of the modified Nordic Musculoskeletal Questionnaire

Participants were asked to indicate the intensity of their pain in the last 7 days on three numeric rating scales (NRSs), as per the recommendations presented in Table 2.3 (Appendix 2.5). The three scales were for pain intensity at its worst, on average, and at its least. The anchors used were 0 "no pain" to 10 "pain as bad as you can imagine", as recommended by Dworkin et al.[401], and in accordance with the Brief Pain Inventory-Intensity Scale[383] (see Appendix 2.8 for a more comprehensive review of this measure). Pain intensity ratings made on the 11-point NRSs are considered valid and reliable[402], and the validity is thought to be improved by combining multiple measures[403] (e.g. at its worst, on average, and at its least[404-406]). Pain was rated rather than MSSs more generally, as validated scales were only available for pain.

The review of data collection tools used for musicians' MSS outcomes (Appendix 2.5) indicated that there was no valid measure of the severity of MRMDs; hence the Brief Pain Inventory[383] items were adapted for this purpose. The severity of MRMDs was also rated for the last 7 days at its worst, on average, and at its least. For example, participants were asked "how much has you music-related musculoskeletal disorder interfered with your musical activity at its WORST in the last 7 days?" (Appendices 1.2 and 2.10). Responses were given on 11-point NRSs, with the anchors "does not interfere" to "completely interferes", which were taken from the Brief Pain Inventory-Interference Scale.[383]

In addition, participants who reported MSSs in the last 7 days were asked to rate 1. their level of concern regarding their MSSs, 2. the emotional impact of their MSSs, and 3. the impact of MSSs on their daily lives. These data were collected using the three relevant items from the

Brief Illness Perception Questionnaire.[407] The ratings were made on 11-point NRSs (see Appendix 1.2). The scales are valid and reliable[407, 408], and have been used in a wide range of studies[408], including of musicians' MSSs.[298] As recommended by Broadbent et al.[407] the term "illness" was changed to the specific condition of interest, in this case ache, pain or discomfort, consistent with the NMQ.[67]

Participants were asked whether they had made changes to their work/ study due to their MSSs in the last 12 months, and whether they had taken leave from their work/ study due to their MSSs in this same time period. The wording of these items was taken from the valid and reliable Extended NMQ.[384] In the present study, however, participants were only asked about these consequences for MSSs overall (i.e. in any body region), rather than specific body regions. Participants were also asked whether the consequences related to musical or non-musical work/study. In addition, participants were asked whether they had claimed workers' compensation in the last 12 months for their MSSs, and whether the WCC related to musical or non-musical work.

As the review of musicians' MSS outcomes and data collection tools used (Appendix 2.5) revealed that there was no consistent approach to collecting data regarding musicians' management of MSSs; items were developed for this purpose. The lists of health professionals and self-management strategies investigated in other studies of musicians' MSSs (Appendix 2.5) formed the basis of those included in the questionnaire for this study (Appendix 1.2). Participants were asked to indicate which of the following health professionals they had consulted in the last 12 months for their MSSs: medical professionals; physiotherapists or occupational therapists; psychologists or counsellors; personal trainers, Pilates instructors or yoga instructors; chiropractors, osteopaths, massage therapists, or Bowen therapists; naturopaths or homeopaths; and, Alexander technique practitioners, Feldenkrais practitioners and body mapping teachers. Participants were then asked which self-management strategies they had utilised for their MSSs in the last 12 months from the following list: exercises/ stretches, medication, heat/ ice, and braces/ strapping/ taping. Participants were also asked to list any additional self-management strategies used, and health professionals consulted, in free text. Additionally, musicians were asked whether they had discussed their MSSs with other musicians in the last 12 months.

Musculoskeletal Health Questionnaire

The reference groups were asked to complete the Musculoskeletal Health Questionnaire (Appendix 1.2) which was similar to Musicians' Musculoskeletal Health Questionnaire, but did not enquire about MSSs related to musical activity, nor psychosocial factors. The Questionnaire was estimated to take 5-10 minutes to complete.

2.2.2 Recruitment and data collection

2.2.2.1 Inclusion criteria

University music students and professional musicians were eligible for inclusion in the study, provided they were aged 18 years or older. Professional musicians were defined as members of the Music Teachers' Association or Musicians' Union, or those employed as musicians (performer, conductor or a singing or instrumental teacher) in the last 12 months.

Participants were eligible for inclusion in the reference group if they were currently employed in the Faculty of Science, Health Science or Humanities at a university; or studying science at the same university; were aged 18 years or older; and were not a current university music student or a professional musician (as per our definition).

2.2.2.2 Sample size

The sample size recommended for Rasch analysis (a method of testing the utility of the measures, described in Section 2.2.3.2) of polytomous scales was at least 10 participants per response category.[409] There were no existing data available for the distribution of the responses for the polytomous scales investigated; hence, the aim was to collect data from as many participants as possible.

Given a range of MSS outcomes were being investigated, some without sufficient existing evidence of the prevalence for the music industry as a whole, the sample size for a prevalence of 50% was determined as a 'worst case scenario'. The sample size was calculated using the formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where n = sample size, Z = Z statistic for the level of confidence, P = the expected prevalence/ proportion, and d the precision.[410] The level of precision was 5% hence d=0.05, the expected proportion was 0.5, and for a 95% level of confidence a Z value of 1.96 was used. Based on this formula a sample size of 384 was required for this 'worst case scenario'.

In comparing groups (e.g. musicians and reference groups, or sub-groups of musicians), to detect a difference of 20%, with 80% power and a 5% level of significance and assuming groups of equal size and a prevalence of 50% in one of those groups, at least 93 participants were required per group. As multivariable analyses were planned, this estimate was increased by 10% to 102 participants in each group.

Given the lack of good quality evidence regarding the factors potentially associated with musicians' MSS outcomes, there were few available results on which to base a sample size calculation. Data were available on the proportion of musicians who were considered psychologically distressed; hence, this was used as the basis of the sample size estimation for this aspect of the project. It has been estimated that 17.5% of professional musicians are psychologically distressed.[191] Using this estimate, and the same parameters reported above (i.e. 5% level of significance, 80% power, 50% prevalence in one group, and 20% difference in prevalence estimates), a total sample size of 285 was required. This estimate was also increased by 10% as multivariable regression was planned, resulting in a final estimated sample size of 314.

2.2.2.3 Recruitment and data collection

Musicians were recruited from two Australian states; South Australia and Western Australia. University music students were recruited from two universities, and professional musicians were recruited from three orchestras, two opera companies, two universities, five military bands, two Music Teachers' Associations, and the Musicians' Union. The reference group was recruited from one Australian university, where science students, as well as staff from the Faculties of Science, Health Science and Arts (excluding music) were asked to participate.

For musicians, recruitment was conducted online and/or face-to-face depending upon logistical constraints, and organisational policy[cc], while the reference groups were recruited online only. In both instances, potential participants were provided with a brief description of the project, an Information Sheet (Appendix 1.2), a paper copy of the questionnaire (along with a reply-paid envelope), and/or a link to the online questionnaire (Survey Monkey). Where permitted by organisational policy, those recruited face-to-face were provided with a link and

[cc]The Australian Defence Force does not allow their personnel to complete questionnaires on Survey Monkey; the platform used in this research

Quick Response (QR) code for the online questionnaire, while those recruited online could request that a paper questionnaire be posted to them.

Paper questionnaires were returned via onsite collection boxes, the supplied reply-paid envelope, or directly to the research team. Where permitted by the organisation, those who returned a completed questionnaire within a 2-3 week timeframe could opt to be included in a prize draw for 1x $250 gift card, or one of 5x $50 gift cards. Monetary incentives have been found to improve response rates in postal surveys when compared with non-monetary or no incentive.[365] While a 2 week time period for the return of questionnaires was intended, this was extended to 3 weeks for some groups, e.g. the universities, where recruitment was conducted in phases (e.g. face-to-face sessions were conducted over a one week period, however the one due date was provided for simplicity).

Participants were reassured of the confidentiality of their data through the Information Sheet (Appendix 1.2) and the introductory presentation, and The University's involvement was made clear to participants through all documentation and at the presentation. Both of these elements are conjectured to improve participation rates.[365] Where possible, posters (Appendix 1.2) were also placed in key locations within the organisations involved to serve as a reminder to potential participants to participate, and another form of recruitment. The poster included a link and QR code to a brief description of the project, the Information Sheet, and the online questionnaire.

2.2.3 Data management and analysis

Online data were exported from Survey Monkey into Microsoft Excel for initial data cleaning and coding. The paper questionnaire data were double entered into the Excel spreadsheet. Double entry allowed for detection of errors, with any inconsistencies checked against the original paper questionnaire and corrected.

2.2.3.1 Data coding and cleaning

Data were initially cleaned in Excel by checking for responses that were clearly inaccurate, and for inconsistencies across responses. Initial coding was also conducted in Excel. Data were then exported from Excel into Stata 14[411] for further coding and analysis. Descriptive statistics, graphs of these, and cross-tabulations were used to identify any data that may have been incorrectly entered, or that were not possible (for example, where participants reported that they had experienced MSSs in the last 7 days but not the last 12 months, or heights reported using different units to the centimetres requested). Body mass index was calculated using cleaned height and weight, while residential postcodes were used to determine socio-economic status quartiles from the Index of Relative Socioeconomic Advantage and Disadvantage.[376] Due to small numbers in some response categories, sitting time was collapsed such that the three groups were <4, 4-8, and >8 hours. Musical activity time categories were also collapsed into three categories <10, 10-20, and >20 hours.

For the ratings of the emotional impact of MSSs, and for the impact on daily life of MSSs, ratings were coded using the quartiles, rather than the raw scores, owing to the small numbers of participants in some cells. There was no existing evidence regarding appropriate cut-points for these scales; hence using quartiles was a suitable approach. Where measures were used, the w-scores derived from the Rasch analysis (described in Section 2.2.3.2) were calculated, and used for analysis. The only measure where a satisfactory result could not be obtained through the Rasch analysis was the pain intensity measure (Appendix 2.9). As a result, the pain 'on average' scale was used, as has been recommended when using only one of the three pain intensity scales (at its worst, on average, and at its least).[412] As with the emotional impact and impact on daily lives scales, there were insufficient numbers in some cells to use the pain intensity on average scale with the 11 response categories, hence categories were collapsed.

Suggested cut-points for 'healthy' community adults using an 11-point NRS for pain intensity are 1-4 for mild, 5-6 for moderate, and 7-10 for severe pain.[413] As only 21 musicians rated their pain on average as 7-10, pain intensity ratings 'on average' of ≥5 were considered moderate/severe.

Drawing on the best available evidence regarding the tools used to collect MSS outcome data from musicians (Appendix 2.5), the identification of valid and reliable items for dependent variables and potential confounders (where available), and the integration of established strategies to improve participation rates in survey research, two comprehensive questionnaires were developed. One questionnaire for musicians, and the other for the reference group. Recruitment and data collection processes drew upon established strategies to improve participation rates, while also addressing ethical and organisational requirements.

2.2.3.2 Rasch analysis

Rasch analysis was applied to all measures used in this research, with the reference group also included in the Rasch analyses for the MSS measures for which data were available. This is the first time that Rasch analysis has been used in studies of musicians' MSSs. Indeed, this is the first time that any of the measures used in this research have been examined using Rasch analysis, resulting in the best available evidence of the utility of these measures in any population. Further, the research presented in this thesis will arguably also provide the best available evidence of the factors associated with musicians' MSS outcomes, owing to this being the only research using measures supported by modern psychometric methods. By conducting Rasch analysis, the present research provides original contributions both to the methodology of public health research, and our understanding of musicians' MSSs.

The utility of the measures selected for the present study were based upon traditional statistics as reported in the literature, such as Cronbach's alpha and factor analyses, rather than modern psychometric tests, like Rasch analysis. The Classical Test Theory (CTT), that underpins traditional statistics, assumes a reported raw score is the sum of the true score and a random measurement error[414, 415], and that errors and the true score are not correlated, are independent of one another, and are randomly distributed.[414] The CTT focuses on the person's measurement relative to the total score.[415] The CTT[416] and Cronbach's alpha[417-419] have a range of issues. One such issue with the CTT, is that traditional statistics are specific to the sample at that point in time[414]; hence the findings are not generalisable. In addition, scales that are tested with traditional statistics also remain ordinal.[414] Often participants are asked to respond to an item on an ordinal scale, such as a NRS or Likert scale, however simply combining (e.g. summing or averaging) the ratings for the scale items is inappropriate given their ordinal nature, as response categories are not necessarily equidistant.[420]

Modern psychometric methods, like Rasch analysis, supplement traditional statistics.[421] Modern psychometric methods consider the person's measurement relative to the probability of their response.[415] Unlike the CTT, the theory underpinning the Rasch measurement model (RMM) can be tested and is robust.[415] The RMM is the simplest model to determine unidimensionality and parameter invariance, with output with the minimum number of parameter estimates, and is easily interpreted on an interval scale with precision estimates.[422-425] In addition, Rasch analysis is the only method to consider Luce and Tukey's[426] general rules of measurement – sufficiency (item score can be predicted from the total score) and invariance of comparisons (interval scaling).[427] For a more detailed discussion of Rasch analysis, a number of resources are available (e.g.[420, 428, 429]).

Rasch analysis was conducted on each of the measures used within the study, using ConQuest[430] software. The specific methods applied to each scale are reported in Appendices 2.9-2.20. Rasch analysis involves fitting the data to one of the RMMs to ensure the items are measuring the latent trait[420], and should be used when items are being combined to provide an overall measure.[420, 429] Three main Rasch models are available, the dichotomous model[431], and two polytomous models; the rating scale model (RSM)[422], and the partial credit model (PCM).[425] The RSM assumes the spacing between response categories is equidistant for each item, whereas this is not the case with PCM.[429] Furthermore, in contrast to the PCM, the RSM assumes that all items are equally discriminating, share the same rating scale structure, and having the same number of response categories.[432] For scales, like the pain intensity and MRMD severity scales used in this study, where empty cells are anticipated[dd], only the PCM was used. Otherwise, data were fit to both polytomous models, and were examined using the Akaike Information Criterion (AIC).[433] The AIC is a fit statistic used to select the optimal model; that is, the model in which the mean squared error is minimised.[434] A lower AIC indicates a more parsimonious model[435, 436]; so the model with the lowest AIC was selected. Ideal fit is indicated by a weighted fit mean square of 0.60-1.40[437, 438] and/or t-values (from cube root transformation) of -1.96 to 1.96.[428] Beyond these ranges, items were flagged as potentially mis-fitting, with items deleted if also indicated by the other output (described below). Overall measurement error and discrimination power was indicated by the separation reliability, with a higher reliability considered favourable.[416] The chi-square test of parameter equality was used to assess overall fit.

The output was checked to ensure that the category estimates, point biserial correlations, mean predicted values, item deltas, and item thresholds were in ascending order.[428, 429, 439, 440] If this was not the case the collapsing of response categories was considered[420, 429, 440, 441], particularly where the discrimination at the threshold between two categories was zero.[439]

A discrimination index (item-total correlations) of <0.20 was considered extremely low[428], and may be remedied through item deletion. The item-rest correlation (biserial correlation) was deemed acceptable if it was positive. Residual fit statistics were used to determine person fit[442], with ideal results between -1.96 to 1.96. If values were well beyond this range, and/ or where a large percentage of participants were considered mis-fitting, these participants were removed from the analysis, and the analysis re-run.

Scale targeting to the population was determined by examining the Wright map. The Wright map reports the participant distribution along a logit scale and the item position. The Wright map can be used to determine whether the mean person location is approximately zero logits, to indicate the scale is well targeted.[429, 441]

Response dependency occurs where two or more items are related, which may inflate reliability.[420] Response dependency is detected through a correlation matrix of the residuals.[420, 429] Low dependency is typically indicated by absolute correlations of <0.40.[443]

Where scales fit one of the RMMs, differential item functioning (DIF) was then examined. Differential item functioning refers to item responses that differ between sub-groups with similar overall scores.[429, 441] Sub-groups considered for DIF were age, gender, being a university music student or not, and socioeconomic status, as well as being a musician or not, where applicable. Two strategies were employed to detect significant DIF: 1) the Wald test, and 2) the weighted mean fit square. The Wald test involved comparing the estimates for the item*group (e.g. item*gender) with the standard error.[444] Potential DIF was indicated where the absolute estimate was greater than twice the error for an item.[444] The weighted mean fit square approach involved examining the weighted mean fit square for the items for each group.[445] The same cut-points to identify potential problems as for the item fit were used,

[dd]Both scales involved ratings at 'its least', 'on average' and at 'its worst', hence empty cells were likely. For instance, in a working/studying population pain ratings of 10 "worst pain imaginable" for pain at its least were highly unlikely.

such that the weighted mean fit square should fall within the range 0.60-1.40, and the corresponding t-value should be between -1.96 and 1.96.

If significant DIF was detected with either approach, the magnitude of the DIF was then determined. Determination of the magnitude involved examining the thresholds (estimates) for the two groups, and considering the difference between them.[445] Where the difference was greater than 0.5 logits, the DIF may be of sufficient magnitude to influence results[445], and the type of DIF was determined. To determine the type of DIF, the expected values for both groups were plotted together against the logit, and examined for uniformity. The DIF was said to be uniform where differences between groups were uniform across all logits.[420, 441, 446] To address uniform DIF, the dataset was split by the group and analysed separately[420, 441], or the DIF item was removed.[420] Where expected values for groups differed at different logit values, the DIF was said to be non-uniform.[420, 429, 441] To remedy this, deletion of the DIF item was considered.[441]

Where the data fit the RMM and no DIF was detected the raw scores were transformed into weighted likelihood estimates (WLE). Weighted likelihood estimates are advantageous over other available transformation methods as estimate bias is minimised.[447] The WLEs were then transformed into w-scores to eliminate negative values, and the need for decimal points.[448] Microsoft Excel was used for this transformation using the formula w=9.1024 x logits + c, where c was a constant term, selected to eliminate the negative values.[448]

Full details of the results and interpretation of the Rasch analyses are reported in Appendices 2.9-2.16. Table 2.5 summarises the findings of the Rasch analyses, specifically any changes made (e.g. item deletion or collapsing of categories) and the transformation from raw scores to w-scores. As mentioned earlier, there was no satisfactory result for the pain intensity scales (Appendix 2.9); hence, the pain intensity scale has not been reported in Table 2.5.

For the first time, Rasch analysis, a modern psychometric method, was applied to a series of commonly used psychosocial measures, providing the best available evidence to date of the utility of these selected measures in any population. Further, the main analyses, described in the next section, were the first analyses of musicians' MSSs to incorporate measures tested using Rasch analysis, thus arguably providing the best available evidence of the factors associated with musicians' MSSs.

2.2.3.3 Answering the research questions

Quantitative analysis

All quantitative analyses were conducted in Stata 14.[411] Descriptive statistics were used to describe the sample, in terms of demographics, exposures, and MSS outcomes. Sub-groups were also investigated in order to determine differences in terms of the priority body regions for MSS outcomes.

To compare the prevalence and profile of MSSs between groups (i.e. different sub-groups of musicians, and musicians and the reference groups), unadjusted binary or ordered logistic, or linear regression were used (depending on the type of outcome variable) to determine whether there were significant differences ($p<0.05$) between the groups. The comparisons were then conducted with adjustment for potential confounders, as per Table 2.3. All models included age and gender, as well as other potential confounders. For comparisons between groups, potential confounders were identified by investigating the variables by which there were significant or near-significant ($p<0.20$) differences between the groups. These significantly or near-significantly different variables were considered in the models, as confounders, if they were associated ($p<0.20$) with the outcome of interest. Correlations between dependent and confounding variables were examined to detect potential

Table 2.5: Summary of the modifications made to the scoring of the measures used in this research and the transformation from raw to W-scores, based on the Rasch analysis

	MRMD severity scale	PHQ– 4	Stress scale	Modified MOAQ-JSS	Musicians' Social Support Scale	Safety climate scale		
						Communication scale	Involvement scale	Prioritisation scale
Number of items and response categories	3 items 11 response categories	4 items 4 response categories	2 items 6 response categories	3 items 5 response categories	2 items 5 response categories	2 items 5 categories	2 items 5 categories	2 items 5 categories
Modifications made	MRMD at its worst was removed MRMD on average ratings were recoded with 3-5 and 4-10 collapsed MRMD at its least were recoded with 2-10 collapsed	Collapsed the highest 2 response categories	Collapsed the lowest 3 response categories	Collapsed 'strongly agree' and 'agree', and 'strongly disagree' and 'disagree' categories	No changes made	No changes made	No changes made	No changes made
Transformation (raw score to W-scores)	0=2 1=25 2=40 3=49 4=60 5=72 6=89	0 = 19 1 = 33 2 = 40 3 = 46 4 = 51 5 = 55 6 = 60 7 = 67 8 = 79	0 = 5 1 = 17 2 = 25 3 = 30 4 = 35 5 = 42 6 = 55	0 = 1 1 = 10 2 = 15 3 = 20 4 = 25 5 = 30 6 = 40	0 = 5 1 = 15 2 = 20 3 = 26 4 = 35 5 = 48 6 = 59 7 = 71 8 = 85	0=6 1=21 2=51 3=69 4=88 5=107 6=122 7=203 8=217	0=5 1=21 2=33 3=44 4=56 5=69 6=87 7=106 8=122	0=5 1=20 2=36 3=52 4=71 5=90 6=105 7=157 8=172
More information	Appendix 2.10	Appendix 2.11	Appendix 2.12	Appendix 2.13	Appendix 2.14	Appendix 2.15	Appendix 2.15	Appendix 2.15

(continued →)

	Short Effort-Reward Imbalance Questionnaire				
	Effort scale	**Reward scale**	**Job security sub-scale**	**Esteem sub-scale**	**Promotion sub-scale**
Number of items and response categories	3 items 4 response categories	7 items 4 response categories	2 items 4 categories	2 items 4 categories	2 items 4 categories
Modifications made	No changes made	Removed Items 2 & 4	No changes made	No changes made	Item 1[a] removed
Transformation (raw score to W-scores)	0 = 4 1 = 17 2 = 26 3 = 34 4 = 42 5 = 50 6 = 64 7 = 77 8 = 87 9 = 101	0=10 1=22 2=27 3=32 4=35 5=39 6=42 7=45 8=49 9=54 10=59 11=65 12=70 13=76 14=83 15=95	0=2 1=12 2=18 3=23 4=30 5=39 6=53	0=1 1=16 2=29 3=41 4=59 5=93 6=108	0=4 1=17 2=25 3=32 4=43 5=56 6=70
More information	Appendix 2.16	Appendix 2.16	Appendix 2.16	Appendix 2.16	Appendix 2.16

(← continued)

Notes: MRMD: music-related musculoskeletal disorders. PHQ-4: Patient Health Questionnaire-4, MOAQ-JSS: Michigan Organizational Assessment Questionnaire-Job Satisfaction Scale, ERI: Effort-Reward Imbalance. [a]Item 1 refers to the first of the promotion items, which is Item 2 of the Reward scale multicollinearity, as indicated by a significant ($p<0.05$) correlation of >0.60. Correlated variables were not considered within the same model. A similar approach was used to determine the association between the investigated modifiable factors and MSS outcomes, where only variables with a significant or near-significant association ($p<0.20$) with the outcome of interest.

Forward and backward stepwise regression was used to assist in identifying the most parsimonious model for each outcome and comparison. The contribution of each variable to the model was assessed, with model selection guided by the AIC[433]; however all models retained age and gender. The variance inflation factor (VIF) was also examined, with a VIF of >10 indicating that there was multicollinearity in the model.[449] All model assumptions were assessed, and violations rectified. The default level of significance (5%) was used throughout. Given the potential for multiple testing to influence results, the focus on the findings has been on identifying patterns of associations across MSS outcomes, rather than focusing on individual results.

Improving on many of the limitations identified in the existing evidence of musicians' MSSs, multivariable analyses were used to adjust for potential confounders in the analyses comparing types of musicians, musicians and the reference group, and in the determination of the associations between various modifiable factors and MSS outcomes. This was also the first study of musicians' MSSs to utilise w-scores from the Rasch analysis for measures of psychosocial and MSS variables.

Description of musicians' perceived causes of their musculoskeletal symptoms

The perceived causes of MSSs reported by musicians who experienced MSSs in the last 7 days were obtained using the Brief Illness Perception Questionnaire.[407] Musicians were asked to list what they believed were the top three causes of their MSSs. Factors were classified as being likely preventable/ modifiable or not, and as musical or non-musical factors. Musical factors included all statements regarding practice, playing, technique, hand or wrist position, warming up, equipment, the profession, pedalling,instrument cases, technical work, and teaching, where it was not clearly related to non-musical activities (e.g. not warming up before playing sport). Studying was also considered a musical factor, providing the participant reported in the questionnaire that they were currently studying music at university. Remaining factors were considered non-musical. Categories to describe the types of perceived causes reported (beyond those described above) emerged from the data, as will be described further in Chapter 7. The percentage of symptomatic musicians who reported the main types of perceived causes was reported.

This study is one of the first to use 'musician-driven' methods of data collection regarding the musicians' perceived causes of their MSSs. In doing so, new insight can be provided into the perceived causes of MSSs for musicians.

SECTION B:
Is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?

Section B includes Chapters 3-5, and answers the question “is there a burden of musculoskeletal conditions in Australian university music students and professional musicians?”. Chapter 3 reports on the analysis of musicians’ workers’ compensation claims in order to determine what proportion and cost of claims relate to musculoskeletal disorders. Chapter 4 reports the prevalence and profile of musculoskeletal symptoms for university music students and professional musicians, as well as their sub-groups. Chapter 4 also includes a comparison of the musculoskeletal symptom prevalence and profile between the sub-groups of musicians, to determine which groups should be prioritised for future research and interventions. Chapter 5 reports the comparative study, where the prevalence and profile of musculoskeletal symptoms were compared between musician and reference groups. These three lines of evidence were used to determine whether there was a burden of musculoskeletal conditions for Australian university music students and professional musicians.

CHAPTER 3: MUSICIANS' WORKERS' COMPENSATION CLAIMS AS INDICATORS OF THE BURDEN OF MUSCULOSKELETAL CONDITIONS

3.1 Introduction

To answer the question: "is there a burden of musculoskeletal conditions among Australian professional musicians?", musicians' workers' compensation claims (WCCs) were analysed. Workers' compensation claims data were only available for 'musicians'[ee], not music teachers who are classified as private tutors. Musicians' WCCs data have not previously been examined (Chapter 1 and Appendix 2.2); a notable evidence gap. Such an analysis would provide insight into the burden of musculoskeletal conditions for musicians, and may therefore lead to recommendations to decrease the burden of musicians' musculoskeletal conditions.

The objective of this study was to determine the number and proportion of WCCs attributed to musculoskeletal disorders (MSDs[ff]) for Australian musicians (2004/2005-2015/2016), the nature and body region of these work-related MSDs (WRMSDs), the median number of hours of work missed, and the cost of WRMSDs.

3.2 Background

Musculoskeletal disorders are the third leading cause of disability globally.[1] When considering specific conditions, lower back pain is the leading cause of disability, with neck pain and other MSDs also ranked in the top 10, both globally and in Australia.[1] In Australia, work-related musculoskeletal conditions (including fractures, joint, ligament and muscle injury, and musculoskeletal disorders) accounted for 42% of the estimated $61.8 billion total cost of occupational illness and injury during the 2012-2013 financial year.[5] Musculoskeletal disorders also accounted for 61.9% of WCCs from 2009-2014[4], and are also a priority area for prevention under the Australian Work Health and Safety Strategy 2012-2022.[6]

Musculoskeletal symptoms (MSSs) are common amongst musicians[48-52], including professionals[52], with MSSs leading to participation restrictions and activity limitations.[63-65] For some musicians, MSSs have led to them stopping playing[450], or changing careers.[61, 62]

Notwithstanding the impact of MSSs for individual musicians, the viability of Australia's orchestras has previously been threatened by the high cost of workers' compensation insurance, which increased from A$ 0.75 million to A$ 1.7 million over a three year period (2001-2004).[451] The insurance premiums equated to 2.5% of the cost of wages and salaries in the 2003/2004 financial year, and as high as 4.8% for one orchestra.[451] These findings highlight the importance of WCCs to the financial viability of musical ensembles, and their cultural contribution to society.

[ee]Included instrumetnalists, singers, musical directors and composers

[ff]All musculoskeletal disorders reported in the workers' compensation claims data are for work-related musculoskeletal disorders

While there is a large body of recent evidence regarding MSSs in musicians (Chapter 1 and Appendix 2.2) and some evidence regarding compensation claiming behaviour[64], no published study has analysed WCCs data for musicians.[gg] Analysis of WCCs data provides an opportunity to fill a number of gaps in the current evidence base; in particular:

1. Whether WRMSDs are the leading compensable health problem for musicians on a numerical basis;
2. Whether WRMSDs are the most costly conditions and result in the most time off from work for musicians; and
3. The nature and location of WRMSDs claimed by musicians.

This information will potentially provide a foundation for future work aimed at reducing the health burden for musicians, and improving the financial viability of their employers.

3.3 Methods

The methods for this chapter were reported in Chapter 2. In short, individual level data were obtained from Safe Work Australia's National Data Set for Compensation-based Statistics (third edition; NDS-3)[360] for musicians (unit group 2112 according to the Australian and New Zealand Standard Classification of Occupations[361]). All claims were included whether they were regarded 'serious'[hh] or not. Claimants' age and gender were obtained, as were the month and year of the incident, the financial year of the claim, details of the claimed condition (i.e. nature, body region), the time lost and claim costs. For the purpose of this study, fractures and traumatic joint/ ligament and muscle/ tendon injury were classified as musculoskeletal injuries, and musculoskeletal and connective tissue diseases as musculoskeletal diseases. Data were largely reported descriptively, and based on the number of claims, rather than the incidence, owing to the lack of a valid denominator of musicians (see Chapter 2 for further information).

3.4 Results

For the 12 year period from the 2004/2005 to 2015/2016 financial years, 781 claims for workers' compensation were made by musicians in Australia. Of the claimants, 43.7% were female, and the mean age of claimants was 51.8±11.7 years. A total of 545 (69.8%) claims were made for MSDs (Table 3.1). The demographics of musicians who claimed for MSDs were similar to those of all claims (mean age 52.1±11.4, 46.4% female).

Table 3.1: Proportion of musicians' workers' compensation claims due to each condition type

Condition claimed for	%
Injuries	***58.0***
Traumatic joint/ ligament and muscle/ tendon injury[a]	37.6
Fractures[a]	4.5
Wounds, lacerations, amputations and internal organ damage	10.1
Other injuries	5.8
Diseases	***41.2***
Musculoskeletal and connective tissue diseases[a]	27.7
Nervous system and sense organ diseases	4.5
Mental diseases	3.8
Other diseases	5.3
Other claims	***0.8***

Note: [a] classified as a musculoskeletal disorder

[gg]Based on the systematic mapping review (2007-2016), the update systematic search (January 2017-April 2019), and targeted searches of the literutre published prior to 2007

[hh]Serious workers' compensation claims refer to "an accepted workers' compensation claim for an incapacity that results in a total absence from work of one working week or more".[72]

3.4.1 Musculoskeletal disorder claims

Of the MSD claims, 60.4% were for injuries, rather than diseases. The most common types of MSDs claimed for were diseases of muscle, tendon and related tissue (15.2%), trauma to joints/ ligaments (10.1%), trauma to muscles/ tendons (20.7%), and residual soft tissue disorders due to trauma or unknown mechanisms (23.1%; Table 3.2). Specific diagnoses are reported in Appendix 1.3.

Table 3.2: Proportion of musicians' musculoskeletal disorder claims for each musculoskeletal disorder type

The type of musculoskeletal disorder claimed for	%
Musculoskeletal diseases	***39.6***
Diseases of muscle, tendon and related tissue	15.2
Spinal vertebrae and intervertebral disc diseases - dorsopathies	8.6
Diseases involving the synovium and related tissue	3.3
Joint diseases (arthropathies) and other articular cartilage diseases	2.0
Other soft tissue diseases	7.2
Other musculoskeletal and connective tissue diseases (not classified elsewhere)	3.3
Musculoskeletal injuries	***60.4***
Residual soft tissue disorders due to trauma or unknown mechanisms	23.1
Trauma to muscles/ tendons	20.7
Trauma to joints/ ligaments	10.1
Fractures	6.4

From the 2004/2005 to 2015/2016 financial years, there was a decrease in the number of claims overall made by musicians, including for MSDs specifically (Figure 3.1). For MSD claims, 85.0% of claims occurred within the same financial year as the incident, with a further 13.0% of claims being made in the financial year following the incident. Six claims occurred two years after the incident; three were three years later, and one each for 10 and 16 years after the incident.

There were fewer MSD claims made for incidents occurring in the months of January and December, as well as a drop in musculoskeletal injury claim incidents in January, July and December. For musculoskeletal disease claims, there were fewer incidents in January, June and December (Figure 3.2).

3.4.2 Body regions

The most commonly affected body region for MSDs was the upper limb, representing 50.5% of all MSD claims (Table 3.3). The upper limb was also the most commonly affected body region for both musculoskeletal injuries and diseases specifically, and was the only broad body region for which the disease claims outnumbered injury claims. Within the upper limb region, the shoulder region was the most commonly affected area representing 16.9% of all MSD claims, while the hand/ fingers/ thumb region was affected for 11.7% of MSD claims.

Table 3.3: Proportion of musicians' musculoskeletal disorder claims by body region

	All musculoskeletal disorder claims (%)	Musculoskeletal disease claims (%)	Musculoskeletal injury claims (%)
Upper limb	50.5	65.7	40.4
Lower limb	14.5	5.6	20.4
Trunk	13.8	13.4	14.0
Neck	9.4	10.7	8.5
Head	1.7	0.5	2.4
Multiple	10.3	4.2	14.3

Notes: Multiple areas referred to 'neck and trunk' (n=11), 'trunk and limbs' (n=9), 'upper and lower limbs' (n=4), 'neck and shoulder' (n=14), 'other specified multiple locations' (n=15), and 'unspecified multiple locations' (n=3)

With the exception of the drop in the number of claims in the 2008/2009 financial year for the upper limb, there has been little change in the number of MSD claims by body region during the 12 year study period (Figure 3.1). Figure 3.2 reports the number of claimed incidents per month, indicating that January and December have the lowest number of claimed MSD incidents, across all body regions.

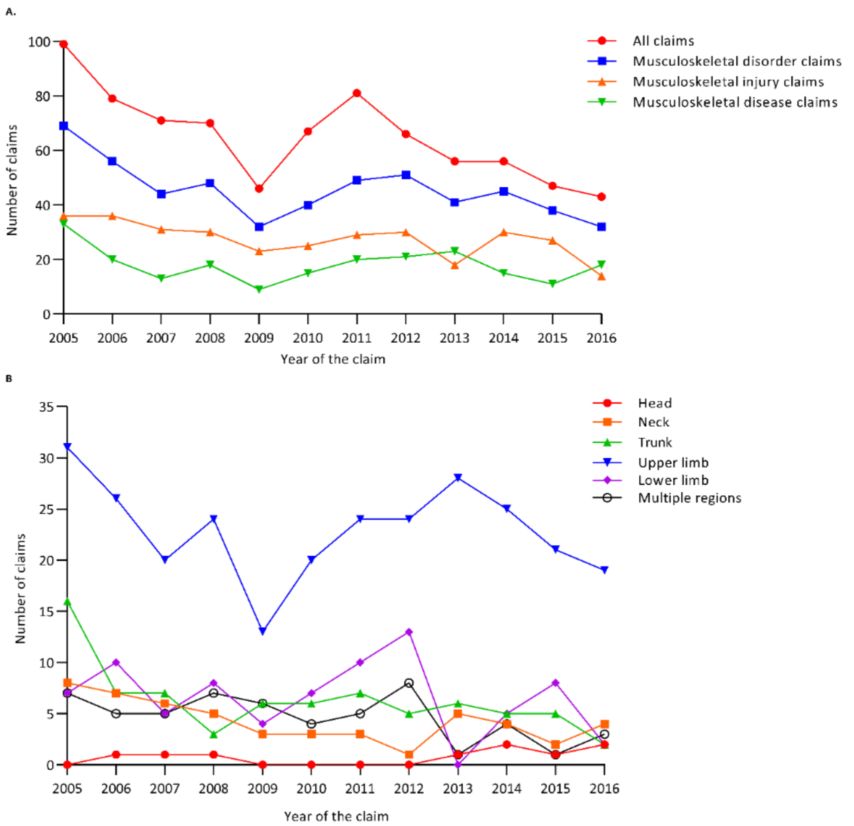


Figure 3.1: Number of musicians' workers' compensation claims per financial year (A) for any type of claim, and musculoskeletal disorder, injury and disease claims, and (B) musculoskeletal disorder claims by body region
Notes: The years reported refer to the financial year ending in the reported year, such that 2005 refers to the 2004/2005 financial year, 2006 refers to the 2005/2006 financial year etc. 2015/2016 data were provisional

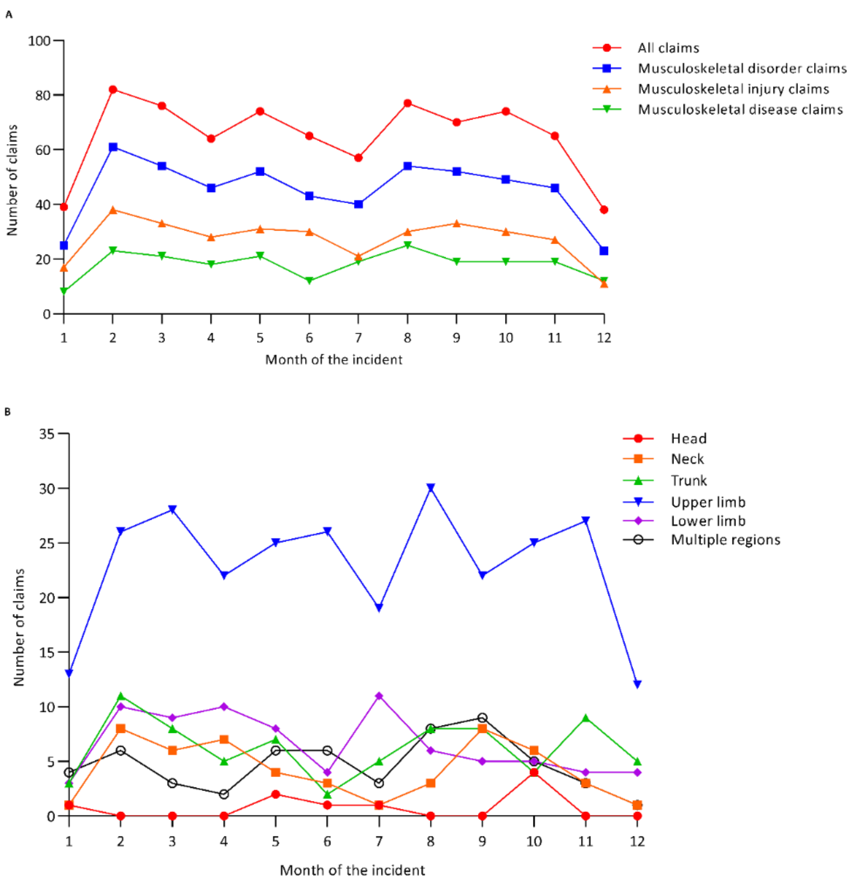


Figure 3.2: Number of musicians' workers' compensation claims per month (A) for any type of claim, and musculoskeletal disorder, injury and disease claims, and (B) musculoskeletal disorder claims by body region
Note: the months are numbered in order from January, e.g. 1 refers to January, 2 refers to February etc.

3.4.3 Time off and costs of claims

The median time off from work for all claims was 7.0 hours, while for MSDs it was 10.0 hours (Table 3.4). Musculoskeletal injuries resulted in a median of 7.6 hours off work, whereas musculoskeletal diseases resulted in a median of 24.0 hours off work. The body regions with the longest time lost were the upper limb (median 38.0 hours) and neck (median 30.0 hours; Table 3.4).

Musicians' WCCs cost a total of A$9 291 470 in the 12 years from 2004/2005 to 2015/2016. Musculoskeletal disorders accounted for A$7 224 999 (77.8%) of the total cost of claims, with 57.6% of the MSD cost being attributed to injuries. The total cost of upper limb MSDs was A$4 633 785, accounting for 49.9% of the cost of all claims, and 64.1% of all MSD claims.

Table 3.4: The median time lost and cost of musicians' workers' compensation claims by condition type

	Work hours lost (median, IQR)	Cost (A$) of a claim (median, IQR)
All claims	***7.0 (0.0-152.0)***	***2 104 (427-10 578)***
Musculoskeletal disorders	10.0 (0.0-160.0)	2 520 (574-12 325)
Non-musculoskeletal conditions	0.0 (0.0-152.0)	1 242 (0-5 524)
Nature of musculoskeletal disorders		
Injury	7.6 (0.0-153.6)	2 426 (699-10 652)
Disease	24.0 (0.0-176.6)	2 701 (255-14 634)
Location of the musculoskeletal disorders		
Head	0.0 (0.0-288.5)	4 148 (1 209-31 547)
Neck	29.0 (0.0-187.0)	1 355 (378-14 482)
Trunk	0.0 (0.0-40.0)	1 015 (130-3 711)
Upper limb	38.0 (0.0-208.0)	4 981 (1 071-16 389)
Lower limb	0.0 (0.0-57.6)	1 263 (288-5 658)
Multiple	7.0 (0.0-126.4)	1 739 (689-12 260)

Notes: A$: Australian dollar, IQR: interquartile range

The median total cost per MSD claim was A$2 520, whereas the median total cost per non-MSD claim was A$1 242 (Table 3.4). With the exception of common law benefits[ii] (which were only seen in non-musculoskeletal condition claims), MSD claims accounted for the majority of costs in each category. The highest treatment costs for MSDs were for medical services, followed by allied health services (Figure 3.3).

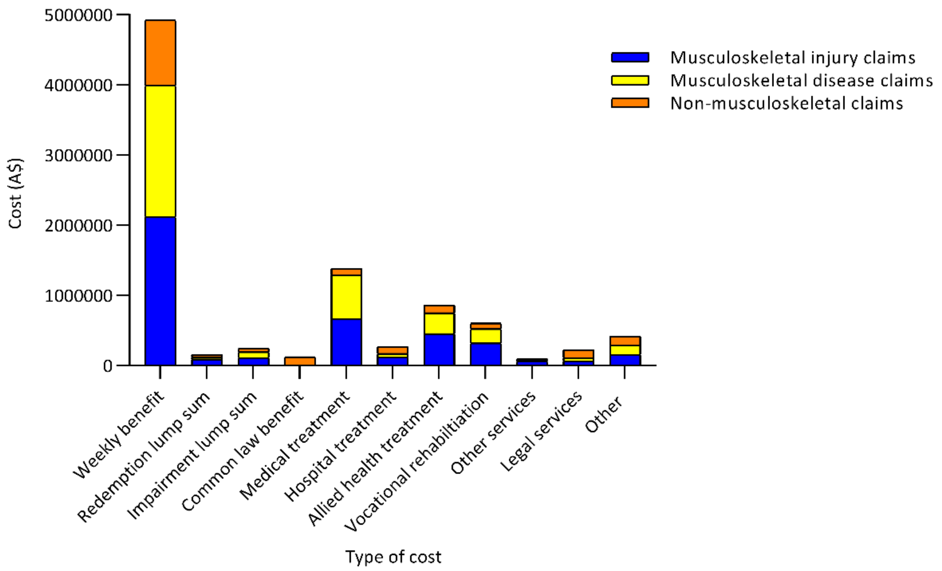


Figure 3.3: Costs associated with musicians' workers' compensation claims

[ii]Common law benefits refer to payments made for economic loss[362]

3.5 Discussion

3.5.1 Key findings

The present study appears to be the first to analyse MSD WCCs for a population of musicians globally. The overall objective of this study was to determine whether MSDs were the biggest compensable health problem for professional musicians, and the profile of claimed MSDs. Musculoskeletal disorders were found to be the biggest health problem for professional musicians, accounting for 69.8% of WCCs, which appears to be slightly higher than that of the general working population (61.9%).[4] Comparisons between musicians and the general workforce could not be made as Safe Work Australia's[72] reports only include serious WCCs, yet the definition of a serious WCC is not appropriate for musicians given that they do not typically work full time.[21] For musicians, the high proportion of MSD claims, and the finding that 77.8% of the cost of musicians' WCCs were attributed to MSDs, highlights the importance of addressing MSDs for musicians.

Of the MSD claims, 60.4% were for injuries, rather than diseases, which is in contrast with previous suggestions that most musicians' MSDs have a gradual onset (i.e. diseases).[452] Potential reasons for this discrepancy include the symptom severity, and claiming behaviour. It is possible that the symptoms following an injury are more severe and therefore require time off, when compared with diseases. Musculoskeletal injuries may also be easier to justify as legitimate conditions as they may have more visible signs, when compared with diseases[329], with musicians reporting difficulties in convincing health professionals of the existance of their MSSs.[194] Injuries may also be easier to report owing to having a 'incident' where the date, location, mechanism and agency can easily be reported, in comparison with the ongoing exposure leading to disease which may include a combination of work-related and non-work-related activities.[64] As a result, a higher proportion of those with musculoskeletal injuries may claim and receive compensation, when compared with musculoskeletal diseases.

3.5.2 Under-reporting

Owing to the lack of a valid denominator the incidence of MSDs among musicians could not be determined. Chimenti et al.[64] recently suggested that orchestral musicians under-report playing-related symptoms to compensation bodies. In their cross-sectional survey only 3.4% of orchestral musicians had claimed workers' compensation for playing-related symptoms during their careers.[64] Chimenti et al.[64] did not report the career prevalence of playing-related symptoms, however the 12 month prevalence was 93%; hence a small minority of orchestral musicians with playing-related symptoms claimed compensation. Importantly, 58.2% of orchestral musicians in Chimenti et al.'s[64] study reported that they did not claim compensation as the injury was not bad enough to require time off, with a further 6.1% indicating that they did not do so because there was too much paperwork to complete. This is similar to the Australian workforce, wherein 57.9% of those who experienced a work-related injury but did not claim compensation stated that they had not claimed because the injury was minor and reporting the injury was too much effort.[8] Chimenti et al.[64] also reported that 10.0% of musicians who did not claim workers' compensation chose not to do so for fear of demotion, with a further 11.1% indicating that they did not want their co-workers to be aware of their injury. The fear of a claim having a negative impact on employment is not restricted to musicians, with 5.3% of Australian workers who experienced a work-related injury or illness not claiming compensation because of the negative impact it may have on their employment.[8] While the WCCs data may represent the minority of musculoskeletal conditions, they provide insight into the characteristics of arguably the most severe MSDs for musicians, and therefore those that require the most attention to reduce the burden of MSDs for musicians specifically, and to reduce the cost of WCCs for this population more generally.

3.5.3 Upper limb conditions

Similar to a recent cross-sectional study[224] of self-reported pain or injury among Australian professional orchestral musicians, the present study identified that the upper limb should be prioritised. Upper limb MSDs accounted for 50.5% of all MSDs, 65.7% of musculoskeletal diseases, and 40.4% of musculoskeletal injuries. Similarly, upper limb MSDs were the most costly MSDs, accounting for 64.1% of the total cost of MSD claims. Furthermore, upper limb MSDs resulted in the longest time lost (median 38.0 hours) of MSDs in any body region. Upper limb MSDs, therefore warrant the most attention when investigating and intervening for musicians' musculoskeletal conditions.

3.5.4 Temporal trends

While there is some evidence of a decrease in all musicians' WCCs, as well as MSD claims specifically from 2004/2005 to 2015/2016, much of the reduction for MSD claims occurred prior to the 2006/2007 financial year. This reduction may be due to changes in reporting behaviour, following the 2005 inquiry[451] into the viability of Australia's eight main symphony orchestras, where the high cost of workers' compensation insurance was identified as a threat to the orchestras' viability. As data regarding the type of musician (e.g. orchestral, opera) were not available, it was not possible to determine whether the drop in claims from 2004/2005-2006/2007 was predominantly seen in orchestral musicians. It is estimated that, based on the number of musicians employed by the orchestras[227], data from the Census of Population and Housing[58] and the estimate that only 14% of musicians are in ongoing employment[21], the majority of musicians who are eligible for workers' compensation in Australia are employed by the eight main orchestras. As such, changes in the reporting behaviour of orchestral musicians in Australia would be expected to influence the overall trends in musicians' WCCs. With the exception of a notable trough in the number of WCCs in the 2008/2009 financial year, there was little difference in the number of WCCs from 2006/2007 to 2014/2015 (with the 2015/2016 data being provisional at the time of the study). This finding is in spite of many interventions being introduced into Australian orchestras[227, 453] in response to the orchestral inquiry.[451] It is possible that Strong's[451] report and the subsequent interventions led to a change in reporting behaviour. Owing to the lack of a valid denominator, changes in the incidence of musicians' MSD claims over time could not be determined. There was little change in the number of professional musicians in Australia from 2006 to 2011[58], but an increase in the proportion of professional musicians working in a freelance or self-employed capacity from 2009 to 2016[21, 54]; which may indicate an increase in the incidence of musicians' WCCs over the study period, if the number of eligible musicians has in fact decreased.

The trough in the 2008/2009 financial year aligns with the Global Financial Crisis (GFC), which commenced in the latter half of 2008.[454] Similar to the findings of this study regarding Australian professional musicians, there was a sharp decline in MSD claims for the general working population in Canada at the time of the GFC.[455, 456] The decline in MSD claims in Canada was, however, found not to relate to changes in the size of the workforce, nor the number of hours worked.[455, 456] The authors of that study[455, 456] suggested that the decline may therefore have been due to changes in claiming behaviour owing to the instability in employment at the time. In Australia, there was no such decrease in the number nor incidence of any WCCs for the general workforce[4], however for MSDs (where time was lost) specifically there was a modest decline in the incidence of MSDs, particularly for males aged <55 years.[457] In Canada, the declines in the incidence of MSDs (where time was lost) for males were steeper than in Australia, with more modest declines also evident for females aged <55 years.[457] Unlike the temporal changes for musicians, the incidence of WCCs continued to decline for the general population[457], rather than having a sharp increase from 2008/2009 to 2009/2010 as was the case for musicians. For musicians, the GFC may have influenced the number of claims due to a potential reduction in the size of the musician workforce at this time, a reduction in the hours worked by musicians, and/or a change in claiming behaviour. Musicians' employment is often precarious, and reliant on having paying audiences. The GFC may have reduced the disposable income in the general population and was therefore likely to have influenced the number of employed musicians and/or the number of hours worked because of reduced audiences.

The instability of musical employment, particularly at this time, may have altered musicians' perceived job stability and future opportunities, and in turn a greater reluctance to claim workers' compensation. Further, the potential change in reporting behaviour in the 2008/2009 financial year may have been exaggerated by the 2005 report[451] into the viability of the orchestras.

3.5.5 Variation throughout the year

There was variation in the number of claims across the year, with the lowest number both for all claims, and for MSD claims specifically occurring in December and January. There was also some evidence of a decline in claims in April and September. A clearer reduction was observed in July, with the exception of musculoskeletal disease claims which were lower in June and increased in July. These temporal changes may relate to fewer musicians working during these months, or to a reduction in total work hours. Noteably, the months where there were fewer claims align with school holidays in Australia. While WCCs for music teachers were not included, performing musicians often engage in teaching; hence these months may reflect times when they are working less in total. The decline in musculoskeletal disease claims in June, which did not fit the overall pattern, may reflect a temporal change in claiming behaviour. As diseases are more ongoing in nature than injuries, it may be that musicians are less inclided to claim for musculoskeletal diseases when they know they will have a quieter workload in the coming weeks. Future research into changes in the occurence of MSDs, and MSD claims, with particular reference to changes in the size of the musician population and the number hours worked is recommended to further explore these temporal trends.

3.5.6 Future directions

One of the limitations of using WCCs data is that some workers are not eligible for compenstion. This is particularly true of Australian musicians where the majority are freelance or self-employed.[21] Self-employed musicians and musicians employed by the Australian Defence Force are not eligible for workers' compensation, while freelance musicians (e.g. casual) may be more reluctant to claim, given the precarious nature of their employment. The Australian Bureau of Statistics' Work-Related Injuries survey[458] provides another strategy to explore work-related injuries and illness, however data are not available for musicians specifically.[9]

To overcome some of the issues with WCCs data, findings should be triangulaged with other sources of information, such as surveys. By triangulating the findings of the WCCs data analysis presented in this chapter and those of the questionnaire survey (Chapters 4-5), some of the limitations of the WCC analysis can be overcome, resulting in a valid conclusion regarding whether there is a burden of musculoskeletal conditions in Australian university music students and professional musicians.

The findings of this study suggest that existing occupational health and safety (OHS) policies and practices for employers of musicians do not adequately address the main health problem for musicians – MSDs. As identified in the systematic review (summarised in Chapter 1, reported in full in Appendix 2.4), there is insufficient evidence to suggest that any of the previously trialed strategies to prevent and/or manage MSSs in musicians should be implemented without further evalution of their safety and effectiveness. In order to develop evidence-based recommendations for policy and practice changes in organisations that employ musicians, research should be directed towards investigating the association between modifiable factors, particularly organisational factors, and MSS outcomes. This evidence gap will be partially addressed in Chapters 8 and 9. Knowledge of the risk factors for MSS outcomes can then be used to develop interventions. If the interventions are found to be safe and effective they should then be incorporated into OHS policies and practice for the music industry, to reduce the burden of musculoskeletal conditions for professional musicians.

3.5.7 Conclusion

Musculoskeletal disorders are the most important work-related health problem for professional musicians, accounting for 69.8% of claims, and 77.8% of the cost of WCCs. In order to reduce the burden of health issues among professional musicians in Australia, research into and interventions addressing MSDs are paramount. As upper limb MSDs account for 50.5% of MSD claims, and 64.1% of the cost of MSD claims, the focus should be on upper limb MSDs, in order to most cost-effectively address the burden of MSDs for musicians.

Key findings:

- 69.8% of all musicians' WCCs were for MSDs
- 60.4% of MSD WCCs were for injuries
- 50.5% of MSD WCCs were for the upper limb
- 65.8% of musculoskeletal disease WCCs were for the upper limb
- 77.8% of the cost of all WCCs were for MSDs
- 57.6% of the cost of MSD WCCs were for injuries
- 64.1% of the cost of MSD WCCs were for upper limb conditions

The analysis of musicians' WCCs provides evidence that there is a substantial burden of musculoskeletal conditions among Australian professional musicians.

CHAPTER 4: THE PREVALENCE AND PROFILE OF MUSCULOSKELETAL SYMPTOMS AND THEIR IMPACT ON MUSICIANS

4.1 Introduction

Musculoskeletal disorders (MSDs) were identified as the most common health condition leading to musicians' workers' compensation claims (WCC), and were also the most costly type of musicians' WCC in Chapter 3. As discussed in Chapter 3, the analysis of WCCs had unavoidable limitations, including the lack of a valid denominator, only being of relevance to the minority of musicians (i.e. not self-employed musicians or musicians employed by the Australian Defence Force), and were influenced by reporting behaviour. To overcome these limitations a targeted questionnaire survey was also conducted, to support the WCCs data analysis, such that findings from the WCCs and survey data could be triangulated leading to a more accurate understanding of the burden of Australian musicians' musculoskeletal conditions.

Chapter 4 reports the burden of musculoskeletal symptoms (MSSs) for Australian university music students and professional musicians. In this chapter the prevalence and profile of MSS outcomes and their impact for university music students and professional musicians, including an analysis of subgroups, is reported.

The three questions addressed within Chapter 4 are:

1) What is the prevalence and profile of MSSs for university music students and professional musicians?,
2) Which body regions have the highest prevalence of MSSs and music-related musculoskeletal disorders[jj] (MRMDs)), across the whole sample, and various sub-groups?, and
3) Which sub-groups of musicians have the highest prevalence and ratings of MSS outcomes?.

Sub-group comparisons were conducted between students and professionals, performance and non-performance students, classical performance and non-classical performance (e.g. musical theatre, jazz, contemporary) students, employed and self-employed musicians, those employed in education and performance organisations, and for those in performance organisations the ensemble types (i.e. opera, orchestra, military band and 'other') were compared (Figure 4.1). Concerning students/ professionals, employed/ self-employed and education/ performance organisations there were musicians who fit both groups, and therefore 'both' categories were added (e.g. student only, professional only, both student and professional), as identified by the overlapping green circles in Figure 4.1.

The findings regarding the priority body regions identified in the present chapter, inform the MSS outcomes to prioritise in Chapters 8-9 (where the association between modifiable factors, and key MSS outcomes is investigated), as well as future research into the risk factors and interventions for musicians' MSSs.

[jj]Music-related musculoskeletal disorders were defined as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed"

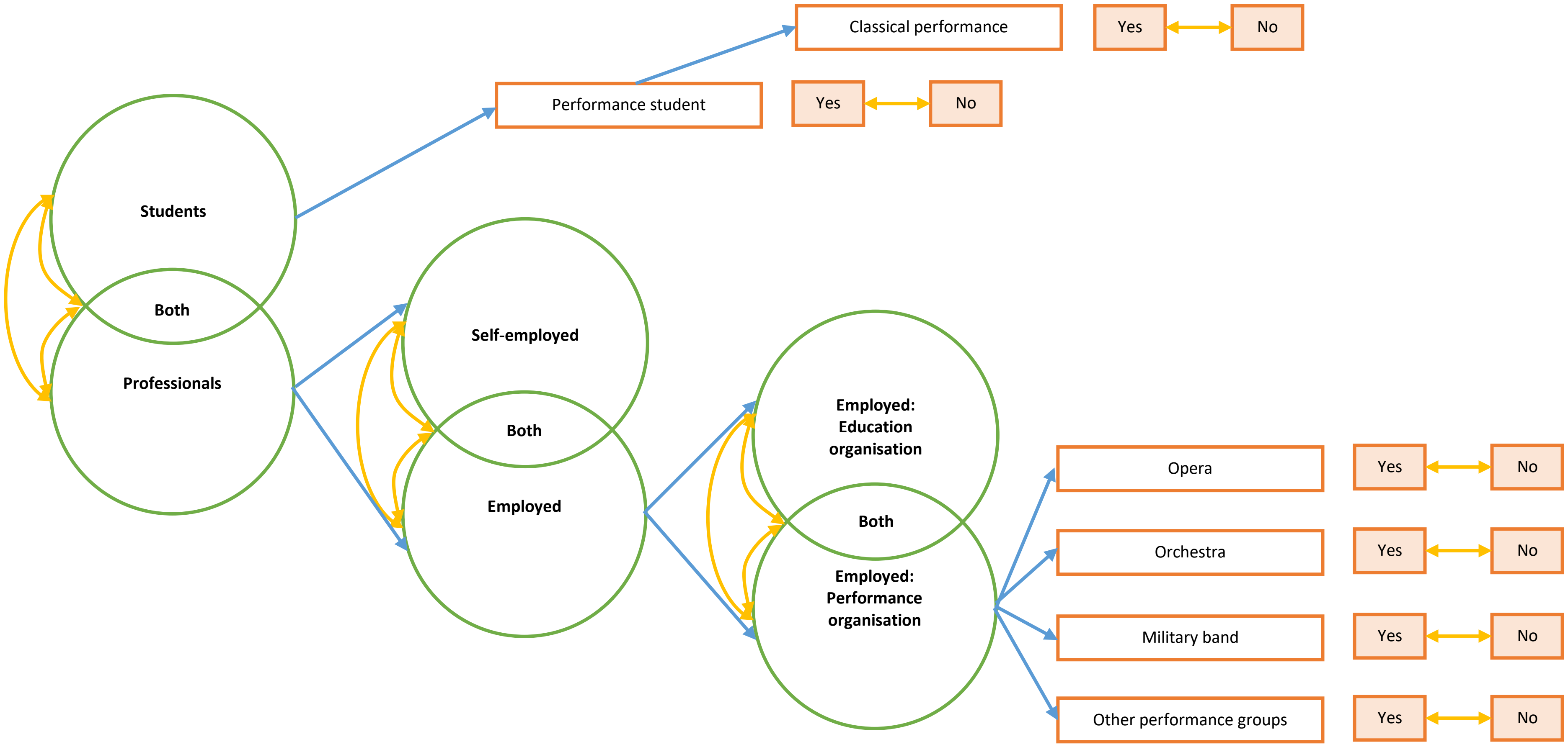


Figure 4.1: Schematic diagram of the comparisons between musician sub-groups
Notes: Blue arrows indicate sub-groups. Yellow arrows indicate comparisons. Orange rectangles represent discrete groups, and green circles indicate overlapping groups

4.2 Background

The majority of musicians experience MSSs.[48-52] A recent systematic review of university music students and professional musicians reported that the 12 month prevalence of MSSs[kk] was 86-89%.[52] Despite a large body of evidence around musicians' MSSs, the systematic mapping review of the recent[ll] literature pertaining to musicians' MSSs (Appendix 2.2) identified a number of gaps in the current evidence, including for university music students and professional musicians. These gaps remained following an update search of the literature, performed in April 2019 (Chapter 1 and Appendix 1.1). The majority of studies of professional musicians (where the genre or ensemble type was specified) have targeted orchestral musicians, while the majority of studies of university music students (where the genre or ensemble have been reported) have investigated classical or orchestral students (Chapter 1 and Appendix 2.2). This bias has left a number of other groups of musicians un- or under-investigated.[mm] These un- or under-investigated groups of musicians include professional military band and opera musicians, music teachers, and non-classical performance students. As summarised in Chapter 1 (and reported in Appendix 2.3), there are potential differences in the exposures encountered by different groups of musicians, hence the findings for one group of musicians cannot necessarily be generalised to another.

Additionally, few studies were identified in the systematic searches that compared different types of musicians (e.g. students/ professionals, different genres; Chapter 1 and Appendix 2.2). With the exception of one study[286] that compared classical and rhythmic university music students, these comparative studies have either been limited to a specific instrument (bassists[240, 261], pianists[201, 296], cellists[228], or percussionists[262]) or musicians performing in different ensemble settings within orchestras (pit, stage, or pit and stage orchestras[225]) and military bands (chorus, concert, blues, and ceremonial units).[226] There is insufficient recent evidence to prioritise research and interventions to address musculoskeletal conditions in one group of musicians over another. Identifying the musical groups with the highest prevalence and impact of MSSs would allow for priority groups to be targeted, potentially leading to the greatest reduction in the burden of MSSs for university music students and professional musicians.

Although there is evidence that the majority of university music students and professional musicians experience MSSs[52], the prevalence and profile of MSSs across all types of musicians (e.g. instruments, ensembles, genres) has not recently been investigated, and in some cases may never have previously been investigated (Chapter 1 and Appendix 2.2). The present study will also be the first to report the prevalence and profile of MSSs in opera musicians, and self-employed musicians specifically[nn], and one of few to compare musicians from different sub-groups (Chapter 1 and Appendix 2.2).

[kk]Reported as non-playing-related by Kok et al.[52]

[ll]Studies published 2007-2016

[mm]Also confirmed through an update systematic search of the literature published January 2017-April 2019

[nn]Based on the systematic mapping review (2007-2016) and update systematic search (January 2017-April 2019), and targeted searches of the literature published prior to 2007

The three questions addressed within Chapter 4 are:

1) What is the prevalence and profile of MSSs for university music students and professional musicians?,
2) Which body regions have the highest prevalence of MSSs and MRMDs, across the whole sample, and various sub-groups?, and
3) Which sub-groups of musicians have the highest prevalence of MSS outcomes, and ratings of impact?

Questions 2 and 3 are designed to inform future research into risk factors and interventions for musicians' MSS outcomes, by prioritising the MSS outcomes of interest (e.g. focusing on the body regions with the highest MSS/MRMD prevalence), and the sub-groups of musicians to target (e.g. those with the highest prevalence of MSS outcomes and ratings of impact).

4.3 Methods

Details of the methods are reported in Chapter 2, with a summary specific to Chapter 4 reported below.

The sample was drawn from university music students and professional musicians in two Australian states (Western Australia and South Australia). All musician participants were included within the present chapter. That is, both university music students (classical performance, non-classical performance and non-performance) and professional musicians (self-employed and employed, performance and education, opera, military band, orchestral and 'other' performance musicians), as defined in Chapter 2.

As reported in Chapter 2, data were collected using the Musicians' Musculoskeletal Health Questionnaire (Appendix 1.2). The MSS outcomes and methods of data collection are summarised in Table 4.1. Details of the data collection for the potential confounders in this study, as well as data coding are reported in Chapter 2.

All analyses were conducted in Stata 14.[411] Descriptive statistics were used to describe the sample, in terms of demographics and exposures, for the whole sample and sub-groups. Descriptive statistics were used to report the prevalence and profile of MSS outcomes. For dichotomous outcomes, the percentage corresponding to each of the outcomes was reported, along with 95% confidence intervals (CIs). For MSS and MRMD outcomes, the denominator was the whole sample, with the exception of where the prevalence of chronic MSSs and MRMDs was reported for symptomatic[oo] musicians only. Similarly, MSS consequences were reported using the denominator of musicians who reported MSSs in the last 12 months. Ratings of pain intensity, the emotional impact of MSS, and the daily impact of MSS were for musicians who reported MSSs in the last 7 days only, while ratings of MRMD severity were only for musicians who reported MRMDs in the last 7 days.

Unadjusted and adjusted regression analyses were conducted to compare the MSS outcomes between sub-groups of musicians (Figure 4.1). Variables included in the adjusted regression analyses are reported in Chapter 2 (Table 2.2). Regression analyses were conducted according to the methods reported in Chapter 2. The adjusted odds ratios (AORs) and adjusted beta coefficients were reported where $p<0.05$.

[oo]For chronic MSS the denominator of symptomatic musicians was those reporting MSS in the last 7 days. For chronic MRMD the denominator of symptomatic musicians was those reporting MRMD in the last 7 days.

Table 4.1: Musculoskeletal symptom outcomes and data collection tools used relevant to Chapter 4

Musculoskeletal symptom outcomes	Data collection tools used
The presence and location of MSSs in the last 12 months and 7 days	NMQ[67] modified for this study such that participants were asked whether they had experienced ache, pain or discomfort in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MSSs in the last 7 days, participants were also asked to indicate the laterality of their MSSs, and whether they had experienced their MSSs on most days for at least the last 3 months.
The presence and location of MRMDs in the last 12 months and 7 days	NMQ[67] modified to investigate MRMDs such that participants were asked whether they had experienced MRMDs in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MRMDs in the last 7 days, participants were also asked to indicate the laterality of their MRMDs, and whether they had experienced their MRMDs on most days for at least the last 3 months.
The intensity of pain on average in the last 7 days	Pain intensity on average was rated on a 11-point NRS, using the wording and anchors from the Brief Pain Inventory-Pain Intensity scale.[459]
The severity of MRMDs in the last 7 days	MRMD severity ratings at its worst and on average were rated on 11-point numeric rating scales, with the anchors from the Brief Pain Inventory-Pain Interference scale.[459] The two scales were combined and transformed to w-scores as described in Chapter 2 and Appendix 2.10.
The impact of MSSs on daily life, the emotional impact of MSSs, and level of concern regarding MSSs in the last 7 days	Ratings were made on the consequences (impact on daily life), emotional impact, and concern scales of the Brief Illness Perceptions Questionnaire[407], which uses 11-point NRSs. The scales asked about "ache, pain or discomfort" rather than "illness".
The work/ study impact of MSSs in the last 12 months	Participants were asked whether they had made changes to their work/ study in the last 12 months due to MSSs, or had taken leave from work/ study in the last 12 months due to MSSs, with these items being based on the Extended NMQ[384] and enquiring as to whether the work/ study was musical or not. Participants were also asked whether they had claimed workers' compensation for their MSSs in the last 12 months for any work, and for musical work specifically.
The health professionals consulted for MSSs in the last 12 months	Participants were asked to indicate whether they had consulted the following health professionals for their MSSs in the last 12 months: medical professionals; physiotherapists or occupational therapists; psychologists or counsellors; personal trainers, Pilates instructors or yoga instructors; chiropractors, osteopaths, massage therapists, or Bowen therapists; naturopaths or homeopaths; Alexander technique practitioners, Feldenkrais practitioners and body mapping teachers; or other health professionals
The self-management strategies used for MSSs in the last 12 months	Participants were asked to indicate the self-management strategies that they had tried for their MSSs in the last 12 months: heat or ice, medication, exercises or stretches, braces, strapping or taping, or other self-management strategies.
Discussing their MSSs with other musicians in the last 12 months	Participants were asked whether they had discussed their MSSs with other musicians in the last 12 months.
Current treatment for their MSSs	Participants were asked whether they were currently having treatment for their MSSs.

Notes: MSS: musculoskeletal symptom. NMQ: Nordic Musculoskeletal Questionnaire. MRMD: music-related musculoskeletal disorder (defined as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed"). NRS: numeric rating scale

4.4 Results

A total of 317 musicians were included in the study, 55.4% of whom were female. The median age of participants was 25 years (interquartile range 20-46). Further details of the demographic characteristics of the overall sample are reported in Table 4.2 (see Appendix 1.4 for the demographic information for each of the sub-groups).

The results for Chapter 4 are reported in three sections. The focus of Section 4.4.1 is the findings for the whole sample of musicians: that is, all university music students and professional musicians. Here the findings regarding the prevalence of MSSs and their consequences are reported. Findings relating to symptomatic body regions are covered in Section 4.4.2, where the focus is on determining priority body regions. The comparisons between sub-groups are reported in Section 4.4.3, in order to establish priority sub-groups of musicians.

Table 4.2: Demographic information for the musician sample (n=317)

	All musicians
Age in years (median, IQR)	25.0 (20.0-46.0)
Gender (%)	
Female	55.4
Male	44.3
Other	0.3
Body mass index (median, IQR)	24.3 (21.3-27.3)
Typical daily sitting time (%)	
<4 hours	20.6
4-8 hours	53.2
8+ hours	26.3
Socioeconomic status quartile[a] (%)	
1	24.1
2	24.4
3	24.4
4	27.0
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)
Hours worked in the last 7 days (median, IQR)	9.0 (0.0-20.0)
Age (year) they started their musical activities (median, IQR)	8.0 (6.0-10.0)
Years of musical activity (median, IQR)	18.0 (12.0-38.0)
Amount of musical activity in the last 7 days (%)	
0-10 hours	36.1
10-20 hours	30.1
20 or more hours	33.9
Performed in the last 12 months (%)	90.3
Performed in the last 7 days (%)	56.0
Musical biomechanical exposure in the last 12 months (%)	
Singing/ woodwind/ brass	67.8
Singing	46.2
Brass	16.9
Woodwind	26.2
Flute	12.3
Reed	17.9
Saxophone	13.6
Upper string	14.5
Hands elevated at shoulder level to play	52.5
Repetitive elbow movement to play	74.9
Repetitive finger flexion/ extension to play	92.0
Repetitive finger adduction/ abduction to play	70.4
Repetitive foot movement to play	59.1
Musical biomechanical exposure in the last 7 days (%)	
Singing/ woodwind/ brass	58.5
Singing	35.5
Brass	13.2
Woodwind	21.2
Flute	8.7
Reed	15.6
Saxophone	11.5
Upper string	13.2
Hands elevated at shoulder level to play	42.0
Repetitive elbow movement to play	64.9
Repetitive finger flexion/ extension to play	88.4
Repetitive finger adduction/ abduction to play	64.4
Repetitive foot movement to play	48.2
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)
Social support score[b] (median, IQR)	48.0 (35.0-59.0)
Psychological distress score[b] (median, IQR)	40.0 (19.0-55.0)
Psychosocial stress score[b] (median, IQR)	25.0 (12.0-30.0)

Notes: IQR: interquartile range. [a]based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]using the W-scores derived from Rasch analyses (Appendices 2.11-2.14). For demographic information for the sub-groups, refer to Appendix 1.4.

4.4.1 Overall prevalence and consequences of musculoskeletal symptoms

The vast majority (90.1%) of musicians reported experiencing MSSs overall (i.e. in any body region) in the last 12 months, and in the last 7 days (72.1%). Of the musicians who reported MSSs in the last 7 days, 49.3% reported chronic[pp] MSSs.

In the last 12 months, 57.1% of all musicians in the study reported experiencing MRMDs: that is, MSSs that impaired their musical activity. Of the 40.5% of musicians who reported MRMDs in the last 7 days, 60.5% reported that they had experienced MRMDs on most days for at least the last 3-month period (i.e. chronic MRMDs).

For musicians reporting MSSs in the last 12 month period, 15.8% made changes to work or study (11.1% specific to music), and 21.5% took leave from work or study due to their MSSs in the last 12 months (15.7% specific to music; Figure 4.2). Nine musicians (3.7% of symptomatic musicians who worked in the last 12 months) reported claiming workers' compensation in the last 12 months for their MSSs; however only five of these (3.1% of those who worked as musicians in the last 12 months) were for musical work. The denominators for the reported percentages for WCCs included those who were self-employed or worked for the Australian Defence Force and were therefore ineligible for workers' compensation. Therefore, the true percentage of eligible musicians may in fact be higher.

The majority (65.1%) of musicians who reported MSSs in the last 12 months consulted a health professional to manage their MSSs during this time-period. The most commonly consulted professionals in the last 12 months were medical professionals (38.9%), physiotherapists or occupational therapists (34.7%), and chiropractors, osteopaths, massage therapists or Bowen therapists (26.8%; Figure 4.2). These same three types of health professional were the most commonly consulted across most sub-groups of musicians (Figure 4.3). Of those reporting MSSs in the last 7 days, 33.5% were currently having treatment for their MSSs.

When health professionals were grouped together as "conventional" (medical professionals, physiotherapists, occupational therapists, psychologists and counsellors) or "alternative" (personal trainers, Pilates instructors, yoga instructors, chiropractors, osteopaths, massage therapists, Bowen therapists, naturopaths, homeopaths, Alexander technique practitioners, Feldenkrais practitioners, and body mapping teachers), 55.5% of those with MSSs in the last 12 month period saw a conventional professional, and 38.5% an alternative professional. Of those who saw an alternative professional, 70.6% also saw a conventional professional. Of the musicians who only consulted alternative professionals, 25 (83.3%) saw a chiropractor, osteopath, massage therapist or Bowen therapist, six (20.0%) saw personal trainer, or a yoga or Pilates instructor, and one (3.3%) did Alexander technique, Feldenkrais, or body mapping.

Self-management strategies were used by 85.7% of musicians who reported MSSs in the last 12 months, most commonly exercises or stretches (78.9% Figure 4.2). This pattern was consistent across most sub-groups of musicians (Figure 4.4). Of the musicians who reported MSSs in the last 12 months, 26.7% reported speaking to other musicians to help manage their MSSs.

Of the musicians who reported MSSs in the last 7 days, 96.4% felt that their MSSs impacted on their lives in some way, 80.5% were impacted emotionally, and 91.4% were concerned about their MSSs.[qq]

[pp]Musculoskeletal symptoms present on most days for at least the last 3 months

[qq]Indicated by a rating of at least one for the respective 11-point numeric rating scales during the last 7 days. Ratings were made on the scales from the Brief Illness Perception Questionnaire.[407]

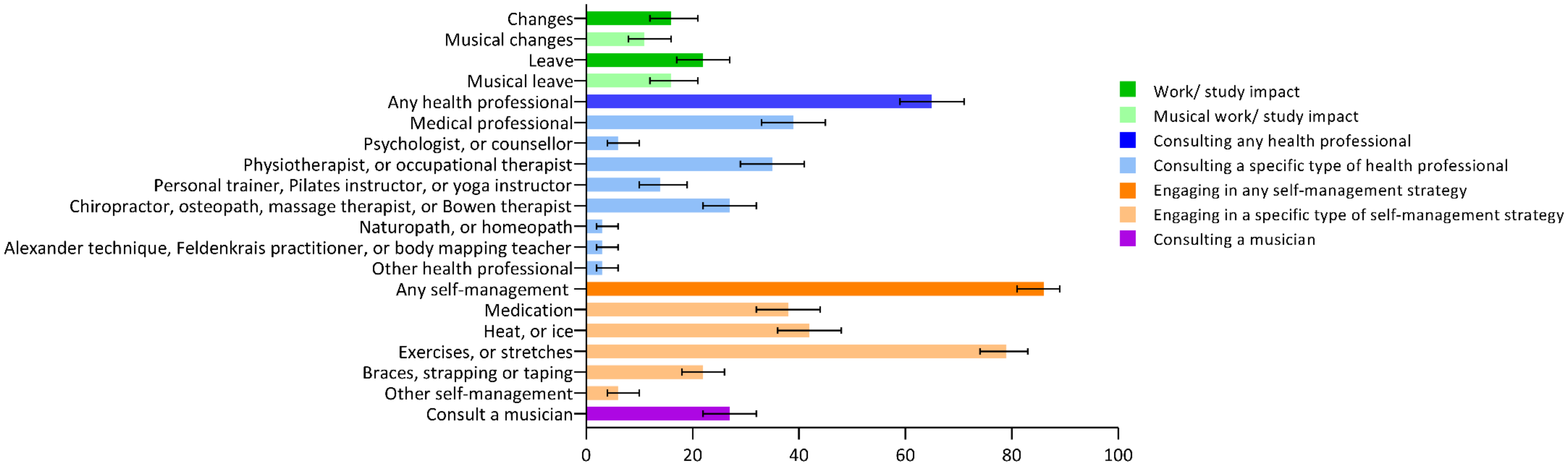


Figure 4.2: Percentage of symptomatic musicians who experienced consequences in the last 12 months
Note: 95% confidence intervals are reported

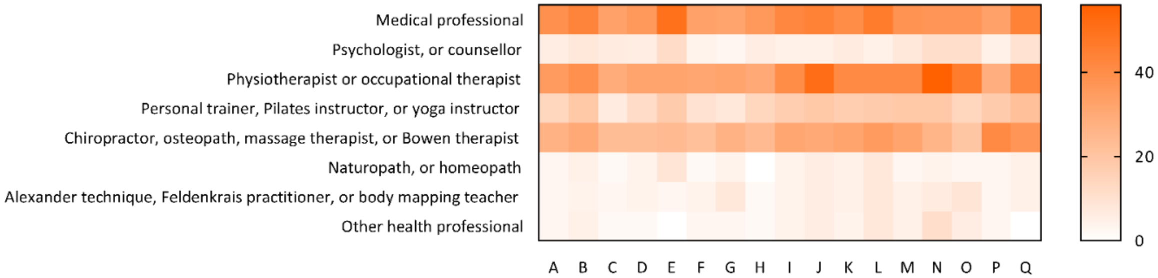


Figure 4.3: Heat map of the types of health professionals consulted by musicians for musculoskeletal symptoms in the last 12 months for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups.

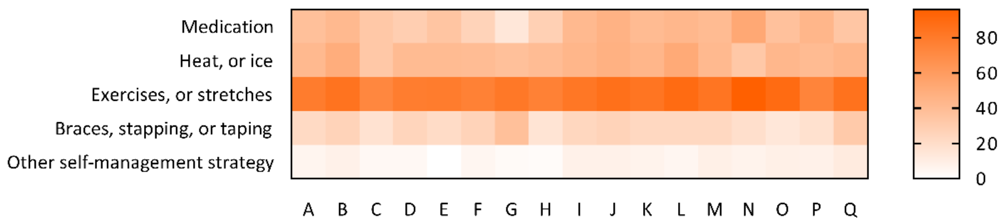


Figure 4.4: Heat map of the types of self-management strategies used by musicians to manage musculoskeletal symptoms in the last 12 months for all musicians, and sub-groups of musicians

Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups.

Question 1: What is the prevalence and profile of MSSs for university music students and professional musicians as a whole?

Key points

- 90.1% of musicians reported MSSs in the last 12 months
- 72.1% of musicians reported MSSs in the last 7 days
- 49.3% of those with MSSs in the last 7 days reported chronic MSSs
- 57.1% of musicians reported MRMDs in the last 12 months
- 40.5% of musicians reported MRMDs in the last 7 days
- 24.7% of those with MRMDs in the last 7 days reported chronic MRMDs
- Of those with MSSs in the last 12 months:
    - 21.5% took leave from work/ study due to MSSs,
    - 26.7% consulted other musicians about their MSSs,
    - 65.1% consulted a health professional (most commonly medical professionals (38.9%)) for their MSSs, and
    - 85.7% engaged in self-management strategies (most commonly exercises/ stretches (78.9%)) for their MSSs.
- Of those with MSSs in the last 7 days:
    - 96.4% felt that their MSSs had impacted their lives,
    - 91.4% were concerned about their MSSs, and
    - 80.5% felt that their MSSs had impacted them emotionally.

4.4.2 Priority body regions

In Section 4.4.2, the prevalence proportions of MSSs and MRMDs in the last 12 month and 7 day periods in specific body regions are reported. The prevalence was determined for the whole sample, various sub-groups of musicians reported Figure 4.1, and by gender. The prevalence for the sub-groups is represented in heat maps (Figures 4.6, 4.8, 4.10, 4.12, 4.14, and 4.16), with the prevalence estimates and 95% CIs reported in full in Appendix 1.4. Findings were reported in this manner because the main objectives of the section were to determine the priority body regions for further research (i.e. those with the highest prevalence), and to assess whether these affected body regions were consistent across the various sub-groups of musicians. Analysis of the difference in prevalence estimates between the sub-groups of musicians will be addressed in Section 4.4.3.

4.4.2.1 Prevalence of musculoskeletal symptoms

For the whole sample, the majority of musicians reported MSSs in the neck (63.1%), shoulder (61.8%), lower back (54.2%) and wrist/ hand (50.8%) regions in the last 12 months, with a relatively high prevalence of 44.2% for the upper back region. There was a clear distinction between the prevalence estimates for these five body regions and the remaining body regions (Figure 4.5). The top five regions were consistent across most sub-groups of musicians, apart from some minor variations for classical performance students, professional orchestral musicians and professional opera musicians (Figure 4.6).

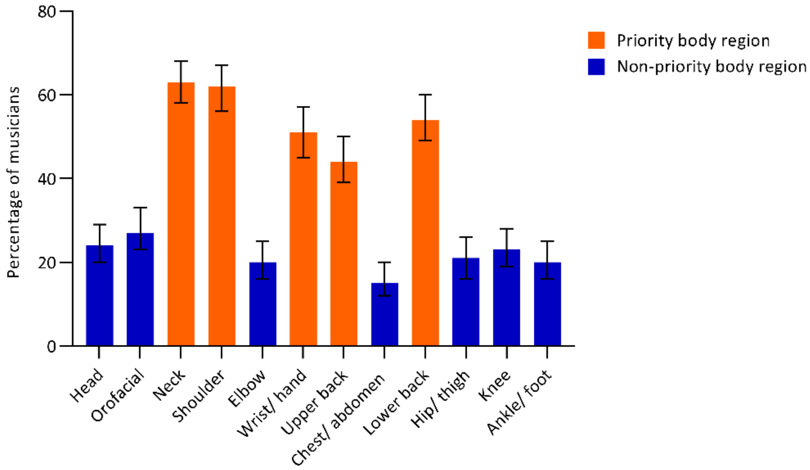


Figure 4.5: 12 month prevalence of musicians' musculoskeletal symptoms by body region
Note: 95% confidence intervals reported.

Figure 4.6: Heat map of the 12 month prevalence of musicians' musculoskeletal symptoms across each of the body regions for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

As with the 12 month prevalence of MSSs, the most commonly affected body regions for the last 7 day period were the shoulder (38.6%), neck (37.7%), lower back (36.0%), wrist/ hand (29.9%), and upper back (26.9%) regions (Figure 4.7). These five priority regions were the top five body regions for most sub-groups of musicians, apart from some minor variations for professional orchestral and opera musicians (Figure 4.8).

Regarding the laterality of MSSs in the last 7 days, there were no statistically significant differences in prevalence proportions between left and right sides for any of the investigated body regions (Figure 4.9). Consistent with the findings reported above, when considering the laterality of MSSs, the top 10 regions were the neck, shoulders, wrist/ hand, upper back and lower back for both sides, for musicians overall and most of the sub-groups (Figure 4.10).

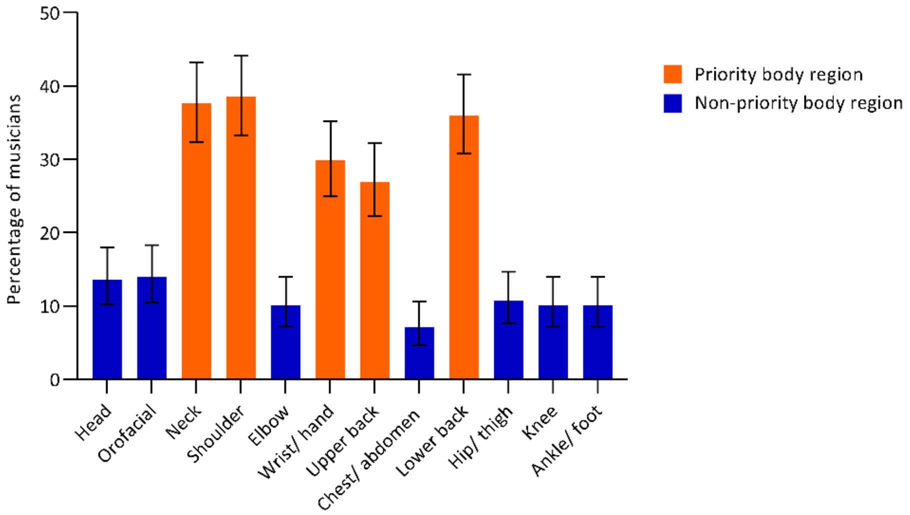


Figure 4.7: 7 day prevalence of musicians' musculoskeletal symptoms by body region
Notes: 95% confidence intervals reported.

Figure 4.8: Heat map of the 7 day prevalence of musicians' musculoskeletal symptoms across each of the body region for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

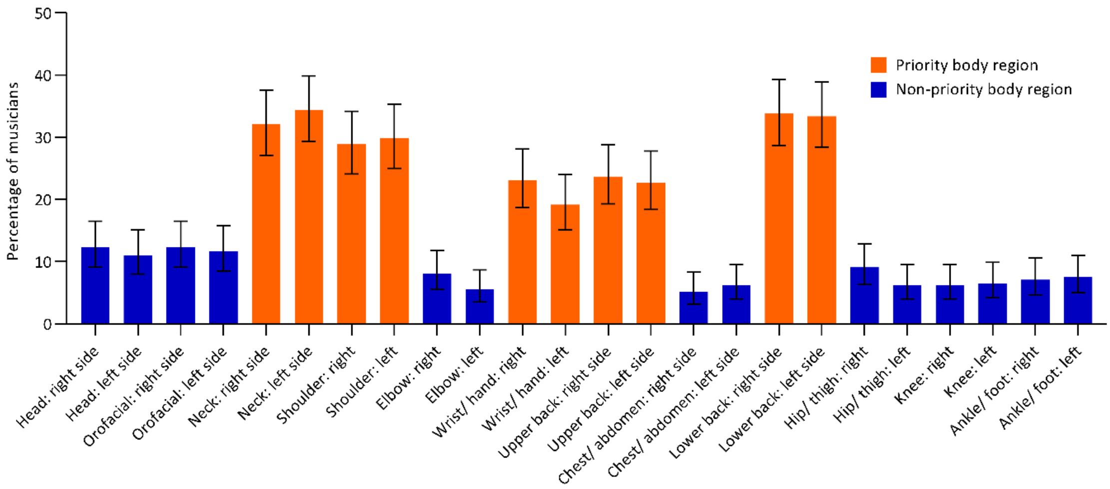


Figure 4.9: 7 day prevalence of musicians' musculoskeletal symptoms by left and right body region
Note: 95% confidence intervals reported

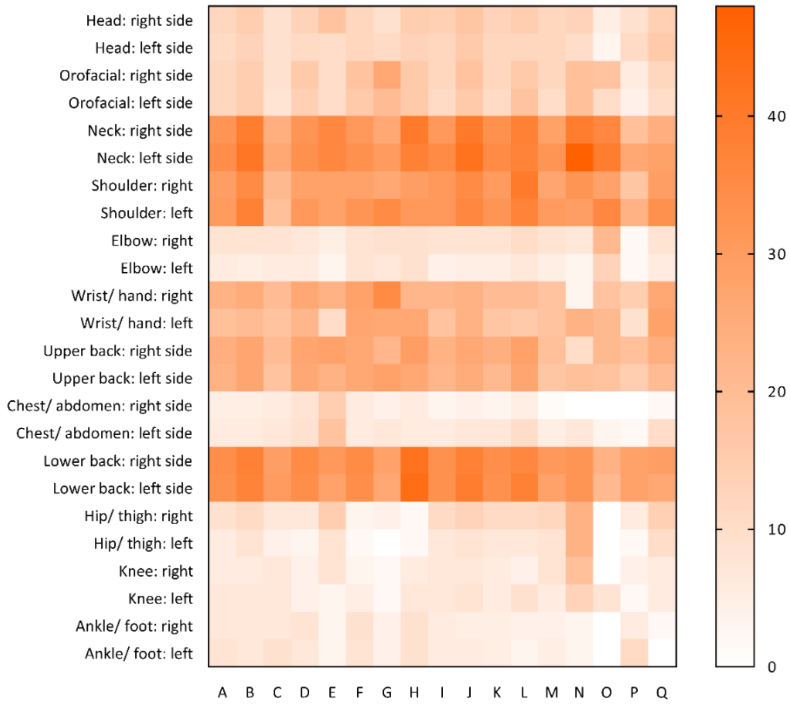


Figure 4.10: Heat map of the 7 day prevalence of musicians' musculoskeletal symptoms by left and right body region for all musicians, and sub-groups of musicians

Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

4.4.2.2 Prevalence of music-related musculoskeletal disorders

For MRMDs in the last 12 months, the prevalence was highest in the shoulder (36.7%), neck (36.0%), wrist/ hand (31.8%), lower back (28.2%), and upper back (27.6%) regions (Figure 4.11), matching the regions most commonly affected by MSSs in the last 12 months. These five regions were again in the top five for most sub-groups of musicians (Figure 4.12).

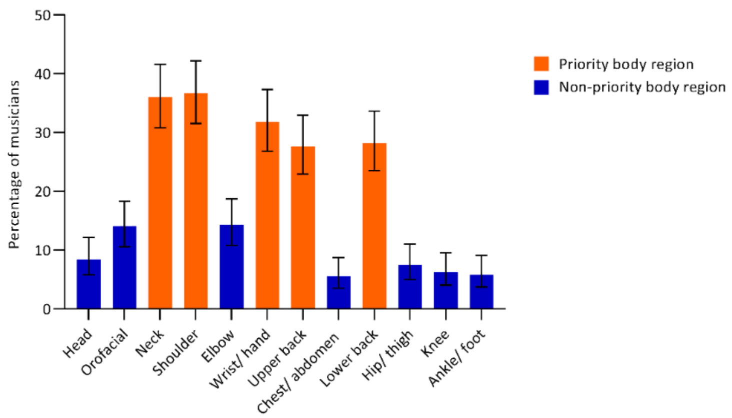


Figure 4.11: 12 month prevalence of music-related musculoskeletal disorders, by body region

Note: 95% confidence intervals reported

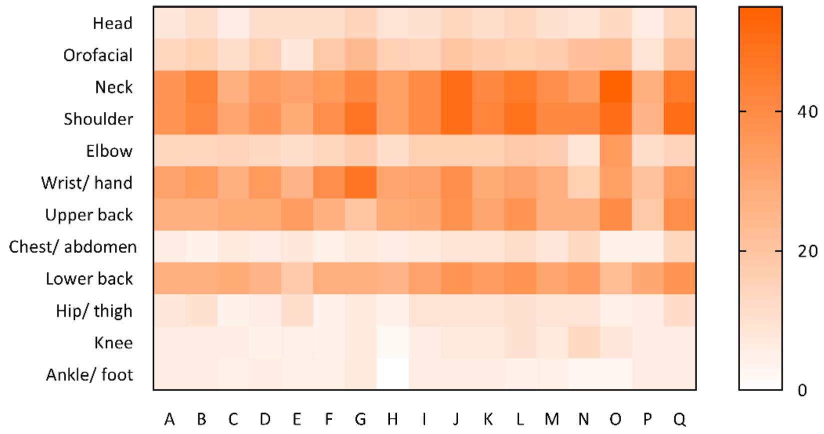


Figure 4.12: Heat map of the 12 month prevalence of music-related musculoskeletal disorders across each of the body regions for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

As with other prevalence outcomes, the most commonly affected MRMDs areas in the last 7 days were the shoulder (23.4%), neck (20.5%), wrist/ hand (18.8%), upper back (17.9%), and lower back (17.2%) regions (Figure 4.13), with a high degree of consistency in the top five regions for most of the sub-groups (Figure 4.14).

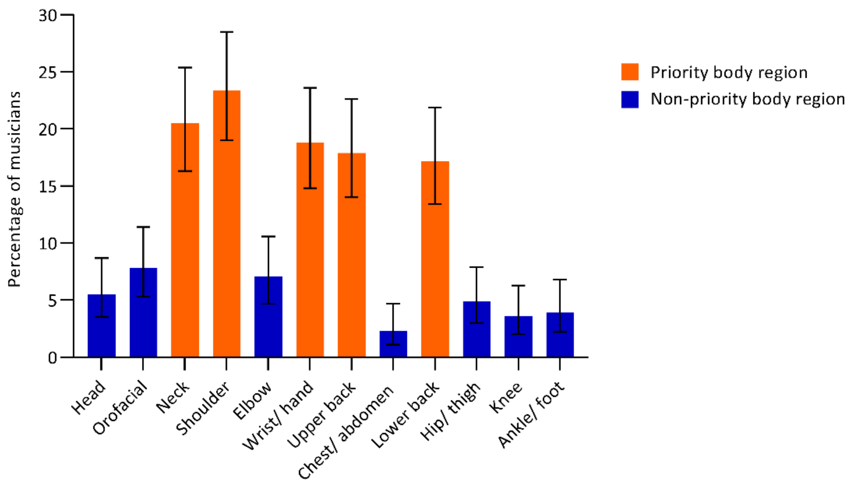


Figure 4.13: 7 day prevalence of music-related musculoskeletal disorders, by body region
Note: 95% confidence intervals reported

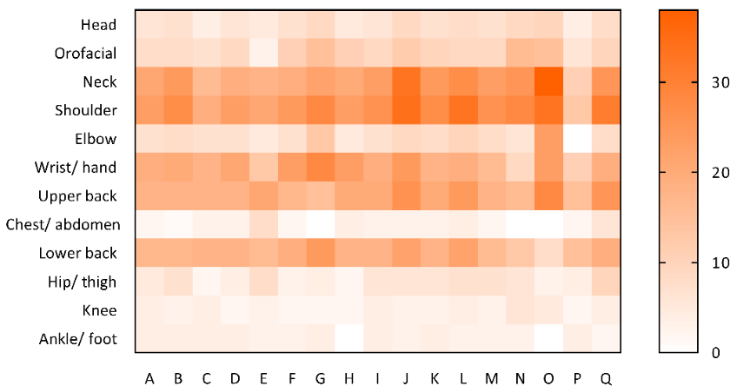


Figure 4.14: Heat map of the 7 day prevalence of music-related musculoskeletal disorders across each of the body regions for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

The top 10 body regions affected by MRMDs when the laterality of MRMDs in the last 7 days was considered, was similar to the outcomes reported above (Figure 4.15), although there were more inconsistencies compared with the priorities when considering either side (Figure 4.16). Deviations from the 'top 10' were reported for classical performance students, professional orchestral, opera and military band musicians. There were no statistically significant differences between the prevalence of MRMDs in the left and right sides, for any of the body regions (Figure 4.15).

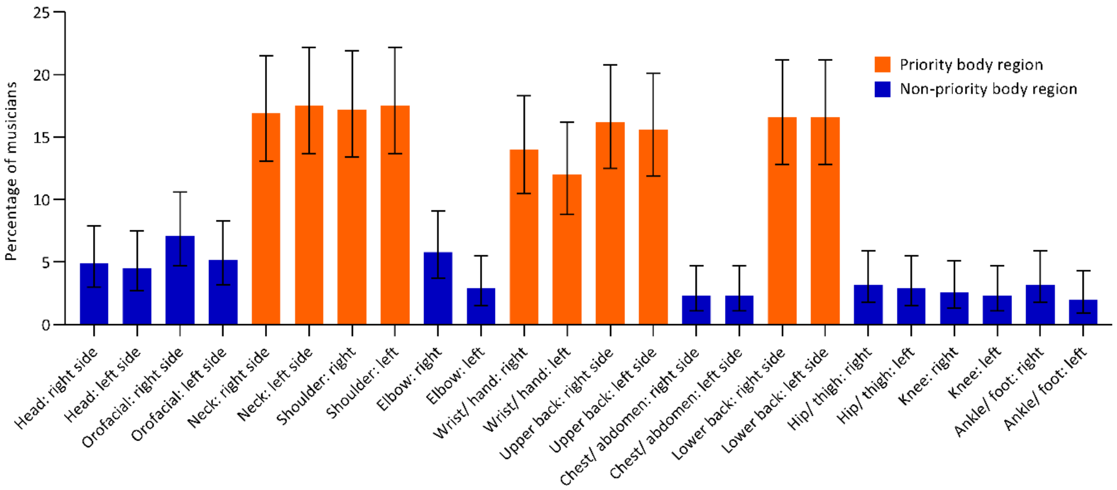


Figure 4.15: 7 day prevalence of music-related musculoskeletal disorders by left and right body region
Note: 95% confidence intervals reported

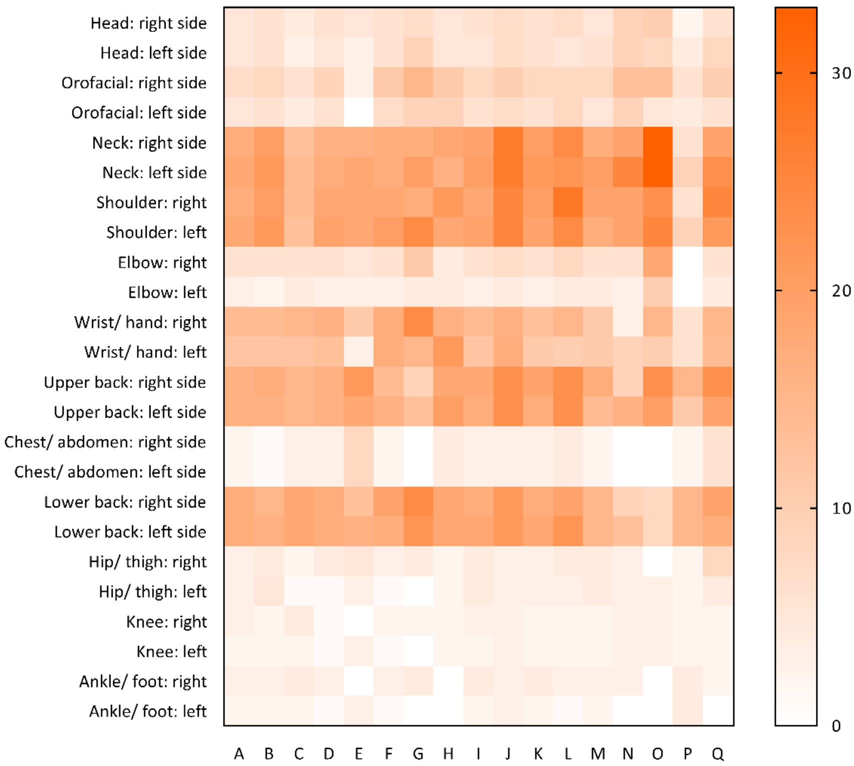


Figure 4.16: Heat map of the 7 day prevalence of music-related musculoskeletal disorders across each of the body regions by laterality for all musicians, and sub-groups of musicians
Notes: A: all musicians, B: female musicians, C: male musicians, D: student musicians, E: non-performance students, F: performance students, G: classical performance students, H: non-classical performance students, I: professional musicians, J: self-employed musicians, K: employed musicians, L: musicians employed by education organisations, M: musicians employed by performance organisations, N: musicians employed by opera companies, O: musicians employed by orchestras, P: musicians employed by military bands, Q: musicians employed by 'other' performance groups

Question 2: what are the priority body regions for interventions, across the whole sample, and various sub-groups?
Key points:

- There was consistent evidence that the most commonly affected regions for MSSs and MRMDs over the last 12 month and 7 day periods were the upper back, lower back, neck, shoulder, and wrist/ hand overall, and for most sub-groups.
- Some sub-groups of musicians had additional body regions that may be of importance in future research. For instance,
  - the orofacial region for classical performance students, professional opera musicians and 'other' professional performance musicians,
  - the elbow region for professional orchestral musicians, and
  - the hip/ thigh region for professional opera musicians.

4.4.3 Priority sub-groups of musicians

In this section, the differences in the prevalence and profile of MSSs between the sub-groups of musicians (Figure 4.1) is explored. The focus of Section 4.4.3 relates to MSS outcomes overall (i.e. in any body region), including ratings and the proportion of musicians reporting various MSS consequences. Comparisons of the prevalence of MSSs and MRMDs in specific body regions follow in order to infer the body regions driving the overall differences between groups. Given the small number of participants in some cells, comparisons were first made between the groups for four main combined body regions:

(i) the head/ orofacial region,
(ii) the upper limb region (shoulder, elbow, and wrist/ hand),
(iii) the neck/ trunk region (neck, upper back, lower back, and chest/ abdomen), and
(iv) lower limb regions (hip/ thigh, knee, and ankle/ foot).

These comparisons were followed by comparisons specifically for the five priority body regions identified in Section 4.4.2 (i.e. the shoulder, wrist/ hand, neck, upper back and lower back regions). Given there were no significant differences in symptom laterality (Section 4.4.2); comparisons were only made for whether MSSs or MRMDs were experienced on either side of the body.

The overall patterns in the comparisons between musician sub-groups are reported in Tables 4.3-4.5. Table 4.3 summarises the comparisons in MSS/MRMD outcomes overall (i.e. in any body region), Table 4.4 the comparisons in MSS outcomes by body region, and Table 4.5 the comparisons in MRMD outcomes by body region. In the three tables, orange up arrows (↑) indicate a significant difference ($p<0.05$) between the groups, where the adjusted odds ratio (AOR) is >1, or the adjusted beta coefficient is >0. The blue down arrows (↓) indicate a significant difference ($p<0.05$) between the groups, where the adjusted odds ratio is <1, or the adjusted beta coefficient is <0

The most consistent pattern that was identified indicated that professional musicians who were both self-employed and employed had a higher MSS/MRMD prevalence than musicians who were employed only, with some indication that self-employed (only) musicians had a higher prevalence than employed (only) musicians (Tables 4.3-4.5).

In the following sections, each of the sub-group comparisons are reported in turn. Here the effect size and p-values are only reported where there is a significant difference ($p<0.05$) between groups after adjusting for confounders, and is reported as the AOR or adjusted beta coefficient (as appropriate), along with a 95% CIs. Appendix 1.4 reports all findings, including the unadjusted analyses, where $p<0.10$.

Table 4.3: Summary of the significant (p<0.05) differences between sub-groups of musicians in the overall musculoskeletal symptoms outcomes (i.e. in any body region)

	Student/ professionals			Students		Professionals			Employed			Employed performance			
	Professionals only compared with students only[a]	Both compared with professionals only[a]	Both compared with students only[a]	Performance students compared with non-performance students[a]	Classical performance students compared with non-classical performance students[a]	Employed only compared with self-employed only[a]	Both compared with self-employed only[a]	Both compared with employed only[a]	Education employer only compared with performance employer only[a]	Both compared with performance employer only[a]	Both compared with education employer only[a]	Orchestral compared with non-orchestral performance employer[a]	Opera compared with non-opera performance employer[a]	Military band compared with non-military band employer[a]	Other[b] compared with non-other employer[a]
Musculoskeletal symptoms															
Last 12 months		↓													
Last 7 days						↓									
Moderate-severe pain[d]	↓		↑												↑
Music-related musculoskeletal disorders															
12 months				↑				↑							
7 days						↓		↑						↓	
Chronic[c]		↑													
MRMD severity[e]	↓	↑			↓										
Consequences of musculoskeletal symptoms															
General impact[d]															
Emotional impact[d]								↑						↓	
Leave from work/ study[f]					↑										
Leave from musical work/ study[f]					↑										
Any health professional[f]				↓				↑							
Any self-management[f]				↓											
Consult a musicians[f]			↑						↓	↓				↓	↑
Current treatment[d]			↑					↑						↓	

Notes: MRMD: music-related musculoskeletal disorder. Orange up arrows (↑) indicate an adjusted odds ratio >1 or adjusted beta coefficient (for ratings) of >0. Blue down arrows (↓) indicate an adjusted odds ratio <1 or adjusted beta coefficient (for ratings) of <0. [a]indicates the reference group in the analysis. [b]refers to performance organisations that were not classified as orchestral, opera, or military band. [c]chronic refers to musculoskeletal symptoms or music-related musculoskeletal disorders (depending on the outcome) experienced on most days for at least the last 3 months. [d]for those reporting musculoskeletal symptoms in the last 7 days. [e]for those reporting music-related musculoskeletal disorders in the last 7 days. [f]for those reporting musculoskeletal symptoms in the last 12 months

Table 4.4: Summary of the significant (p<0.05) differences between sub-groups of musicians in the musculoskeletal symptoms prevalence, by body region

	Student/ professionals			Students		Professionals			Employed			Employed performance			
	Professionals only compared with students only[a]	Both compared with professionals only[a]	Both compared with students only[a]	Performance students compared with non-performance students[a]	Classical performance students compared with non-classical performance students[a]	Employed only compared with self-employed only[a]	Both compared with self-employed only[a]	Both compared with employed only[a]	Education employer only compared with performance employer only[a]	Both compared with performance employer only[a]	Both compared with education employer only[a]	Orchestral compared with non-orchestral performance employer[a]	Opera compared with non-opera performance employer[a]	Military band compared with non-military band employer[a]	Other[b] compared with non-other employer[a]
Musculoskeletal symptoms															
Last 12 months															
Combined regions															
Upper limb												↑			
Lower limb												↓			
Priority regions															
Neck							↑	↑							
Shoulder												↑			
Wrist/ hand												↑		↓	
Upper back					↑		↑								
Lower back					↑										
Last 7 days															
Combined regions															
Head/ orofacial						↓		↑					↑		
Neck/ trunk	↑		↓												
Lower limb												↓			
Priority Regions															
Neck								↑					↑		
Wrist/ hand			↑												

Notes: Orange up arrows (↑) indicate an adjusted odds ratio >1. Blue down arrows (↓) indicate an adjusted odds ratio <1. [a]indicates the reference group in the analysis. [b]refers to performance organisations that were not classified as orchestral, opera, or military band.

Table 4.5: Summary of the significant (p<0.05) differences between sub-groups of musicians in the music-related musculoskeletal disorder prevalence, by body region

	Student/ professionals			Students		Professionals			Employed			Employed performance			
	Professionals only compared with students only[a]	Both compared with professionals only[a]	Both compared with students only[a]	Performance students compared with non-performance students[a]	Classical performance students compared with non-classical performance students[a]	Employed only compared with self-employed only[a]	Both compared with self-employed only[a]	Both compared with employed only[a]	Education employer only compared with performance employer only[a]	Both compared with performance employer only[a]	Both compared with education employer only[a]	Orchestral compared with non-orchestral performance employer[a]	Opera compared with non-opera performance employer[a]	Military band compared with non-military band employer[a]	Other[b] compared with non-other employer[a]
Music-related musculoskeletal disorders															
12 months															
Combined regions															
Head/ orofacial												↑		↓	
Upper limb				↑		↓		↑							
Neck/ trunk								↑							
Priority regions															
Neck							↑	↑							
Shoulder								↑							
Wrist/ hand			↑			↓									
Upper back								↑						↓	↑
7 days															
Combined regions															
Upper limb								↑							
Neck/ trunk						↓									
Lower limb															↑
Priority regions															
Neck								↑					↑		
Wrist/ hand			↑												
Upper back															↑

Notes: Orange up arrows (↑) indicate an adjusted odds ratio >1. Blue down arrows (↓) indicate an adjusted odds ratio <1. [a]indicates the reference group in the analysis. [b]refers to performance organisations that were not classified as orchestral, opera, or military band.

4.4.3.1 University music students compared with professional musicians

To compare the MSS outcomes for university music students and professional musicians, three groups were formed: those who were students only (n=92), professionals only (n=151), and both students and professionals (n=74; referred to henceforth as 'both'). Details of the demographics of the three groups are reported in Appendix 1.4.

After adjusting for confounders, musicians in the 'both' group reported a lower 12 month prevalence of MSSs overall (i.e. in any body region; AOR 0.230, 95% CI 0.053-0.996, p=0.049) compared with professionals only. There were no significant differences between these two groups regarding the 12 month prevalence of MSSs in any of the combined, nor priority regions, suggesting that this difference does not appear to be driven by MSSs in a specific body region. In contrast, the 'both' group also had a higher prevalence of chronic MRMDs (AOR 2.558, 95% CI 1.092-5.992, p=0.031), compared with professionals only. There were no significant differences in the MRMD outcomes by body regions.

For comparisons between students only and those in the 'both' group, the most consistent differences were for the wrist/ hand region. Compared with the students only group, musicians in the 'both' group reported a higher prevalence of MSSs in the last 7 days (AOR 3.202, 95% CI 1.255-8.168, p=0.015), and MRMDs in both the last 12 months (AOR 2.771, 95% CI 1.123-6.840, p=0.027) and 7 days (AOR 3.071, 95% CI 1.053-8.959, p=0.040). Musicians who were professionals only reported a higher 7 day prevalence of neck/ trunk MSSs compared with students only (AOR 2.555, 95% CI 1.085-6.016, p=0.032), and musicians who were both students and professionals (AOR 2.326, 95% CI 1.013-5.319, p=0.046).

There were differences in the proportion of symptomatic musicians who reported pain intensity on average that was classified as moderate-severe. A lower proportion of symptomatic professional musicians reported moderate-severe pain than student musicians (AOR 0.158, 95% CI 0.036-0.694, p=0.015), and symptomatic musicians who were 'both' students and professionals had a higher prevalence of moderate-severe pain than students only (AOR 5.145, 95% CI 1.437-18.421, p=0.012).

There were also differences between the three groups for the severity of their MRMDs.[rr] Professional musicians reported lower MRMD severity w-scores compared with student musicians (adjusted beta coefficient -23.540, 95% CI -43.244- -3.835, p=0.020), while musicians classified as 'both' reported higher MRMD severity w-scores than professional musicians (adjusted beta coefficients 25.081, 95% CI 7.854-42.308, p=0.005). There were no differences between the three groups of musicians regarding the emotional impact of MSSs and the daily impact of MSSs.

A higher proportion of symptomatic musicians classified as 'both' reported consulting other musicians (AOR 4.527, 95% CI 1.578-12.985, p=0.005) and engaging in current treatment (AOR 4.105, 95% CI 1.418-11.886, p=0.009) compared with professionals.

4.4.3.2 University performance students compared with non-performance music students

A total of 122 performance students, and 40 non-performance students were included in the present analysis (see Appendix 1.4 for demographic characteristics). There were no significant differences in the MSS prevalence or ratings between performance and non-performance students. However, performance students reported a higher 12 month prevalence of MRMDs overall (AOR 2.338, 95% 1.053-5.188, p=0.037), which may be driven by a higher 12 month prevalence of MRMDs in the upper limb region as well (AOR 2.343, 95% CI 1.003-5.477,

[rr] Among musicians who reported music-related musculoskeletal disorders in the last 7 days

p=0.049). The proportion of symptomatic performance students who consulted a health professional (AOR 0.293, 95% CI 0.106-0.814, p=0.019) and engaged in self-management strategies (AOR 0.125, 95% CI 0.023-0.663, p=0.015) was lower than that of non-performance students.

4.4.3.3 University classical performance students compared with non-classical performance students

Classical performance (n=46) and non-classical (jazz/ popular/ contemporary) performance students (n=56) were compared in this section [ss] (see Appendix 1.4 for demographic characteristics). There were no statistically significant differences between the two groups in any of the MSS or MRMD outcomes overall (i.e. in any body region). By body region, non-classical performance students reported a higher 12 month prevalence of upper back and lower back MSSs (AOR 2.372, 95% CI 1.022-5.507, p=0.044, and AOR 2.341, 95% CI 1.006-5.448, p=0.048), respectively) compared with classical performance students, although these differences in specific body regions do not lead to an overall difference in MSS prevalence.

Non-classical performance students reported lower MRMD severity w-scores than classical performance students did (adjusted beta coefficient -17.296, 95% CI -30.265- -4.327, p=0.010). Regarding the other consequences of MSSs, the only significant difference between symptomatic musicians in the classical and non-classical performance student groups were for leave from work or study. A higher proportion of symptomatic non-classical performance students took leave from work or study in the last 12 months for their MSSs, compared with classical performance students (AOR 7.073, 95% CI 1.405-35.603, p=0.018); this pattern was also observed for leave from musical work or study specifically (AOR 10.513, 95% CI 1.440-76.756, p=0.020).

4.4.3.4 Self-employed professional musicians compared with employed professional musicians

For comparisons of self-employed and employed professional musicians, three groups were formed: self-employed only (n=45), employed only (n=87), and those who were both self-employed and employed (n=96; see Appendix 1.4 for demographic characteristics of the groups).

Musicians who were employed (only) had a lower 7 day prevalence of both MSSs and MRMDs, compared with those were self-employed (only; Table 4.6). By body region, these differences may relate in a lower prevalence proportions for head/orofacial MSSs and of trunk MRMDs in the last 7 days (Table 4.6). Musicians who were classified as both self-employed and employed reported a higher 12 month and 7 day prevalence of MRMDs compared with those who were employed only; a difference most likely driven by the higher MRMDs prevalence proportions for a number of upper limb and neck/ trunk regions (Table 4.6).

The only differences in the ratings across the three groups was for the emotional impact of MSSs. Compared with symptomatic employed musicians, symptomatic musicians classified as 'both' (employed and self-employed) reported higher ratings of the emotional impact of their MSSs (adjusted beta coefficient 0.787, 95% CI 0.120-1.454, p=0.021). A higher proportion of symptomatic musicians classified as 'both' reported seeing a health professional in the last 12 months for their MSSs (AOR 2.393, 95% CI 1.181-4.851, p=0.015) and undergoing current treatment (AOR 2.206, 95% CI 1.048-4.643, p=0.037), compared with employed musicians.

[ss] The performance type (e.g. classical) could not be determined for 20 musicians, and were subsequently excluded from this analysis.

Table 4.6: Adjusted odds ratios (95% confidence intervals) for the significant differences (p<0.05) in the comparison musculoskeletal symptoms and music-related musculoskeletal disorder prevalence between the self-employed, employed, and 'both' groups (i.e. both self-employed and employed)

	Employed only compared with self-employed only[a]	Both compared with self-employed only[a]	Both compared with employed only[a]
Musculoskeletal symptoms			
Last 12 months			
Priority regions			
Neck		3.747 (1.235-11.362), p=0.020*	2.396 (1.167-4.922), p=0.017*
Upper back		3.271 (1.012-10.570), p=0.048*	
Last 7 days			
Overall	0.198 (0.050-0.782), p=0.021*		
Combined regions			
Head/ orofacial	0.280 (0.082-0.952), p=0.042*		2.765 (1.232-6.207), p=0.014*
Priority regions			
Neck			2.177 (1.126-4.208), p=0.021*
Music-related musculoskeletal disorders			
Last 12 months			
Overall			2.153 (1.108-4.186), p=0.024*
Combined regions			
Upper limb	0.252 (0.087-0.732), p=0.011*		2.598 (1.306-5.167), p=0.006**
Neck/ trunk			2.220 (1.212-4.066), p=0.010*
Priority regions			
Neck			2.973 (1.460-6.055), p=0.003**
Shoulder			2.984 (1.490-5.976), p=0.002**
Wrist/ hand	0.288 (0.104-0.798), p=0.017*		
Upper back			2.677 (1.298-5.518), p=0.008**
Last 7 days			
Overall	0.297 (0.105-0.837), p=0.022*		2.382 (1.198-4.734), p=0.013*
Combined regions			
Upper limb			2.264 (1.062-4.826), p=0.034*
Neck/ trunk	0.340 (0.117-0.998), p=0.047*		2.447 (1.197-5.004), p=0.014*
Priority regions			
Neck			2.491 (1.055-5.884), p=0.037*

Notes: Orange text indicates a statistically significant (p<0.05) adjusted odds ratio of >1. Blue text indicates a statistically significant (p<0.05) adjusted odds ratio of <1. [a]indicates the reference group. *p<0.050, **p<0.010, ***p<0.001

4.4.3.5 Employed performance musicians compared with employed education musicians

A total of 47 musicians were employed by education organisations only, 90 in performance organisations only, and 46 by both education and performance organisations (see Appendix 1.4 for demographic details). The only significant difference between the MSS outcomes for the three groups was for the proportion of symptomatic musicians who discussed their MSSs with other musicians. Compared with symptomatic musicians who were employed only by education organisations, a lower proportion of those employed by performance organisations only (AOR 0.299, 95% CI 0.111-0.805, p=0.017), and musicians employed by both performance and education organisations reported discussing their MSSs with other musicians (AOR 0.315, 95% CI 0.105-0.941, p=0.039).

4.4.3.6 Comparisons between musicians employed by different types of performance organisations

Because musicians may be employed by more than two performance organisations, those in opera, orchestral, military band and ‘other’ performance groups were compared with employed performance musicians of other types only (e.g. opera musicians with non-opera employed performance musicians). A total of 42 orchestral musicians, 33 opera musicians, 48 military band musicians, and 52 employed by ‘other’ performance groups were included (see Appendix 1.4 for demographic details).

There were no significant differences reported for the overall MSS outcomes. For MRMD outcomes, the only difference was for the overall 7 day prevalence with a reduced AOR for military band musicians compared with non-military band musicians (Table 4.7). There were differences between the groups regarding MSS and MRMD prevalence in specific body regions (Table 4.7).

A higher proportion of symptomatic musicians employed by ‘other’ performance organisations reported moderate-severe pain, than musicians only employed by military bands, opera companies or orchestras (non-‘other’ organisations; AOR 3.934, 95% CI 1.204-12.859, p=0.023). Symptomatic military band musicians rated the emotional impact of their MSSs lower than that of non-military band musicians (adjusted beta coefficient -0.935, 95% CI -1.818- -0.053, p=0.038).

Furthermore, a lower proportion of symptomatic military band musicians discussed their MSSs with other musicians (AOR 0.074, 95% CI 0.009-0.590, p=0.014), or were currently undergoing treatment for their MSSs (AOR 0.338, 95% CI 0.117-0.976), p=0.045). A higher proportion of symptomatic musicians employed by ‘other’ organisations discussed their MSSs with other musicians, compared with non-‘other’ musicians (AOR 3.100, 95% CI 1.024-9.387, p=0.045). All symptomatic opera musicians reported that they engaged in self-management strategies for their MSSs in the last 12 months.

Table 4.7: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) differences in the prevalence of musculoskeletal symptoms and music-related musculoskeletal disorders between musicians in the different the types of performance organisations

	Opera compared with non-opera[a]	Orchestral compared with non-orchestral[a]	Military band compared with non-military band[a]	'Other' compared with non-'other'[a]
Musculoskeletal symptoms				
Last 12 months				
Combined regions				
Upper limb		5.736 (1.581-20.807), p=0.008**		
Lower limb		0.283 (0.111-0.725), p=0.008**		
Priority regions				
Shoulder		3.704 (1.361-10.081), p=0.010*		
Wrist/ hand		2.338 (1.019-5.362), p=0.045*	0.390 (0.177-0.859), p=0.019*	
Last 7 days				
Combined regions				
Head/ orofacial	3.156 (1.070-9.310), p=0.037*			
Lower limb		0.124 (0.032-0.487), p=0.003**		
Priority regions				
Neck	2.620 (1.030-6.664), p=0.043*			
Music-related musculoskeletal disorders				
Last 12 months				
Combined regions				
Head/ orofacial		3.456 (1.108-10.778), p=0.033*	0.249 (0.065-0.950), p=0.042*	
Priority regions				
Neck		2.384 (1.065-5.338), p=0.035*		
Upper back			0.225 (0.007-0.729), p=0.013*	3.328 (1.309-8.464), p=0.012*
Last 7 days				
Overall			0.382 (0.152-0.962), p=0.041*	
Combined regions				
Lower limb				3.405 (1.011-11.472), p=0.048*
Priority regions				
Upper back				4.065 (1.374-12.021), p=0.011*

Notes: Orange text indicates a statistically significant (p<0.05) adjusted odds ratio of >1. Blue text indicates a statistically significant (p<0.05) adjusted odds ratio of <1. *p<0.050, **p<0.010, ***p<0.001

Question 3: What are the priority sub-groups of musicians?
Key points:

- Overall, musicians who were both self-employed and employed had a higher prevalence/ impact of MSSs compared with those who were employed only. To a lesser extent, musicians who were only self-employed reported higher prevalence/ impact of MSSs compared with those who were only employed.
- MRMD prevalence was higher among musicians who were:
    - Both students and professionals compared with professionals only (for chronic MRMDs);
    - Performance students compared with non-performance students (for MRMDs in the previous 12 months);
    - Self-employed compared with employed musicians (for MRMDs in the previous 7 days);
    - Both self-employed and employed compared with employed musicians (for MRMDs in the previous 12 months and 7 days) and
    - Non-military band musicians compared with military band musicians (for MRMDs in the previous 7 days)
- MRMD severity was rated higher among musicians who were:
    - Students compared with professionals;
    - Both students and professionals, compared with professionals only; and
    - Classical performance students compared with non-classical performance students.
- The emotional impact of MSSs was rated higher among musicians who were:
    - Both self-employed and employed compared with employed musicians only; and
    - Non-military band musicians compared with military band musicians.

4.5 Discussion

Chapter 4 provides an analysis of 1. The prevalence and consequences of MSSs for university music students and professional musicians; 2. The priority body regions for intervening to reduce the burden of MSSs; and 3. The priority sub-groups of musicians to target to reduce the burden of MSSs. The present study was the first to investigate the whole cohort of university music students and professional musicians groups (e.g. not focusing on a specific instrument group, genre or ensemble type), and to compare the sub-groups of musicians. The present study was also the first internationally to investigate opera musicians and self-employed musicians specifically, and the first Australian study to investigate military band musicians.[tt] The findings of this study are reported below for each objective.

4.5.1 The prevalence and ratings of musculoskeletal symptom outcomes

4.5.1.1 Musculoskeletal symptoms

Overall, 90.1% of musicians reported experiencing MSSs in the last 12 month period, which is consistent with that reported in a recent systematic review of university music students and professional musicians (86-89%).[52] The 7 day prevalence of MSSs overall (i.e. in any body region) was 72.1%, which is similar to the point prevalence reported in Kok et al.'s[52] systematic review (61-68%).

Chronic MSSs were reported by 35.3% of musicians (49.3% of those reporting MSSs in the last 7 days), which is lower than the 58% estimate for chronic MSSs reported in Kok et al.'s[52] review (based upon only one study[460]). The estimate of 49.3% of symptomatic musicians reporting

[tt]Based on the systematic mapping review (Appendix 2.2), the update systematic search (Chapter 1), and targeted searches for studies published before 2007

chronic MSSs is comparable to that from a recent study of Australian orchestral musicians.[224, 227] The two reports[224, 227] of the same study differed in this estimate, with one reporting that 50% of musicians with current[uu] performance-related musculoskeletal disorders had their disorder for more than three months[227], and that 58% with current pain experienced this symptom for more than 12 weeks.[224] The terms 'pain' and 'performance-related musculoskeletal disorders' appear to have been used interchangeably in these two studies, and do not match the terminology used in the questionnaire.[347] Nevertheless, the findings of the present study regarding MSSs appear to approximate those of other studies of Australian musicians, and indicate that chronicity of MSSs may be a major problem (see Chapter 1 and Appendix 2.1 for a further description).

The comparative prevalence of MSSs, including chronic MSSs, in musicians versus a reference group of university staff and students will be reported in Chapter 5.

4.5.1.2 Music-related musculoskeletal disorders

Music-related musculoskeletal disorders were reported by 57.1% of musicians for the last 12 month period and 40.5% for the last 7 day period, both estimates being consistent with the prevalence of playing-related musculoskeletal complaints reported in Kok et al.'s[52] systematic review (point prevalence 9-68%, and 12 month prevalence 41-93%). The case definitions of many of the studies included in Kok et al.'s[52] review did not match the definition of MRMDs used in this study, nor Zaza et al.'s[68] definition upon which the MRMD definition was based. Indeed, it appears that Kok et al.'s[52] classifications were based simply on the terminology used in the included studies (see Appendix 2.5 for a review of the 'music-related' MSS terminology).

Of those reporting MRMDs in the last 7 days, 60.5% reported that they had experienced MRMDs on most days for longer than three months. Árnason et al.[286] reported that 73% of university music students who reported current playing-related MSDs[vv] had experienced these disorders for more than three months. The disparity in findings may relate to Árnason et al.[286] defining 'current' performance-related musculoskeletal disorders as those that were present for at least 7 days, rather than MSSs that were present during the last 7 days. No other recent studies have reported the prevalence of chronic MRMDs (or similar outcomes). The findings of the present study indicate that MRMDs are not a transient problem for the majority of musicians with MRMDs.

4.5.1.3 Other consequences of musculoskeletal symptoms

Qualitative studies[68, 321] have suggested that musicians are reluctant to seek treatment from health professionals for their MSSs. However, in the present study 65.1% of musicians who reported MSSs in the last 12 months reported visiting a health professional. The most commonly consulted health professionals were medical professionals (38.9%), and physiotherapists or occupational therapists (34.7%), which is consistent with the existing evidence.[65, 287] Although it has previously been suggested in a small study of Australian univeristy woodwind students that musicians choose more 'passive' approaches to manage their MSSs[60], the present study identified that 85.7% of musicians who reported MSSs in the last 12 months used self-management strategies; most commonly exercises or stretches (78.9%). Of note, all symptomatic musicians employed by opera companies reported that they had engaged in self-management strategies for their MSSs in the last 12 months.

It has also been reported that musicians are reluctant to discuss their MSSs with other musicians for fear of negatively impacting their reputations.[68] Consistent with this suggestion, the current analysis found that only 26.7% of musicians who experienced MSSs in the last 12

[uu]'Current' pain or injury was defined as "pain or injury present, or that has been present for at least the past 7 days" which is unclear[347 (p101)]
[vv]Defined as "any pain, weakness, numbness, or other physical symptom that interferes with one's ability to play a musical instrument in the manner one is accustomed to"[286 (p 74)] citing Brusky[348]

months reported discussing their MSSs with other musicians. During the previous 12 months, 21.5% of symptomatic musicians reported taking leave from work or study because of their MSSs, consistent with the existing literature.[63, 64] It is unclear whether musicians feel that they do not have to take leave for their MSSs, or whether they are choosing not to given the loss of work opportunities, pay, and potential damage to their reputations. Chimenti et al.[64] reported that 58.2% of professional orchestral musicians [ww] had not claimed workers' compensation during their careers for playing-related symptoms, because the symptoms were not sufficiently severe to warrant time off. Hence, it is likely that the majority of musicians who reported MSSs in the last 12 months did not feel that they had to take leave in relation to their MSSs.

The prevalence of the consequences of MSSs will be compared between musician and reference groups in Chapter 5, which will provide further insight into whether musicians' response to MSSs is different to that of other populations.

4.5.2 Priority body regions

For the overall sample, and for most sub-groups, the neck, upper back, lower back, wrist/ hand, and shoulder regions were the most commonly affected regions for both MSSs and MRMDs, during the previous 12 month and 7 day periods. These body regions also appear to be the most commonly affected in the studies included in Kok et al.'s[52] systematic review. Furthermore, the analysis of the workers' compensation claims (WCCs) data revealed that the majority of musicians' musculoskeletal disorder claims were for the upper limb (Chapter 3). Indeed, when using the same body regions as the WCCs data, MSSs and MRMDs were consistently most prevalent in the upper limb region in the present chapter.

Despite the relative consistency of the top five body regions for MSSs and MRMDs, there were exceptions to this general pattern for some groups. For classical performance students, professional opera musicians and 'other' professional musicians, the orofacial region was considered a priority (top five) region. For professional orchestral musicians, the elbow region was also a priority region, and for professional opera musicians, the hip/ thigh region also ranked highly. These findings may relate to the differences in the exposures inherent in these groups (Chapter 1 and Appendix 2.3). However as some of these sub-groups were small, there is less certainty regarding the prevalence estimates, which may have altered the rankings of body regions. Nonetheless, the relative consistency of the five priority regions across most body regions, suggests that these five body regions that should be prioritised in risk factor and intervention research.

To address the burden of MSSs in university music students and professional musicians, interventions should focus on the shoulder, wrist/ hand, neck, upper back and lower back regions. By extension, the factors associated with MSSs and MRMDs in these five body regions need to be first established, as will be explored in Chapters 8 and 9.

4.5.3 Priority sub-groups of musicians

The present study was one of few analyses[225, 226, 286] to compare different types of university music students and professional musicians, beyond the comparison within specific instrument groups.[201, 228, 240, 261, 262, 296] The following sections cover each of the comparisons between sub-groups of musicians, in the same order as the Results section, with a focus on the overall MSS findings (i.e. in any body region).

[ww]Chimenti et al.[64] included all musicians in the denominator, and did not report how many had experienced playing-related symptoms during their careers. However, 93% reported having experienced playing-related symptoms in the last 12 months.

4.5.3.1 Comparison between student and professional musicians

Few differences in MSS outcomes were identified between those who were professional musicians only and students only. Regarding the ratings, symptomatic students reported higher intensity of pain and severity of their MRMDs compared with professionals. In contrast, professional musicians reported a higher 7 day prevalence of MSSs in the neck/trunk region compared with students. The prevalence findings are largely consistent with the existing evidence in that there were a lack of significant differences between professionals and students in most body regions, in these instances for cellists[228] and percussionists.[262]

In contrast with findings on MSSs prevalence of the present study, Rickert et al.[228] reported that professional cellists had a significantly higher prevalence of pain or injury in the last 18 months than university music students did, although these authors identified no significant differences in the point prevalence of pain or injuries in any specific body regions (15 upper limb and spinal regions). Similarly, Papandreou et al.[262] only reported an association between musical activity type (soloists, orchestral, teachers and advanced students) and upper limb tremor, albeit using Pearson correlations. The present study reports the most comprehensive comparison of university student and professional musicians, indicating that there is not strong evidence for prioritising one group over another.

Although the 12 month prevalence of MSS overall was lower among musicians in the 'both' group compared with professionals only, musicians who were both students and professionals reported a higher prevalence of chronic MRMD and MRMD in the wrist/ hand region, as well as higher ratings of MRMD severity. A higher prevalence of MRMDs in the wrist/ hand region was identified for musicians in the 'both' group, compared with students only. Music-related musculoskeletal disorders in the wrist/ hand region could, potentially, result in greater musical interference than other body regions, owing to the precise, repetitive movements of the fingers required for most instrumentalists.

The poorer MRMD outcomes among musicians who are both students and professionals, compared with students only, may relate to the increased pressure placed on students who have the opportunity to work in a professional capacity, where their playing technique and familiarity with the repertoire is not as well established as those who were professionals only. Furthermore, students working as professionals need to protect, and ideally build, their reputations, and make the most of their professional opportunities to secure future work. There is a possibility that this additional pressure and the intensity of practice (not simply the time spent playing), may lead to their higher proportion of MSSs, particularly in the wrist/ hand region. The finding may also be due to differences in the musicians' ability to detect impairment of their musical activities. Student musicians who are given professional opportunities may be more sensitive to these impairments, and therefore more likely to report MRMDs.

4.5.3.2 Performance students compared with non-performance students

The present study is the first to compare the MSS outcomes between performance and non-performance students. Performance students had a higher 12 month MSS prevalence overall and in the upper limb specifically, compared with non-performance students. Interestingly, a lower proportion of symptomatic performance students consulted a health professional or engaged in self-management strategies in the last 12 months, compared with non-performance students. This difference may relate to the aforementioned reluctance of musicians to seek treatment from a health professional[68, 321], and by extension may influence engagement in self-management strategies likely to be suggested by health providers.

4.5.3.3 Classical performance students compared with non-classical performance students

This present study is the second to compare classical and non-classical performance students. Non-classical performance students reported a higher 12 month prevalence of upper back and lower back MSSs than the classical students did. This difference may relate to the manual handling demands often imposed on non-classical musicians, but not typically classical musicians (as discussed in Chapter 1, and Appendix 2.3). Árnason et al.'s[286] study reported that classical musicians reported a higher lifetime prevalence of performance-related musculoskeletal disorders[xx] compared with rhythmic students. Given that classical musicians typically commence their musical studies earlier than non-classical musicians (Chapter 1, and Appendix 2.3), the differences in lifetime prevalence of performance-related MSDs must be considered in relation to the longer prevalence period (from commencing musical activities until the point of data collection). Arguably, the present study provides a more accurate representation of the differences between classical and non-classical students, owing to more appropriate recall periods and adjustment for potential confounders in the analyses. The findings suggest that future research may consider the manual handling demands of non-classical musicians as a potential risk factor for MSSs.

In addition to the prevalence findings, classical performance students rated the severity of their MRMDs higher than that of non-classical performance students. The difference may relate to the higher technical demands of classical performance and the lack of flexibility in classical music compared with non-classical music (as discussed in Chapter 1 and Appendix 2.3).

A significantly higher proportion of symptomatic non-classical performance students took leave from work or study (including musical work or study specifically), compared with classical performance students. Although not specifically examined in this project, it is possible that such differences may relate to the aforementioned increased flexibility in performance situations (Chapter 1 and Appendix 2.3), which in turn may lead to more relaxed leave policies, and potentially less stigma around musicians' MSSs.

4.5.3.4 Comparison between self-employed and employed musicians

Comparisons of the MSS prevalence and profile between self-employed and employed musicians have not previously been published.[yy] The present study revealed that self-employed musicians had a higher 7 day prevalence of both MSSs and MRMDs compared with employed musicians. Furthermore, musicians who were both self-employed and employed had a higher 12 month and 7 day prevalence of MRMDs, higher ratings of the emotional impact of MSSs, and a higher probability of seeking treatment when symptomatic, compared with those who were employed only. Self-employed musicians do not have the same organisational support as those who are employed, and do not have access to entitlements such as sick leave and workers' compensation. Such characteristics may make self-employed musicians more vulnerable than their employed counterparts. Because this project did not collect further details on the nature of self-employed work (e.g. teaching and/or performing), it was not possible to ascertain whether the differences between self-employed and employed musician was driven by the type of work conducted. However, as there were no significant differences in the prevalence and profile of MSS outcomes between musicians who were employed by education or performance organisations (with the exception of discussing MSSs with other musicians) it is not anticipated that the type of self-employed work (e.g. teaching)

[xx]Playing-related musculoskeletal disorders were defined as "any pain, weakness, numbness, or other physical symptom that interferes with one's ability to play a musical instrument in the manner one is accustomed to"[286(p74)] citing Brusky[348]

[yy]Based on the systematic mapping review (Appendix 2.2) and update search (Chapter 1), as well as targeted literature searches for studies published prior to 2007

was the driver of the identified differences between musicians' MSS outcomes based on self-employed/ employed status. Nonetheless, the findings of this study indicate that self-employed musicians should be targeted for future research and interventions. To date, studies investigating public health interventions for musicians' MSSs have focussed on students and employed musicians (Chapter 1 and Appendix 2.4), and therefore the self-employed group has been under-investigated. With 86% of Australian professional musicians working in a freelance or self-employed capacity[21], this finding is critical in reducing the burden of MSSs in Australian musicians.

4.5.3.5 Comparison between musicians employed by education and performance organisations

Comparisons between teachers and performers have been made before, with regards to pianists[201] and percussionists[262] only. As previously discussed, the statistical methods used by Papandreou et al.[262] were not appropriate[zz], hence their findings have not been considered here. Allsop and Ackland[201] found no significant difference in ratings of the level of discomfort among performing pianists and piano teachers, consistent with the findings of this study regarding pain intensity. Indeed, the only significant difference between the three groups was the proportion of symptomatic musicians who discussed their MSSs with other musicians.

4.5.3.6 Comparison between musicians employed in various types of performance organisations

Musicians who were employed by orchestras, operas, military band and 'other' performance organisations were compared in relation to MSS outcomes. The only difference in MSS/MRMD prevalence overall was for MRMDs in the last 7 days, where military band musicians reported a lower prevalence than non-military band performance musicians. There were, however, differences in the specific body regions affected (see Table 4.7), which may - along with the findings reported in Section 4.4.2 - guide the prioritisation of body regions for interventions with these specific groups. Both MRMD severity and the emotional impact of MSSs were rated lower among military band musicians, compared with non-military band musicians. The latter finding potentially relates to differences in the personalities and coping mechanisms of those drawn to military work, and the health and psychological screening conducted at recruitment (Appendix 2.3).

The lower prevalence and ratings of MSS outcomes for military band musicians may be also due to the presence of a 'healthy worker effect'[461] because these musicians undergo physical and fitness testing when recruited, and during their service (Chapter 1 and Appendix 2.3). It is also possible that the policies in place to prevent and manage MSSs in the military may be more effective than those in place for other groups. A limitation of the analysis is that the military bands in both states involved in the study are reservist bands, and are therefore part-time. These findings may differ if full-time military band musicians were included.

4.5.4 Conclusions

The findings of the present study indicate that there is a burden of MSSs in Australian university music students and professional musicians. The majority (72.1%) of musicians have experienced MSSs in the last 7 days. Of these, 96.4% reported that the MSSs had an impact on their lives and 80.5% specifically reported an emotional impact. Importantly, almost half (49.3%) of those reporting MSSs in the last 7 days reported that they had experienced MSSs on most days for more than three months. A total of 40.5% of musicians reported that in the last 7 days they had experienced MSSs that impaired their musical activity. Collectively, these findings indicate that there is a substantial burden of MSSs in Australian musicians.

[zz]Pearson correlations were used, although the categorisation of percussionist types reflects nominal data

Both MSSs and MRMD are most common in the neck, upper back, lower back, shoulder, and wrist/ hand regions. These findings were reasonably consistent across the sub-groups of musicians investigated, and are consistent with the findings of the WCCs data analysis (Chapter 3). To maximise the impact of future research and interventions, these five body regions should be prioritised, as will be done in Chapters 8 and 9, which will explore the associations between modifiable factors and MSS outcomes.

The present study identified self-employed musicians as the priority group for MSS research and interventions. The reasons why this group appears to have a higher MSS prevalence and burden should be explored, and targeted interventions developed and implemented. Such initiatives are particularly important given the majority of Australian professional musicians are working in a self-employed or freelance capacity.[21] By targeting self-employed musicians, the likelihood of reducing the MSS burden for musicians will be increased.

Key findings

Question 1: What is the prevalence and profile of MSSs for university music students and professional musicians as a whole?

- 72.1% of musicians reported MSSs in the last 7 days
- 49.3% of those with MSSs in the last 7 days had chronic MSSs
- 40.5% of musicians reported MRMDs in the last 7 days
- Of the 90.1% of musicians with MSSs in the last 12 months:
  - 21.5% took leave from work/ study due to MSSs,
  - 65.1% consulted a health professional (most commonly medical professionals (38.9%)) for their MSSs, and
  - 85.7% engaged in self-management strategies (most commonly exercises/ stretches (78.9%)) for their MSSs.
- Of those with MSSs in the last 7 days:
  - 96.4% felt that their MSSs had impacted their lives,
  - 91.4% were concerned about their MSSs, and
  - 80.5% felt that their MSSs had impacted them emotionally.

Question 2: What are the priority body regions for interventions, across the whole sample, and various sub-groups?

- The most commonly affected regions for MSSs and MRMDs over the last 12 month and 7 day periods were the upper back, lower back, neck, shoulder, and wrist/ hand overall and for most sub-groups.
- Future research should focus on the risk factors and interventions for MSSs/MRMDs in these body regions.

Question 3: What are the priority sub-groups of musicians?

- Overall, musicians who were both self-employed and employed (and to a lesser extent self-employed only) had a higher prevalence/ impact of MSSs compared with those who were employed only.
- MRMD prevalence was higher among musicians who were:
  - Both students and professionals compared with professionals only (for chronic MRMDs);
  - Performance students compared with non-performance students (for MRMDs over the last 12 months);
  - Self-employed compared with employed musicians (MRMDs over the last 7 days);
  - Both self-employed and employed compared with employed musicians (MRMDs over the last 12 months and 7 days); and
  - Non-military band musicians compared with military band musicians (MRMDs over the last 7 days).
- MRMD severity was rated higher among musicians who were:
  - Students compared with professionals;
  - Both students and professionals, compared with professionals only; and
  - Classical performance students compared with non-classical performance students.
- The emotional impact of MSSs was rated higher among musicians who were :
  - Both self-employed and employed compared with employed musicians only; and
  - Non-military band musicians compared with military band musicians.
- Future research should focus on identifying risk factors and later effective interventions for MSSs outcomes in self-employed musicians

CHAPTER 5: ARE MUSICIANS AT 'HIGH-RISK' OF EXPERIENCING MUSCULOSKELETAL SYMPTOMS? A COMPARATIVE STUDY

5.1 Introduction

In Chapter 4 it was established that the majority of musicians experienced musculoskeletal symptoms (MSSs) in both the last 12 months (90.1%) and 7 days (72.1%), and that the majority of musicians with MSSs in the last 12 months sought treatment and were engaged in self-management strategies.

The purpose of the study presented in Chapter 5 was to determine whether Australian university music students and professional musicians have a different prevalence and profile of MSSs, including MSS consequences (e.g. impact on daily life, emotional impact, leave from work/ study, treatment), compared with reference groups.

The present study informs whether musicians' MSSs should be targeted in future research, and helps to determine which specific MSS outcomes are more prevalent or severe among musicians compared with reference groups, which may be used to guide future research into risk factors and interventions.

5.2 Background

Musicians have been described as being a 'high-risk' group for MSSs.[342-344] Musculoskeletal symptoms are common among musicians[48-52], and may have a considerable impact on musicians, both musically and in their general lives.[60-65] It is, however, acknowledged that MSSs are also common among the general working population.[345] To determine whether musicians can be accurately described as a 'high-risk' group, a comparative study is required.

There have only been six studies (reported across eight articles[63, 182-184, 202, 207, 287, 298]) in the recent literature comparing university music students and professional musicians with some kind of reference group.[aaa] One of these studies[202], reported only on differences in ankle sprains and recurrent ankle lesions, whereas the other studies[63, 182-184, 207, 287, 298] reported on MSSs more generally. These studies compared professional steel drummers[182] and professional orchestral musicians[63] with the general workforce, professional choristers with the general population[207], and university music students with health[184] or medical students.[183, 287, 298] Four of these five studies provided some evidence of musicians having a higher prevalence of MSSs overall (i.e. in any body region)[182, 183], and also for specific spine and upper limb regions.[63, 183, 184] Some variations were noted depending on the recall period used[63, 183], and the participants' gender in the gender-stratified analyses.[63] Conversely, Vaiano et al.[207] found that professional choristers had a lower prevalence of MSSs in these body regions, as well as the head region, compared with the general population. Regarding the consequences of MSSs, Kok et al.[287] reported that - compared with medical students with neck or upper limb MSSs - a higher proportion university music students with MSSs in these regions sought medical care, specifically from specialists, physiotherapist or alternative medicine therapists, but not from general practitioners. The limitation of these studies is inadequate control of potential confounders[63, 183, 184, 207, 287, 298], and inappropriate reference groups.[183, 184, 207, 287, 298] It is also unclear whether these findings could be generalisable across different types of musicians, and whether they are applicable to Australian musicians.

[aaa]as per the systematic mapping review (Appendix 2.2), and the update search (Chapter 1)

The purpose of this study was to determine whether the prevalence and profile of MSS outcomes differed between Australian university music students and professional musicians, and their respective reference groups. These findings will inform whether musicians are a 'high risk' group for MSS outcomes that should be prioritised in research and interventions to address the MSS burden. Furthermore, the study findings will better focus research regarding musicians' MSSs (e.g., which body regions to focus on).

5.3 Methods

The methods are described in detail in Chapter 2, with the details specific to Chapter 5 reported below.

The present study involved all eligible participants who had completed the survey questionnaire. The musician groups comprised of university music students and professional musicians. The reference groups were non-music university staff (to compare with professional musicians), and university science students (to compare with university music students).

Musicians completed the Musicians' Musculoskeletal Health Questionnaire, while the reference group completed the Musculoskeletal Health Questionnaire (Appendices 1.2). The MSS outcome questions from these questionnaires were drawn from the:

- Nordic Musculoskeletal Questionnaire (NMQ)[67] (modified to include the head, orofacial, and chest/ abdominal regions, and to obtain the laterality for all body regions for the last 7 days);
- 11-point numeric rating scales for pain intensity on average during the last 7 days, using the wording and anchors of the Brief Pain Inventory Intensity scale[459];
- the emotional impact and daily impact scales from the Brief Illness Perception Questionnaire[407]; and
- modified items from the Extended NMQ[384] that enquired about taking leave from work/ study, and making changes due to work/ study due to MSSs in any body region in the last 12 months.

Additional items were developed to obtain information regarding 1. whether the MSSs were chronic (i.e. experienced on most days at least the last 3 months)[399], 2. whether workers' compensation was claimed for the MSSs, 3. the types of health professionals consulted, and 4. the types of self-management strategies utilised for MSSs in the last 12 months.

To maintain consistency with Chapter 4, the comparisons were conducted for the combined body regions (i.e. head/ orofacial, upper limb, neck/ trunk, and lower limb), and all 12 of the specific body regions.[bbb] Pain intensity ratings were classified as moderate-severe where ratings of 5-10 were made[413], and the ratings of emotional impact of MSS and the impact of MSS on daily life were analysed as quartiles (see Chapter 2 for further information).

The analysis was stratified, such that university music and science students were compared, and professional musicians and university non-music staff were compared, using the methods described in Chapter 2. Within these groups, the analysis was also stratified by gender. The differences between the type of health professional consulted, and the type of self-management strategy used were not examined.

[bbb]Analysis of all 12 body regions was possible given the larger sample size in each group within this study, compared with the group sample sizes in Chapter 4.

5.4 Results

5.4.1 Demographics

The analysis included 425 student participants (39.1% of whom were musicians), and 433 professionals (52.0% of whom were musicians). The demographic characteristics of these groups are reported in Table 5.1 (see Appendix 1.5 for gender-stratified demographics).

5.4.2 12 month prevalence of musculoskeletal symptoms

Musculoskeletal symptoms within the last 12 months were reported by 92.5% of university music students, 94.8% of science students, 87.9% of professional musicians, and 97.6% of university staff. The differences in prevalence were not statistically significant for the musician and reference groups, respectively, after adjusting for confounders (Table 5.2).

Regarding the 12 month prevalence of MSSs in specific body regions, over 50% of participants reported MSSs in the neck, shoulder, and lower back, in each of the four groups (Figure 5.1). The only region where music students had a higher prevalence of MSSs than science students was in the wrist/ hand region, a pattern that was also noted for female music students but not males (Table 5.2). There were no body regions where professional musicians had a higher MSS prevalence than university staff. There were however a number of body regions where those in the musician groups had a lower prevalence of MSSs in the last 12 months, compared with the respective reference groups, particularly in the head, and lower limb regions (Table 5.2).

5.4.3 7 day prevalence of musculoskeletal symptoms

The prevalence of MSSs in the last 7 days was 72.6% for music students, 76.4% for science students, 71.5% for professional musicians, and 87.0% for university staff. Prevalence proportions for the music and reference groups did not significantly differ in the adjusted models.

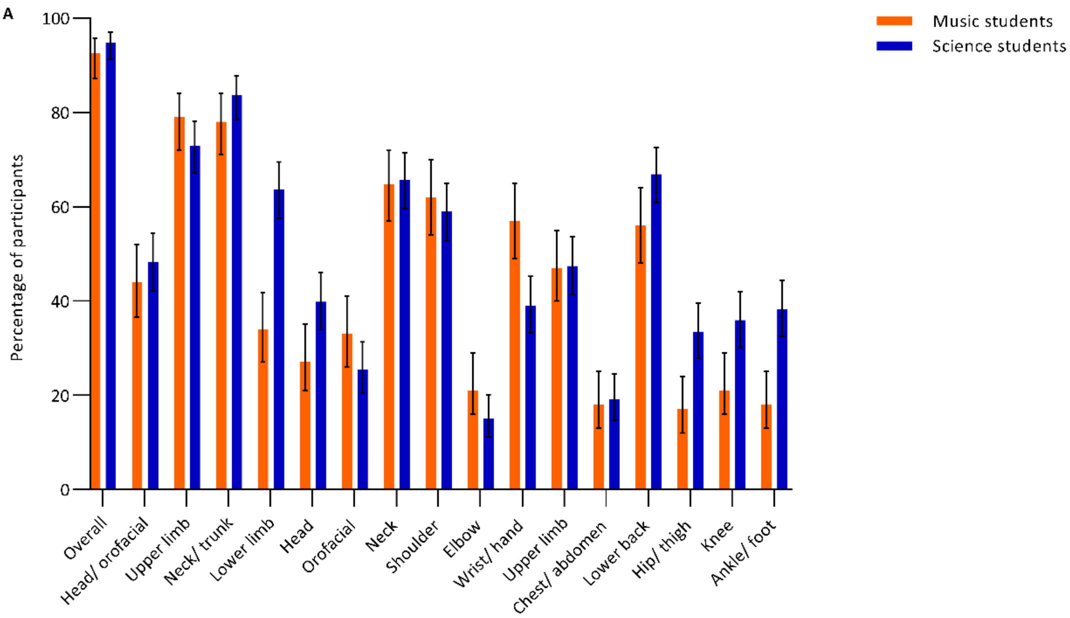
Of those reporting MSSs in the last 7 days, 42.2% of music students, 44.4% of science students, 54.6% of professional musicians, and 51.1% of university staff also reported that their current MSSs were present on most days for at least the last 3 months. Comparisons between the music and science students, and professional musicians and university staff, revealed no significant difference after adjustment for confounders.

Musculoskeletal symptoms were most commonly reported (>30%) in the neck and lower back regions in all groups, as well as the wrist/ hand region for university music students, the shoulder region in university music students and professional musicians, and hip/ thigh region for university staff (Figure 5.2). As with the 12 month prevalence, after adjustment for confounders, university music students had a significantly higher prevalence of MSSs in the wrist/ hand region than the science students (Table 5.3). There were no body regions in which professional musicians had a higher 7 day prevalence of MSSs compared with university staff. There were a number of body regions where musicians had a lower 7 day prevalence of MSSs, particularly in the lower limb, compared with their respective reference groups (Table 5.3).

Table 5.1: Sample characteristics

	University students			Professional musicians & university staff		
	Music students (n=166)	**Science students (n=259)**	**p-value**	**Professional musicians (n=225)**	**University staff (n=208)**	**p-value**
Age in years (median, IQR)	20.0 (19.0-23.0)	19.5 (18.0-23.0)	0.292	37.0 (22.0-54.0)	41.0 (31.0-52.0)	0.087
Female (%)	57.2	64.0	0.166	57.0	74.5	<0.001***
Body mass index (median, IQR)	22.9 (20.5-25.5)	22.0 (20.1-23.9)	0.021*	25.0 (22.2-27.7)	24.1 (21.7-27.2)	0.314
Typical daily sitting time (%)[a]			0.004**			<0.001***
<4 hours	16.3	6.2		23.2	8.7	
4-8 hours	54.2	56.2		54.9	41.4	
8+ hours	29.5	37.6		21.9	50.0	
Socioeconomic status (%)[b]			0.432			0.050
1	20.5	26.0		20.1	24.9	
2	26.1	27.5		20.6	21.5	
3	28.0	22.1		22.8	29.3	
4	25.5	24.4		36.5	24.4	
Currently studying at university (%)	100.0	100.0	NA	40.0	18.3	<0.001***
Full time study (%)	90.2	96.5	0.010*	NA	NA	NA
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	1.0 (0.0-2.0)	<0.001***	2.0 (1.0-3.0)	1.0 (1.0-2.0)	<0.001***
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)	0.0 (0.0-0.0)	<0.001***	1.0 (1.0-2.0)	1.0 (1.0-1.0)	<0.001***
Hours worked in the last 7 days (median, IQR)	2.8 (0.0-12.0)	0.0 (0.0-0.0)	<0.001***	12.0 (4.0-28.0)	37.5 (28.5-45.0)	<0.001***

Notes: IQR: interquartile range. NA: not applicable. [a]categories were collapsed given the small numbers of respondents. [b]based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376]
*p<0.050, **p<0.010, ***p<0.001. Gender-specific demographics are reported in Appendix 1.5.



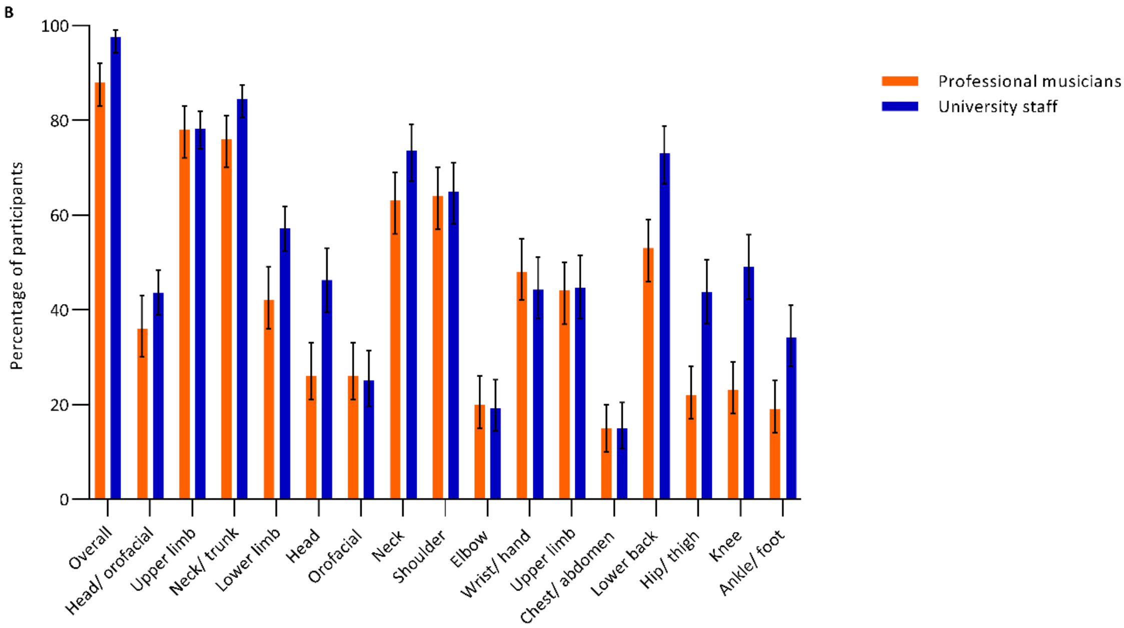
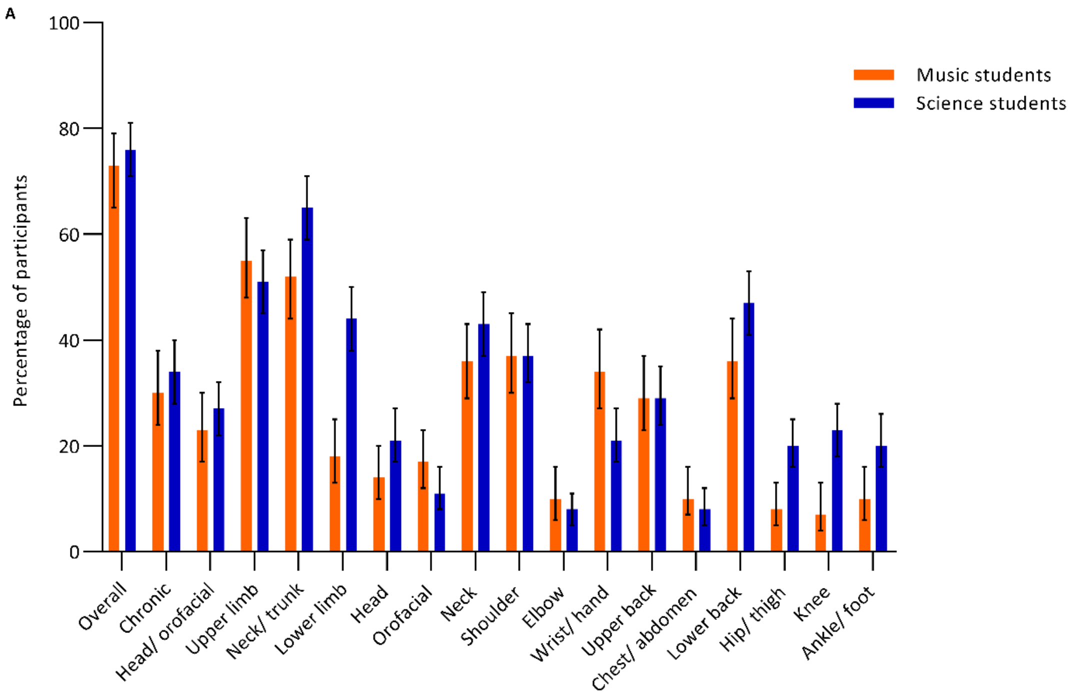


Figure 5.1: Graph of the 12 month prevalence of musculoskeletal symptoms overall (i.e. in any body region), the combined and specific body regions for (A) university music and science students, and (B) professional musicians and university staff
Notes: 95% confidence intervals shown. The values for these estimates, as well as gender-specific estimates are reported in Appendix 1.5.

Table 5.2: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) differences between musician and reference groups in the 12 month prevalence of musculoskeletal symptoms

	Student comparisons			Professional comparisons		
	All students	**Female students**	**Male students**	**All professionals**	**Female professionals**	**Male professionals**
Overall						0.081 (0.010-0.628), p=0.016*
Combined regions						
Head/ orofacial				0.568 (0.376-0.858), p=0.007**	0.574 (0.350-0.942), p=0.028*	
Neck/ trunk				0.442 (0.219-0.891), p=0.022*		
Lower limb	0.295 (0.194-0.450), p<0.001***	0.310 (0.181-0.532), p<0.001***	0.273 (0.139-0.536), p<0.001***	0.320 (0.209-0.489), p<0.001***	0.359 (0.209-0.616), p<0.001***	0.274 (0.134-0.562), p<0.001***
Specific regions						
Head	0.597 (0.385-0.926), p=0.021*	0.480 (0.277-0.832), p=0.009**		0.450 (0.292-0.695), p<0.001***	0.475 (0.284-0.795), p=0.005**	0.326 (0.138-0.767), p=0.010*
Wrist/ hand	2.000 (1.322-3.023), p=0.001**	2.672 (1.566-4.560), p<0.001***				
Lower back				0.504 (0.329-0.774), p=0.002**	0.482 (0.288-0.807), p=0.006**	0.355 (0.172-0731), p=0.005**
Hip/ thigh	0.409 (0.249-0.672), p<0.001***	0.476 (0.256-0.885), p=0.019*	0.334 (0.136-0.821), p=0.017*	0.419 (0.270-0.650), p<0.001***	0.453 (0.271-0.758), p=0.003**	0.346 (0.148-0.805), p=0.014*
Knee	0.498 (0.314-0.790), p=0.003**	0.546 (0.306-0.975), p=0.041*	0.427 (0.200-0.915), p=0.029*	0.349 (0.227-0.535), p<0.001***	0.349 (0.206-0.593), p<0.001***	0.344 (0.160-0.738), p=0.006**
Ankle/ foot	0.470 (0.279-0.793), p=0.005**	0.372 (0.200-0.690), p=0.002**	0.355 (0.167-0.754), p=0.007**	0.513 (0.324-0.812), p=0.004**	0.445 (0.254-0.777), p=0.004**	

Notes: Orange text indicates a significant difference (p<0.05) in the adjusted analyses, where the adjusted odds ratio was >1. Blue text indicates a significant difference (p<0.05) in the adjusted analyses, where the adjusted odds ratio was <1. Musculoskeletal outcomes where there were no significant differences between any of the analyses (i.e. unadjusted and adjusted, across all group comparisons) were omitted from the above table. All findings with p<0.10, unadjusted and adjusted, are reported in Appendix 1.5. *p<0.050, **p<0.010, ***p<0.001



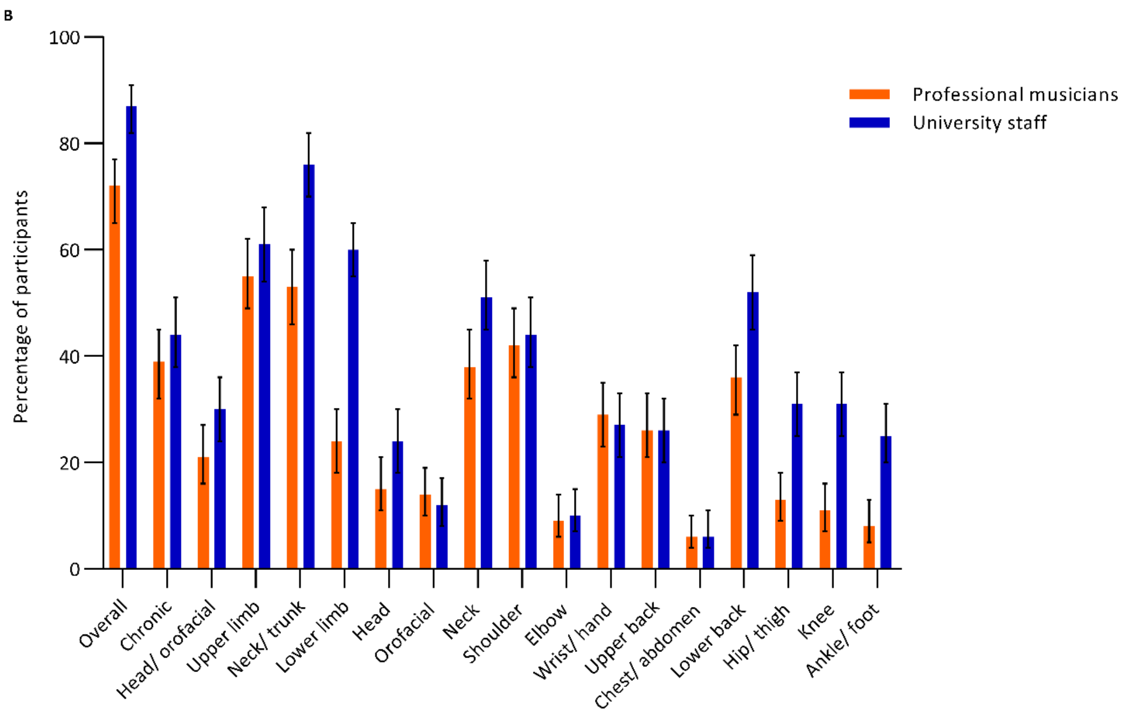


Figure 5.2: Graph of the 7 day prevalence of musculoskeletal symptoms overall (i.e. in any body region), chronic musculoskeletal symptoms, and the combined and specific body regions for (A) university music and science students, and (B) professional musicians and university staff

Notes: 95% confidence intervals shown. The values for these estimates, as well as gender-specific estimates are reported in Appendix 1.5.

Table 5.3: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) differences between musician and reference groups in the 7 day prevalence of musculoskeletal symptoms

	Student comparisons			Professional comparisons		
	All students	Female students	Male students	All professionals	Female professionals	Male professionals
Combined regions						
Neck/ trunk				0.542 90.335-0.875), p=0.012*		
Lower limb	0.295 (0.194-0.450), p<0.001***	0.310 (0.181-0.532), p<0.001***	0.273 (0.139-0.536), p<0.001***	0.276 (0.168-0.453), p<0.001***		0.292 (0.139-0.612), p=0.001**
Specific regions						
Head	0.597 (0.385-0.926), p=0.021*	0.480 (0.277-0.832), p=0.009**				
Wrist/ hand	2.000 (1.322-3.023), p=0.001**	2.672 (1.566-4.560), p<0.001***				
Hip/ thigh	0.409 (0.249-0.672), p<0.001***	0.476 (0.256-0.885), p=0.019*	0.334 (0.136-0.821), p=0.017*	0.374 (0.225-0.624), p<0.001***	0.303 (0.164-0.560), p<0.001***	
Knee	0.498 (0.314-0.790), p=0.003**	0.546 (0.306-0.975), p=0.041*	0.427 (0.200-0.915), p=0.029*	0.284 (0.163-0.495), p<0.001***	0.170 (0.070-0.409), p<0.001***	0.371 (0.158-0.870), p=0.023*
Ankle/ foot	0.470 (0.279-0.793), p=0.005**	0.372 (0.200-0.690), p=0.002**	0.355 (0.167-0.754), p=0.007**	0.326 (0.166-0.637), p=0.001**	0.231 (0.106-0.503), p<0.001***	0.262 (0.087-0.793), p=0.018*

Notes: Orange text indicates a significant difference (p<0.05) in the adjusted analyses, where the adjusted odds ratio was >1. Blue text indicates a significant difference (p<0.05) in the adjusted analyses, where the adjusted odds ratio was <1. Musculoskeletal outcomes where there were no significant differences between any of the analyses (i.e. unadjusted and adjusted, across all group comparisons) were omitted from the above table. All findings with p<0.10, unadjusted and adjusted, are reported in Appendix 1.5. *p<0.050, **p<0.010, ***p<0.001

5.4.4 Ratings of pain intensity, and the impact of symptoms

Of the participants reporting MSSs in the last 7 days, 24.7% of professional musicians, 24.8% of university music students, 18.8% of university staff, and 11.5% of science students reported moderate-severe pain (on average). There were no statistically significant differences in the proportion of symptomatic musicians rating their pain as moderate-severe compared with the reference groups. There were however differences in the proportion of participants reporting moderate-severe pain in the gender-stratified analyses. A higher proportion of symptomatic female music students reported moderate-severe pain compared with female science students (AOR 2.283, 95% CI 1.040-5.012, p=0.040), which was also true for male students (AOR 3.446, 95% CI 1.055-11.254, p=0.040). Similarly, a higher proportion of symptomatic female professional musicians reported moderate-severe pain compared with their reference group (AOR 2.033, 95% CI 1.071-3.859, p=0.030), but there was no significant difference between male professional musicians and university staff.

The median ratings for the impact of MSSs on daily life and the emotional impact of MSSs are reported in Table 5.4. In comparison with symptomatic science students, music students reported a higher emotional impact of MSSs (adjusted beta coefficient 0.665, 95% CI 0.137-1.193, p=0.014). Additionally, male university music students reported a higher emotional impact of MSSs compared with male science students[ccc] (AOR 4.218, 95% CI 1.888-9.424, p<0.001). There were no significant differences between female music and science students, nor professional musicians and university staff (including in the gender-stratified analyses). There were no significant differences in the impact of MSSs on daily life for any of the comparisons between musicians and their respective reference groups.

Table 5.4: Median ratings (interquartile ranges) of the impact of musculoskeletal symptoms on daily life and the emotional impact of musculoskeletal symptoms for music students, science students, professional musicians, and university staff

	Music students	Science students	Professional musicians	University staff
Impact of MSS on daily life	3 (2-6)	3 (2-5)	3 (2-6)	3 (2-6)
Emotional impact of MSS	2 (0-5)	2 (1-4)	3 (1-6)	2 (1-5)

Notes: MSS: musculoskeletal symptoms. Gender-specific ratings are reported in Appendix 1.5.

5.4.5 Consequences of musculoskeletal symptoms

5.4.5.1 Work- and study-related consequences

Of those with MSSs in the last 12 months, changes to work or study due to MSSs in this same time period were reported by 20.4% of music students, 10.6% of science students, 13.5% of professional musicians, and 7.7% of university staff (Figure 5.3). A higher proportion of symptomatic music students made changes to work/ study due to MSSs compared with science students (AOR 2.182, 95% CI 1.194-3.990, p=0.011), which was also the case when comparing females specifically (AOR 2.050, 95% CI 1.011-4.160, p=0.047). There were no significant differences between professional musicians and university staff.

Leave from work/ study was taken for MSSs in the last 12 months by 23.9% of symptomatic music students, 16.3% of science students, 21.6% of professional musicians, and 20.6% of university staff (Figure 5.3). There were no significant differences between musicians and their respective reference groups, regarding leave from work/ study, including in the gender-stratified analyses.

[ccc]This finding was based on a logistic regression, where a median cut point of three was used, rather than the quartiles. This approach was taken as the ordered logistic regression analysis using the quartiles violated the parallel lines assumption.

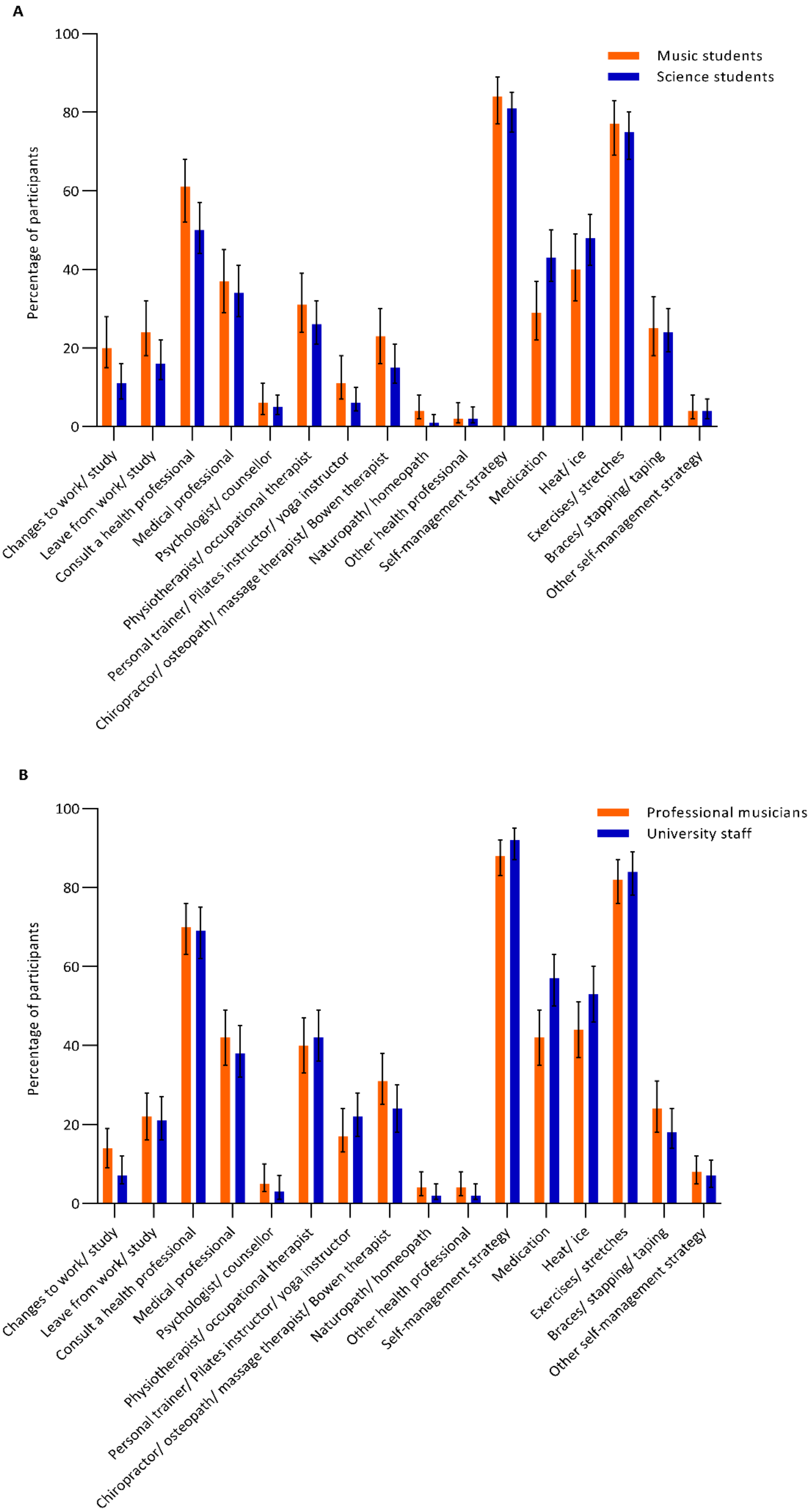


Figure 5.3: Proportion of symptomatic (A) music students, sciences students, (B) professional musicians and university staff who reported consequences of their musculoskeletal symptoms in the last 12 months

Notes: 95% confidence intervals shown. The estimates, including the gender-specific estimates, are reported in Appendix 1.4.

Workers' compensation was claimed for MSSs in the last 12 months by eight professional musicians (five for musical work specifically) and only one university staff member. The difference was significant (p=0.037), using the Fisher's exact test[ddd], however the difference was no longer statistically significant when claims specifically for musical work were considered.

5.4.5.2 Consultation with health professionals

A total of 65.1% of music students, 50.4% of science students, 69.8% of professional musicians, and 68.7% of university staff who reported MSSs in the last 12 months sought treatment from a health professional - most commonly from medical professionals, and physiotherapists or occupational therapists (Figure 5.3). Engagement with any type of health professional did not significantly differ between the music and reference groups.

5.4.5.3 Self-management strategies used

Self-management strategies were utilised to manage MSSs in the last 12 months by 83.7% of symptomatic music students, 80.7% of science students, 88.4% of professional musicians, and 91.5% university staff who reported MSSs during the same time period. The most common strategy used across all groups were exercises/ stretches (Figure 5.3). The proportion of symptomatic musicians who engaged in any type of self-management strategy did not significantly differ between the musician and reference groups.

5.5 Discussion

The present study is one of few[63, 182-184, 202, 207, 287, 298] to compare the MSS outcomes between university music students and professional musicians, and respective reference groups (in this case university science students and university staff). In the following sections, the findings of this study are discussed with reference to the existing literature.

5.5.1 Prevalence of musculoskeletal symptoms

The majority of participants in all four groups reported MSSs in the last 12 months (87.9-97.6%) and 7 days (71.5-87.0%). The 12 month prevalence of MSSs for all groups is comparable with that of the New Zealand general population.[345] There were no significant differences between music and reference groups in the overall 12 month and 7 day prevalence of MSSs. These findings are consistent with Ginsborg et al.'s[184] comparison between music and health students, but differ from two of the other studies: Joseph et al.'s[182] comparison of professional steel drummers and the general workforce, and Kok et al.'s[183] comparison of music and medical students. In both of these studies[182, 183] musicians had a significantly higher prevalence of MSSs compared with their reference groups. Joseph et al.'s[182] reported a small study (n=13 drummers and n=13 in the general workforce), of a very specific group of musicians (steel drummers), and is therefore not comparable with the findings of the present study. The contrasting finding with Kok et al.'s[183] study appears to arise from differences in the prevalence of MSSs in the reference groups. Kok et al.[183] reported a similar 12 month MSSs prevalence estimate for musicians (89.2%) to the present study (92.5%), but they reported that the reference group (medical students) had a 12 month MSSs prevalence of 77.9%. In contrast, 94.8% of the reference group (science students) in the present study reported MSSs in the last 12 months. As acknowledged by both Kok et al.[183, 287, 298] and Ginsborg et al.[184], health or medical students might not be the most appropriate reference groups, because they are likely to differ from 'typical' university students in their knowledge of and behaviours regarding MSSs. The present study therefore improves upon these existing studies by selecting more appropriate reference groups for the student comparison.

[ddd]Only partcipants who reported musculoskeletal symptoms in the last 12 months were included

5.5.1.1 Specific body regions

Although the prevalence of MSSs overall was not higher among the music groups compared with the reference groups, music students were found to have a higher prevalence of wrist/ hand MSSs in both the last 12 months and 7 days compared with the science students. There was no such difference between professional musicians and university staff. Three of the previous comparative studies[63, 183, 184] also identified that musicians had a higher prevalence of MSSs in the wrist/ hand region in comparison with their reference groups. However Vaiano et al.[207] reported that the professional choristers in their study had a lower prevalence of hand pain, compared with the general population. The difference between the findings of present study and that of Vaiano et al.[207] is likely because the latter study investigated choristers, whose biomechanical exposures differ from instrumentalists. There are a number of contrasting findings between the present study and the existing literature[63, 183, 184, 202, 207, 287, 298], with the exception of the higher prevalence in the reference group of lower limb MSSs.[183] As with the finding that musicians do not have a higher prevalence of MSSs overall, the inconsistent findings regarding MSSs in specific body regions may relate to the differences in the reference groups.

5.5.2 Pain intensity ratings

A higher proportion of symptomatic female and male music students reported moderate-severe pain compared with their respective science student groups. This finding was also true of the comparison between female professional musicians and university staff, with a higher proportion of musicians rating their pain as moderate-severe, compared with the university staff. These findings indicate that, although there were no significant differences in the prevalence overall of MSS between musicians and the reference groups, the intensity of the pain experienced by musicians appears higher.

5.5.3 Impact of musculoskeletal symptoms

There were no significant differences in the ratings of MSSs impact on daily life between music and science students, or between professional musicians and university staff. These findings are inconsistent with that of Kok et al.[298], where music students reported a higher impact than medical students. Similar to the prevalence estimates, this inconsistency may relate to differences in the reference groups used.

Another key finding was that music students with MSSs in the last 7 days rated the emotional impact of their MSSs significantly higher than did science students with MSSs; a difference also present for male students specifically. This result is consistent the findings of Kok et al.'s[298] study. The ratings of the emotional impact of MSSs did not, however, differ significantly between professional musicians and university staff. Having differences in the university student comparison but not the professional musician comparison may suggest a 'healthy worker effect'[461]; hence these outcomes require further investigation in university music students. The emotional impact of MSSs experienced by musicians appears to be a problem that warrants further attention. Current evidence suggests that professional musicians experience higher levels of psychological distress than the general workforce[191], and university music students report higher levels of psychological distress than the population norms.[192] It is possible that MSS experiences may contribute to distress. The relationship between psychological distress and MSS outcomes will be explored further in Chapter 8.

5.5.4 Consequences for work or study

This was the first study to compare the proportion of symptomatic musicians with a reference group for work or study consequences. Across the four groups, it was not particularly common to report changes to work or study (7.7-20.4%) or taking leave from work or study (16.3-23.9%) due to MSSs in the last 12 months. The only significant difference was in the proportion of symptomatic participants who made changes to work or study due to MSSs, with a higher proportion of music students making such a change compared with science students. Future research should therefore explore which symptomatic body regions lead to work/ study changes being made, as well as the nature and impact of any such changes.

Few professionals in either group (eight musicians and one university staff member) claimed workers' compensation for their MSSs in the last 12 months; substantially lower than the proportion of participants who reported experiencing MSSs. The finding for musicians mirrors that of Chimenti et al.[64] who reported that 3% of professional orchestral musicians had claimed workers' compensation for their playing-related symptoms during their careers, despite 93% reporting that they had experienced such symptoms (in the last 12 months). As discussed in Chapter 3, most (58.2%) of the musicians in Chimenti et al.'s[64] study did not claim workers' compensation because the injury was not bad enough to require time off. In the present study, only 13.5% of professional musicians who reported MSSs in the last 12 months reported having time off work or study due to their MSS, which may account for the discrepancy between the proportion of musicians reporting MSSs and WCCs for their MSSs. Furthermore, musicians who were only self-employed and/or employed only by the Australian Defence Force would not have been eligible for WCCs.

To compare WCCs for MSSs between musicians and university staff, a Fisher's exact test was used given the small number of participants who claimed workers' compensation. A significant difference identified between the two groups, suggesting that workers' compensation claims (WCCs) for musicians may be more common among professional musicians than university staff. Notably only five of these eight musicians reported that their claim was for musical work. The difference was no longer significant between professional musicians and university staff when only claims for musical work were considered for professional musicians. These findings must be considered with caution given the small number of claimants, and that the denominator for musicians may include musicians who are not eligible for WCC, for instance those who were only self-employed and/or employed only by the Australian Defence Force. As indicated in Chapter 3, the incidence of WCCs for musicians cannot be determined given the difficulties in identifying an appropriate denominator. Larger scale surveys may therefore be required to determine how musicians' WCCs compare with those of other working populations.

5.5.5 Symptom management

As discussed in Chapter 4, qualitative studies suggest that musicians are reluctant to consult health professionals for their MSSs.[68, 321] The findings of the present study suggest that healthcare seeking behaviour is similar between musicians and the reference groups, with the majority of symptomatic participants in each of the four groups (50.4-69.8%) consulting health professionals. This finding is inconsistent with Kok et al.'s[287] where a higher proportion of musicians sought treatment than medical students. This inconsistency may, again, arise from differences in the reference group - given that medical students (Kok et al.'s[287] reference group) may be better able to self-manage their MSSs compared with either music or science students (as per the present study) - or from Kok et al.'s[287] focus on neck and upper limb MSSs, rather than MSSs overall (i.e. in any body region).

The majority of symptomatic participants in the four groups engaged in some form of self-management (80.7-91.5%), with exercises or stretches being the most commonly utilised strategy in all groups. As with health professional consultations, there was no significant difference in the proportion engaging in self-management strategies between musicians and the reference groups.

5.5.6 Conclusion

This study population of musicians does not have a higher prevalence of MSSs compared with the reference groups and there is therefore little basis for considering musicians to be a 'high risk' population for MSSs. However, it is recommended that research and interventions for university music students address MSSs in the wrist/ hand region, and the emotional impact of MSSs. Addressing these MSS outcomes would be expected to have the greatest impact in reducing the MSS burden for Australian musicians.

Key findings:

- There was no significant difference in the prevalence of MSSs overall between music and reference groups.
- Music students reported a higher prevalence of wrist/ hand MSSs than science students did.
- Music students reported a higher emotional impact of MSSs than science students did.
- A higher proportion of symptomatic music students made changes to work/ study due to MSSs compared with science students.
- The only significant difference in any MSS outcomes between professional musicians and university staff was that a higher proportion of symptomatic female professional musicians rated their pain (on average in the last 7 days) as moderate-severe, compared with female university staff.

SUMMARY OF SECTION B

Section B comprised of Chapters 3-5 in order to answer the question "is there a burden of musculoskeletal conditions for Australia university music students and professional musicians?". The evidence presented suggests that the answer to this question is yes. The key findings of the three chapters are summarised in Figure B.

Is there a burden of musculoskeletal conditions among Australian university music students and professional musicians?

What proportion and cost of employed musicians' workers' compensation claims were due to musculoskeletal disorders?

What is the profile of these claims?

(Chapter 3: Workers' compensation claims data)

- 70% of all musicians' compensation claims were for musculoskeletal disorders.
- 60% of musculoskeletal disorder claims were for injuries.
- 50% of musculoskeletal disorder claims were for the upper limb.
- 66% of musculoskeletal disease claims were for the upper limb.
- 78% of the cost of all claims were for musculoskeletal disorders.
- 58% of the cost of musculoskeletal disorder claims were for injuries.
- 50% of the cost of musculoskeletal disorder claims were for upper limb conditions.

What is the prevalence and profile of musculoskeletal symptoms among professional and university student musicians?

Which group of musicians has the highest burden?

(Chapter 4: Survey data)

- 90% of musicians reported MSSs in the last 12 months, 72% in the last 7 days.
- Over half the musicians with MSSs reported impaired musical activity due to MSSs (last 12 months, and 7 days).
- Of those with MSSs in the last 12 months,
  - 65% consulted a health professional,
  - 22% took leave from work/study, and
  - 16% made changes to work/ study.
- Of those with MSSs in the last 7 days,
  - 96% reported an impact on their general lives,
  - 81% reported an emotional impact, and
  - 49% had chronic MSSs.
- The most commonly affected regions for MSS and MRMD were the neck, shoulder, wrist/ hand, upper back and lower back, across most sub-groups.
- There were some differences in the prevalence and profile of MSS outcomes across sub-groups of musicians, suggesting that self-employed musicians should be prioritised.

How does the prevalence and profile of MSS differ between musician and reference groups?

(Chapter 5: Survey data)

- There was no significant differences in the overall 12 month and 7 day prevalence of MSSs between the music and reference groups.
- Compared with science students, music students had:
  - a higher prevalence of wrist/ hand MSSs in the last 12 months and 7 days,
  - higher ratings of emotional impact of MSSs, and
  - a higher proportion of symptomatic musicians making changes to work/study due to MSSs.
- The only outcome where professional musicians had a higher MSS outcome prevalence or rating was in the gender-stratified analysis:
  - A higher proportion of symptomatic female professional musicians rated their pain intensity as moderate-severe in the last 7 days, compared with female university staff

Yes

Figure B: Summary of findings to answer the question "Is there a burden of musculoskeletal conditions among Australian university music students and professional musicians?"
Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder

SECTION C:
Is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?

Section C includes Chapters 6-9, which collectively answer the question "is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?". Chapter 6 presents, for the first time, the mechanisms and agencies reported in workers' compensation claims for musicians' musculoskeletal disorders, and Chapter 7 summarises musicians' perceived causes of their musculoskeletal symptoms. These two chapters inform the perceived preventability of musicians' musculoskeletal conditions, and may guide future research into risk factors and interventions into musicians' musculoskeletal conditions.

Chapters 8 and 9 examine associations between modifiable factors and musculoskeletal symptom outcomes, with Chapter 8 focusing on modifiable personal factors, and Chapter 9 on psychosocial organisational factors. The findings of these four chapters are integrated in order to answer the question "is the burden of musculoskeletal conditions in Australian university music students and professional musicians preventable?".

CHAPTER 6: MECHANISMS AND AGENCIES OF MUSICIANS' MUSCULOSKELETAL DISORDER WORKERS' COMPENSATION CLAIMS

6.1 Introduction

Musculoskeletal disorders (MSDs) account for 69.8% of all musicians' workers' compensation claims (WCCs), and 77.8% of the cost of WCCs (Chapter 3). These findings, along with those from the questionnaire survey (Chapters 4-5) indicate that there is a burden of musculoskeletal conditions in Australian professional musicians. Chapter 6 is the first of four chapters in Section C that explore the preventability of musicians' musculoskeletal conditions.

The objective of the study presented in Chapter 6 is to determine the most commonly reported mechanisms and agencies for musicians' work-related musculoskeletal disorders (WRMSDs), as an indicator of their preventability.

6.2 Background

Musculoskeletal symptoms (MSSs) are common among Australian professional musicians (Chapter 4), and MSDs account for the majority of musicians' WCCs, as well as the majority of the costs of claims (Chapter 3). There is, however, little guidance as to how to prevent and manage these symptoms (Appendix 2.4). A recent systematic review regarding the risk factors for MSS outcomes in university music students and professional musicians found that "no conclusion can be drawn regarding risk factors for musculoskeletal disorders in (pre-) professional instrumental musicians".[199(p 621)] Further, the systematic mapping review as part of this thesis (Appendix 2.2) identified that most studies of risk factors for musicians' MSS outcomes investigated non-modifiable factors. In order to progress research into the risk factors of musicians' musculoskeletal conditions, reported causes from clinicians and musicians may provide valuable insight into which factors may be worth investigating in the future. One source of such data is WCCs data whereby the mechanism and agency of musicians' WRMSDs are reported; this has not previously been investigated in musicians.

The research question for this study was what are the most commonly reported mechanisms and agencies for musicians' MSD WCCs?

6.3 Methods

The methods of this study follow those outlined in Chapter 2. In short, individual level data from the Safe Work Australia's National Data-set on Compensation-based Statistics (third edition; NDS-3)[360] were obtained for the financial years 2004/2005-2015/2016 for professional musicians.[eee] All claims were included whether they were defined as 'serious'[fff] or not. In the present study, only WCCs relating to MSDs were considered. The mechanisms and agencies for MSDs were reported descriptively, overall, and for injuries and diseases specifically, as well as for each of the main body regions. Mechanisms refer to the 'action' reportedly leading to the MSDs, including manual handling, being hit, falls, or repetitive movements, while agencies refer to the 'objects' involved, such as equipment, substances, or other people.

[eee] Australian and New Zealand Standard Classification of Occupations[361] unit group 2112. No data were available for music teachers specifically.

[fff] Serious WCCs are defined as "an accepted workers' compensation claim for an incapacity that results in a total absence from work of one working week or more".[72]

6.4 Results

There were 545 claims for WRMSDs made by musicians during the study period, as reported in Chapter 3. Females accounted for 46.4% of MSD claimants, and the mean age was 52.1±11.4 years.

6.4.1 Reported mechanism

Body stressing was the reported mechanism for 72.5% of MSD WCCs, as well as the mechanism for the majority of musculoskeletal injuries (62.3%) and diseases (88.0%) specifically. Body stressing was also the most commonly reported mechanism for MSDs in all body regions, with the exception of the lower limb (Table 6.1). Body stressing still accounted for 38.0% of lower limb WRMSD claims, however falls, trips and slips of a person were more commonly reported (46.8%).

Table 6.1: Percentage of musicians' musculoskeletal disorder workers' compensation claims attributed to each mechanism, by nature and body region

Mechanism	All (%)	Nature (%)		Body regions (%)					
		Injury	Disease	Head	Neck	Trunk	Upper limb	Lower Limb	Multiple locations
Body stressing	***72.5***	***62.3***	***88.0***	***44.4***	***84.3***	***81.3***	***81.8***	***38.0***	***57.1***
Muscular stress while lifting, carrying, or putting down objects	8.6	8.5	8.8	0.0	7.8	25.3	6.6	3.8	5.4
Muscular stress while handling objects	33.6	26.8	44.0	33.3	37.3	37.3	40.0	3.8	35.7
Muscular stress with no objects being handled	10.6	12.8	7.4	0.0	9.8	14.7	5.5	25.3	12.5
Repetitive movement, low muscle loading	19.6	14.3	27.8	11.1	29.4	4.0	29.8	5.1	3.6
Falls, trips and slips of a person	***15.1***	***21.0***	***6.0***	***22.2***	***2.0***	***8.0***	***9.1***	***46.8***	***19.6***
Falls from a height	4.8	7.0	1.4	0.0	0.0	2.7	2.2	19.0	5.4
Falls on the same level	8.6	12.5	2.8	22.2	2.0	4.0	6.2	21.5	12.5
Stepping, kneeling or sitting on an object	1.5	1.2	1.9	0.0	0.0	1.3	0.7	6.3	0.0
Being hit by moving objects	***3.9***	***5.5***	***1.4***	***22.2***	***0.0***	***1.3***	***3.3***	***7.6***	***5.4***
Being hit by falling objects	0.9	1.5	0.0	0.0	0.0	0.0	0.7	2.5	1.8
Being hit by a person accidentally	1.5	1.8	0.9	11.1	0.0	1.3	1.1	3.8	0.0
Being trapped between stationary and moving objects	0.4	0.6	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Being hit by moving objects	0.7	0.9	0.5	0.0	0.0	0.0	0.4	1.3	3.6
Being assaulted by a person or persons	0.4	0.6	0.0	11.1	0.0	0.0	0.4	0.0	0.0
Hitting objects with a part of the body	***0.9***	***0.9***	***0.9***	***0.0***	***0.0***	***1.5***	***1.3***	***0.0***	***5.4***
Hitting stationary objects	0.4	0.6	0.0	0.0	0.0	0.0	0.4	1.3	0.0
Hitting moving objects	0.6	0.3	0.9	0.0	0.0	0.0	1.1	0.0	0.0
Other and unspecified	***7.7***	***10.3***	***3.7***	***11.1***	***13.7***	***9.3***	***4.4***	***6.3***	***17.9***
Vehicle incident	3.9	6.4	0.0	0.0	9.8	2.7	0.7	5.1	14.3
Other and multiple mechanisms of incident	1.1	0.9	1.4	11.1	0.0	1.3	1.1	0.0	1.8
Unspecified mechanisms of incident	2.8	3.0	2.3	0.0	3.9	5.3	2.6	1.3	1.8

Of the types of body stressing, muscular stress while handling objects accounted for at least 30% of WRMSD claims in each body region, with the exception of the lower limb where only 3.8% of claims were attributed to handling objects (Table 6.1). For lower limb WRMSDs, 25.3% were attributed to muscular stress with no objects being handled, while 29.4% of neck and 29.8% of upper limb WRMSD claims were attributed to repetitive movement with low muscle loading.

6.4.2 Reported agency

The main type of agency reportedly leading to any type of WRMSD claim was non-powered hand tools (which includes musical instruments), accounting for 48.2% claims, and was the leading agency for both musculoskeletal injuries (44.2%) and diseases (54.2%). Similarly, non-powered hand tools were the most common reported agency across all body regions, except the lower limb where environmental agencies led to 46.8% of lower limb WRMSD claims.

Within the non-powered hand tools category there is no specific category for musical instruments, but these fit within the "other non-powered equipment" category. "Other non-powered equipment" led to 39.7% of all claimed WRMSDs, 36.0% of musculoskeletal injuries and 45.4% of musculoskeletal diseases (Table 6.2). "Other non-powered equipment" was reported as the agency for 51.3% of upper limb WRMSD claims, and for over 25% of claims in other body regions, except the lower limb (6.3%). Findings regarding the more specific agencies are reported in Appendix 1.6.

Table 6.2: Percentage of musicians' musculoskeletal disorder workers' compensation claims attributed to each type of agency, by nature and body region

Agency	All (%)	Nature (%)		Body region (%)					
		Injury	Disease	Head	Neck	Trunk	Upper limb	Lower limb	Multiple locations
Machinery and (mainly) fixed plant	0.2	0.3	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Mobile plant and transport	4.4	7.3	0.0	0.0	9.8	4.0	0.7	5.1	18.2
Powered equipment, tools and appliances	3.9	2.1	6.5	0.0	5.9	4.0	4.4	2.5	1.8
Non-powered handtools, appliances and equipment	48.2	44.2	54.2	55.6	56.9	44.0	58.9	12.7	41.8
"Other non-powered equipment" (includes instruments)	*39.7*	*36.0*	*45.4*	*55.6*	*49.0*	*26.7*	*51.3*	*6.3*	*36.4*
Materials and substances	9.0	4.3	16.2	0.0	7.8	16.0	9.1	6.3	5.5
Environmental agencies	13.1	19.8	2.8	33.3	2.0	6.7	6.9	46.8	10.9
Animal, human and biological agencies	2.8	3.4	1.9	11.1	2.0	2.7	1.5	3.8	7.3
Other and unspecified agencies	18.6	18.6	18.5	0.0	15.7	21.3	18.6	22.8	14.6

6.4.3 Relationship between reported mechanisms and agencies

"Other non-powered equipment" (which includes musical instruments) accounted for 52.9% of body stressing WRMSD claims. For falls, trips and slips of a person the most commonly reported agency was environmental (74.1%), and for hitting objects with a part of the body the most common agency was non-powered hand tools (60.0%; Table 6.3).

Table 6.3: Percentage of each mechanism type related to each agency type for musicians' musculoskeletal disorder workers' compensation claims

Agency	Mechanism (%)				
	Falls, trips & slips of a person	Hitting objects with a part of the body	Being hit by moving objects	Body stressing	Other & unspecified
Machinery and (mainly) fixed plant	0.0	0.0	0.0	0.3	0.0
Mobile plant and transport	0.0	0.0	9.5	0.3	48.8
Powered equipment, tools and appliances	0.0	40.0	0.0	4.7	0.0
Non-powered handtools, appliances and equipment	18.5	60.0	28.6	60.0	2.3
"Other non-powered equipment" (includes instruments)	*3.7*	*20.0*	*14.3*	*52.9*	*2.3*
Materials and substances	3.7	0.0	9.5	11.2	0.0
Environmental agencies	74.1	0.0	4.8	2.2	2.3
Animal, human and biological agencies	2.5	0.0	38.1	1.0	2.3
Other and unspecified agencies	1.2	0.0	9.5	20.4	44.2

6.5 Discussion

The present study is the first to examine WCCs data for musicians with regards to the mechanisms and agency of WRMSDs. Body stressing was the most commonly reported mechanism for WRMSDs (72.5%), and for both musculoskeletal diseases (88.0%) and injuries (62.3%) specifically. The most common type of reported body stressing was muscular stress while handling objects, with repetitive movement with low muscle loading also being common for upper limb WRMSDs. These findings may be expected given the repetitive movements and sustained postures (often supporting an instrument against gravity) required for playing many musical instruments.

Non-powered hand tools were the most commonly reported agency for WRMSDs overall (48.2%), and for musculoskeletal injuries (44.2%) and musculoskeletal diseases (54.2%) specifically. The most specific category that included musical instruments was "other non-powered equipment" which accounted for 51.3% of upper limb claims, but rarely reported for WRMSDs in other body regions. The relationship between aspects of musical activity and upper limb musculoskeletal condition outcomes should be investigated, as well as the relationship between non-musical modifiable factors and musculoskeletal conditions more broadly. Identifying the modifiable work-related factors associated with musicians' musculoskeletal conditions may lead to new strategies to reduce the burden of musculoskeletal conditions in this population.

A limitation of this study is that findings could not be compared with the general workforce, as Safe Work Australia[72] only reports on 'serious' WCCs, yet the definition of a 'serious' WCC is not appropriate for musicians as they do not typically work full time.[21] Use of WCCs data have several limitations, hence the findings of this chapter should be interpreted with caution. Of relevance to this chapter are limitations including that the data in the NDS-3 are not necessarily entered accurately, that mechanims and agencies have to be fitted into single broad categories (despite MSDs often being multifactorial), and that they represent a perception of the causes of the MSD. Furthermore, these findings only relate to WRMSDs and do not, therefore, consider the potential non-work-related factors that may contribute to MSDs more broadly in musicians. In order to address some these limitations, Chapter 7 explores musicians' top three perceived causes for their MSS, which will provide further guidance for future studies of potential risk factors, and potential intervention points, as will be investigated further in Chapters 8 and 9.

6.5.1 Conclusions

The findings of the present study suggest that WRMSDs are most commonly attributed to body stressing, often related to manual handling or repetitive movements. The majority of upper limb MSD WCCs were attributed to "other non-powered equipment" (including musical instruments), suggesting that the relationship between specific elements of musical activity and upper limb musculoskeletal conditions be explored. However, as only 39.7% of WRMSDs involved "other non-powered equipment", the relationship between non-musical work exposures and musculoskeletal conditions more broadly should also be considered. In doing so, new strategies to address musicians' musculoskeletal conditions, including WRMSDs specifically, may be developed to reduce the burden of musculoskeletal conditions in this population.

Key findings

- The most commonly reported mechanism for WRMSDs was body stressing, accounting for:
    - 88.0% of musculoskeletal disease claims,
    - 62.3% of musculoskeletal injury claims, and
    - 81.8% of upper limb MSD claims.
- Repetitive movement with low muscle loading, and muscular stress while handling objects were the most common types of body stressing reported.
- The most commonly reported agency for MSD WCCs was “other non-powered equipment” (including musical instruments), accounting for:
    - 45.4% of musculoskeletal disease claims,
    - 36.0% of musculoskeletal injury claims, and
    - 51.3% of upper limb MSD claims.
- The potential role of body stressing, particularly related to playing musical instruments, in the development of WRMSDs should be explored in epidemiological studies.
- Further research should also consider the ‘non-musical’ elements to musicians’ work that may contribute to WRMSDs.

CHAPTER 7: WHAT DO MUSICIANS BELIEVE CAUSED THEIR MUSCULOSKELETAL SYMPTOMS?

7.1Introduction

As outlined in Chapter 6, our understanding of the perceived causes of musculoskeletal conditions can be used to inform the preventability of these conditions, and the potential risk factors to consider in future research. The analysis of mechanisms and agencies of work-related musculoskeletal disorders (WRMSDs) reported in workers' compensation claims (WCCs) revealed that body stressing was the main mechanism, accounting for 72.5% of WRMSD claims. The most commonly reported agency was non-powered hand tools (48.2%), appliances and equipment (the category that includes musical instruments; Chapter 6). This analysis provided insight into WRMSDs among employed musicians, but did not account for music teachers, self-employed musicians, university music students, nor musicians employed by the Australian Defence Force.

Another limitation of using WCCs data to determine the perceived causes of musculoskeletal conditions is that the musculoskeletal disorder must be attributed to work, and that only one mechanism and one agency are reported, despite musculoskeletal conditions often being multifactorial. Musicians may have factors contributing to their musculoskeletal symptoms (MSSs) that are not work related, but the resultant MSSs may still influence their ability to engage in musical activities, study and/or work. A more comprehensive research approach is required to understand musicians' musculoskeletal conditions.

The purpose the study presented in this chapter is to determine the types of factors that musicians believe caused their MSSs, and which factors are most commonly reported by musicians. In doing so an appreciation of the preventability of musicians' MSSs from the musicians' perspective can be obtained, and potential factors to consider in future research of risk factors and interventions determined.

7.2 Background

As identified in Section B, there is a burden of musculoskeletal conditions for Australian university music students and professional musicians. The risk factors for musicians' MSS outcomes first need to be established to address the burden of musicians' MSSs, as per van der Beek et al.'s[198] framework for the development and implementation of interventions to address WRMSDs, before interventions can be developed. The factors that musicians believe caused their MSSs inform both the perceived preventability of musicians' MSSs, and guide the selection of potential risk factors to investigate in epidemiological studies for MSSs.

A number of recent studies have reported the percentage of university music students or professional musicians with MSSs who attributed their MSSs to specific causes, however the majority of these did not clearly report the recall period used (Chapter 1 and Appendix 2.2). Of the studies that did report clear recall periods, one study[217] investigated brass military band musicians, two[252, 296] investigated university piano students, and three[64, 65, 224] investigated professional orchestral musicians; hence studies of the music industry as a whole are required.

It appears that five of the six studies[64, 65, 217, 224, 252] that reported the percentage of musicians who attributed their MSSs to particular factors, asked participants to endorse causes of their MSSs from a list of potential causes; a researcher-driven method. There was no evidence that these lists of causes were based on qualitative research or other strategies to ensure that these lists were comprehensive. Nevertheless, the findings of these five studies[64, 65, 217, 224, 252] suggested that the most commonly reported perceived causes of MSSs were long-playing sessions, a sudden increase in playing[ggg], excessive muscle tension, muscle fatigue, poor posture, and insufficient rest (summarised in Chapter 1).

An alternative data collection approach was used by Bragge et al.[296] who asked musicians to list the factors they believed led to their playing-related musculoskeletal disorders.[hhh] Such an approach is musician-driven, and would overcome potential biases in much of the existing evidence. This approach could also be used to provide more comprehensive lists of perceived causes for use in future research, while percentages of musicians reporting each of the causes would aid in determining how important these factors were perceived to be at a population level. Bragge et al.'s[296] reporting regarding musicians' perceived cause of their playing-related musculoskeletal disorders was however limited. Bragge et al.[296] only reported the percentage of pianists who attributed their playing-related musculoskeletal disorders to a change in practice routine, and that the five most commonly reported perceived risk factors were "muscle tension", "posture", "practice time", "technique" and "stress".

Building on the work of Bragge et al.[296], the objective of the present study was to determine the factors Australian university music students and professional musicians believe caused their MSSs in the last 7 days. Specifically, 1) What are the most commonly reported perceived causes for musicians' MSSs?; 2) What proportion of musicians report likely preventable or modifiable factors as the cause of their MSSs?; and 3) What proportion of musicians reported musical factors as the cause of their MSSs?.

7.3 Methods

The data regarding perceived causes of MSSs were obtained through the survey stage of this research. A cross-sectional survey approach was adopted over in-depth interviews, as the focus of this study was simply the types of factors musicians believe caused their MSSs. The survey approach also allowed for data to be collected from a large number of diverse musicians (e.g. different ages, types of musical activities, stages of their careers, and MSS characteristics). The details of the population, recruitment and data collection are reported in full in Chapter 2. Elements unique to the present study are reported below.

The study presented in this chapter included all musicians, both university music students and professional musicians, who had reported experiencing MSSs (i.e. ache, pain or discomfort) in the last 7 days, as per the modified version of the Nordic Musculoskeletal Questionnaire (Appendix 1.2). The study reports the demographics of the participants, and characteristics of their MSSs, as obtained through the questionnaire (Appendix 1.2). Data regarding the perceived causes of their MSSs were obtained using the final item of the Brief Illness Perception Questionnaire.[407] "Ache, pain or discomfort" was substituted for "illness" as suggested by Broadbent et al.[407] As MSSs can be transient, participants were asked only to provide perceived causes for their MSSs from the last 7 days.[iii] Participants were therefore asked to provide the three main causes of their ache, pain or discomfort in the last 7 days.

After entering data into Microsoft Excel, the free-text perceived causes were classified as preventable/modifiable or not, and as musical or non-musical factors. Musical factors included all statements regarding practice, playing, technique, hand or wrist position, warming up, equipment, the profession, pedalling, instrument cases, technical work, and teaching (except where it was clear that the reported cause was not related to musical activity, e.g. warming up before sport). Factors related to study were also classified as musical

[ggg]It is unclear whether the increase referred to playing time, or the intensity of playing
[hhh]Defined as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with your ability to play your instrument at the level to which you are accustomed"[68 (p 2016)]
[iii]Approval for the use of the Brief Illness Perception Questionnaire[407] and the modifications was granted by Elizabeth Broadbent

(providing the participant reported elsewhere in the questionnaire that they were currently studying music). Remaining factors were considered non-musical.

To determine the main types of reported perceived causes, categories for the reported causes were identified. These categories emerged from the data, and the percentage of symptomatic musicians reporting causes that fit within these categories was reported.

7.4 Results

A total of 317 musicians completed the questionnaire, 72.1% of whom reported MSSs in the last 7 days. Some 213 musicians who experienced MSSs in the last 7 days provided at least one perceived cause of their MSSs, and were therefore included in the present study. Sample demographic characteristics are reported in Table 7.1. Percentages reported throughout refer to symptomatic musicians.

Table 7.1: Demographics of the symptomatic musician sample included in this study (n=213)

Characteristic	
Age in years (median (IQR))	25 (20-46)
Female (%)	59.4
Student/professional status (%)	
Student only	30.0
Professional only	46.7
Both student and professional	23.3
Main musical activity[a] (%)	
Conducting/ being a drum major	2.0
Singing	17.2
Playing guitar (or similar)	7.8
Playing a bowed string instrument	10.3
Playing a woodwind instrument	19.0
Playing a brass instrument	10.3
Playing a percussion instrument	4.4
Playing a keyboard instrument	21.7
Playing the harp	0.9
Mixed	6.4
Distribution of ache, pain or discomfort in the last 7 days (%)	
Head	18.8
Orofacial	19.3
Neck	51.6
Shoulder	52.6
Elbow	14.1
Wrist/ hand	42.3
Upper back	36.6
Chest/ abdomen	9.9
Lower back	49.8
Hip/ thigh	14.6
Knee	14.1
Ankle/ foot	14.1

Notes: all descriptive statistics refer to the 213 musicians who reported musculoskeletal symptoms in the last 7 days and provided at least one cause for their musculoskeletal symptoms. IQR: interquartile range. [a]The main musical activity refers to the type of activity they spent at least 50% of their musical time doing. Where no one activity was performed for at least 50% of their musical time, the activity was classified as 'mixed'.

All participants listed at least one perceived cause that was likely modifiable and/or preventable, and 61.0% reported at least one musical perceived cause of their MSSs. Regarding the types of causes reported, four initial main categories emerged from the data: behavioural, psychosocial, biological and external, physical factors, and an 'other' category later added for perceived causes that did not fit these initial four categories.

Behavioural factors were listed by 93.9% of musicians as one of the main three causes of their MSSs, while biological factors were reported by 37.6%, psychosocial factors by 18.8%, external, physical factors by 21.1%, and 'other' factors by 9.9% (Table 7.2). Only one perceived cause was reported by 22 (10.3%) musicians, and two perceived causes by 39 (18.3%) musicians. The causes reported as sole causes are reported in Table 7.3. A description of the perceived causes of MSSs within each category follows, with all perceived causes reported in Appendix 1.7.

Table 7.2: Examples of types reported causes of musicians' musculoskeletal symptoms by broad category

Biological factors (37.6%)	Psychosocial factors (18.8%)	External, physical factors (21.1%)	Behavioural factors (93.9%)	Other factors (9.9%)
Age	Anxiety	Weather	Musical activity	Accident
Genetics	Depression	Guitar footstool	Physical activity	Fall
Acidity	Stress	Piano pedal	Work/ study	Tension[a]
Lack of hydration	Nervousness	Saxophone neck strap	Household tasks	Tiredness
Overweight/ weight gain	Psychosomatic	Instrument/ equipment	Sleep	
Pregnancy	Pressure from others	Props	Posture/ position	
Muscle tension	Family	Chair/ stool	Manual handling	
Musculoskeletal disorders	Lack of knowledge	Footwear	Movement/ muscle use	
Non-musculoskeletal conditions		Bag/ backpack		
Past injuries		Bed		
Fitness/ strength/ flexibility				
Small hands				

Note: [a]classified as biological where it was specified as muscle tension

Table 7.3: Quoted factors reported as the sole cause of musicians' musculoskeletal symptoms

Biological	• Repetitive strain due to instrument ergonomics[a] • Strain in jaw while singing[a] • Pregnancy • Not sure, but think it is linked to a crush fracture due to osteoporosis • Jammed lower neck/ ribs • An "essential tremor"
Behavioural	• Gym • Did the stairs at work • Typing/ mouse use • Heavy lifting • Overuse • Tension-causes tightness in shoulders • Strain in jaw while singing[a] • Tension in shoulders and neck while playing • Standing for extended periods of time • Posture • Posture for playing piano while teaching singing • Amount of hours spent practicing • Practicing too much • Marching with an instrument
Psychosocial	• Stress • Psychosomatic pain
External	• Bed • Repetitive strain due to instrument ergonomics[a]

Notes: Listed responses are quotes from the questionnaire responses. [a]response fits in two categories

7.4.1 Biological factors

Biological factors were reported as perceived causes of MSSs by 81 (37.6%) of musicians. Age was reported as a perceived cause of their MSSs by 14 participants (6.6%), two of whom referred to age-related "wear and tear". Genetics, being overweight or gaining weight, a lack of hydration, and "acidity" were also reported.

Being unfit, lacking flexibility and/or strength were reported as the cause of 13 (6.1%) musicians' MSSs, while muscle fatigue, strain, cramp or tightness were also reported by six participants. These values do not include related factors, such as lack of exercise, as these factors have been categorised as behavioural factors (Section 7.4.3).

Various musculoskeletal conditions were reported by 28 (13.1%) musicians as the cause of their MSSs. The specific musculoskeletal conditions reported included arthritis, bursitis, tendinitis, plantar fasciitis, nerve pain, fractures, scoliosis, osteopenia/ osteoporosis, Ehlers-Danlos syndrome, flat arches, "issues with hip alignment", hypermobility, and fibromyalgia, as well as "spinal damage caused by thoracic kyphosis", "deformation of the temporomandibular joint", "congenital hole in the spine", and "jammed lower neck/ ribs". In addition, 12 (5.6%) participants referred to previous injuries.

Non-musculoskeletal conditions were reported by 11 (5.2%) participants as perceived causes of their MSSs. The reported non-musculoskeletal conditions were an essential tremor, chronic sinus infection, pulmonary embolisms, lupus, pregnancy, growing pains, menstrual pain, and wisdom teeth. More general statements, like “congenital”, and “pre-existing conditions” were also made. Two participants reported recent sickness as reasons for changes in physical activity which they attributed their MSSs. One musician reported that the flu meant that they had had several weeks off cycling, and that returning to cycling led to their MSSs; while the other reported not doing enough yoga or stretches because of sickness. Similarly, one musician reported that the lack of exercise during her pregnancy led to her MSSs.

7.4.2 External, physical factors

External, physical factors were reported by 21.1% of symptomatic musicians as one of the top three main causes of their MSSs. Three musicians reported that the weather was the cause of their MSSs; specifically one reported that they experience cramps in their hands upon waking on cold mornings, and another reported that “windy days led to wind load on the drum” was the cause of their MSSs. Some 31 musicians (14.6%) reported musical equipment as the cause of their MSSs. Musical equipment causes included using a footstool, a drum stool, the piano pedal, and a neck strap for playing saxophone, carrying/holding instruments, the size of the instrument, and sitting angle within the orchestra/ pit, while non-musical equipment included heavy bags, equipment, footwear, chair, “no back support”, ergonomics, bed, and “loading a truck with a low ceiling height”.

7.4.3 Behavioural factors

Behavioural factors, including activities such as musical activities, exercises and sports, work and study, household chores and child minding, and sleeping, were reported as the main MSS cause by 197 (93.9%) symptomatic musicians. The types of behaviours reported are summarised in Table 7.4. The following sections will outline the factors associated with each of the activity types, followed by the more general behavioural factors (e.g. posture, sitting time).

7.4.3.1 Musical activity

A total of 128 musicians (58.4%) reported various behavioural aspects of their musical activity as the cause of their MSSs. Perceived causes related to posture/ position, technique, and manual handling of instruments and/or equipment associated with musical activities, as well as the duration and/or structure of musical activities.

Posture/ position

Music-related posture or position was reported by 44 (20.7%) musicians as a cause of their MSSs. Reported issues included looking down at scores, arm being fixed in one position, sitting or standing, holding the instruments up, awkward positioning, uncomfortable sitting angle in orchestra/ pit, sitting position in relation to the students while teaching, or simply describing their posture as ‘bad’, ‘poor’, or ‘incorrect’, or playing in the ‘wrong position’. A drummer reported that when playing kit the twisting of their body led to their MSSs, however it is unclear whether this meant the twisting movement, or maintaining a rotated position. In addition, a trombonist reported that the positon of the trombone on the shoulder led to their MSSs. Two musicians reported wrist or hand posture/ positioning specifically as the cause of their MSSs.

Table 7.4: Summary of behavioural factors reported as causes of musculoskeletal symptoms

Musical activities	• Too much time spent doing the activity • Insufficient breaks • Position/ posture • Technique/ muscle use • Specific musical tasks • Manual handling • Changing instrument • Not warming up • Cumulative exposure (years of musical activity)
Exercise & sports	• Specific sporting/ exercise activities • Returning to sport after time off • Too much time spent doing sport/ exercise • Too little time spent doing the sport/ exercise activity (or none at all)
Work & study	• Specific work types/ tasks • Awkward posture/ movement • Manual handling • Equipment
Household chores & child-minding	• Manual handling • Playing with children • Cleaning/ chores • Gardening
Sleeping	• Poor position • Not enough time spent sleeping
General	• Poor posture/position • Manual handling • Too much time spent sitting/ standing • Repetitive movement/ movement patterns/ gait • Computer use • Constant cracking • Falls • General strain • Holding tension • Insufficient rest • Return to activity after periods of non-activity • Not addressing their musculoskeletal symptoms appropriately • Poor diet • Wearing long hair down

Manual handling

Music-related manual handling tasks were reported as the cause of MSSs by 28 (13.1%) musicians. The manual handling tasks included holding the instrument against gravity whilst playing, carrying or lifting the instrument or musical equipment, and carrying a mock rifle in an opera rehearsal. Five saxophone players reported that the neck strap or sling used to support the instrument while playing led to their MSSs. One participant stated that the cause of their current MSSs was manual handling of pianos/ keyboards when they were younger.

Musical technique

Issues with technique or muscle tension while undertaking musical activity were reported by 42 (19.7%) musicians. Specific issues reported were having a “bad embouchure”, playing with tension (including gripping the mouth piece or having a tight jaw while playing, straining the jaw while singing, or squeezing the neck of the double bass), and using inefficient movements. One musician reported that pressure from others led to tense playing; thus causing their MSSs (which was also classified as psychosocial).

Specific musical playing tasks were identifies as a cause of some musicians’ MSSs. One pianist stated that “Beethoven tremolo passages” without first strengthening their forearm was the cause of the MSSs, while Hanon exercises and arpeggios, as well as technical work and repertoire more generally, were also listed. A drummer reported that repetitious kick pedalling led to their MSSs, with pedalling also reported as an issue for a pianist - both of which may relate to the repertoire or technical work being played.

Duration and/or structure of musical activity

A total of 26 (12.2%) musicians reported that the duration or structure of their musical activity led to their MSSs. Two musicians reported that their MSSs were due to the length of concerts or performances, while four specified the length of rehearsals. Seven musicians reported not having enough breaks or playing for too long at once as causes of their MSSs. Some musicians specified other physical aspects, such as sitting, standing or holding the instrument up for long durations as other causes of their MSSs. Practice habits were also reported as a cause of MSSs, which included the duration and lack of breaks, but also inefficient practice, intense practice, repetition, not warming up or not warming up enough, and not stretching before or after musical activity. One musician attributed their MSSs to "unsupervised practice", and two musicians reported that the cumulative musical exposure (i.e. playing for 40+ years) caused their MSSs. Two musicians reported that their current MSSs related to previous practice habits.

Specific types of musical activities reported

Orchestral playing and marching were reported as specific types of musical activities that led to symptoms, while others reported teaching. Playing the flute, oboe, bassoon, clarinet, saxophone, trumpet, French horn, trombone, tuba, violin, viola, double bass, bass guitar, guitar, harp keyboard, piano, and drums were reported as causes of MSSs, as were singing and conducting. Some musicians reported specific aspects of these activities as the causes, as reported in Table 7.5.

Table 7.5: Perceived causes of musculoskeletal symptoms reported for specific musical activities

Perceived cause	Associated musical activity
Time spent playing	Flute Saxophone Bass[a] Piano
Posture/ position	Flute Bassoon Saxophone Keyboard Conducting
Manual handling	Saxophone French horn Trombone Tuba Bass guitar Harp Piano Keyboard
Weight of the instrument	Oboe
Weight of the instrument on neck/ shoulders, including the use of neck strap/ sling	Saxophone
Supporting the instrument against gravity while playing	Flute Trumpet
Grip	Trombone
Squeezing the neck of the bass	Double bass
Technique (including pedalling)	Piano
Technique	Singing
Using footstool	Guitar
Sitting on drum stool	Drum kit
Back pressure[b]	Oboe
Specific exercises/ repertoire	Piano
Using the kick pedal repeatedly	Drum kit

Notes: [a]unclear if bass referred to double bass or bass guitar, [b]back pressure likely refers to the pressure created by the resistance of the double reed

7.4.3.2 Work and study
Work or study was reported as a cause of MSSs by 11.7% of musicians. Work- or study-related issues included the amount, duration, or intensity of work, specifically too much time sitting, and a lack of breaks. Two musicians reported issues with ergonomics/ workplace set-up, and another reported that stress and their study/ research demands made it difficult to improve their posture; thus leading to the MSSs.

7.4.3.3 Physical activity
Specific sports or types of exercises were reported as the cause of MSSs by 27 (12.7%) musicians; namely basketball, cycling, dance, gym, hard impact exercise, long jump, personal trainer exercises, golf, rowing, treadmill running, chin ups, weights and tennis, as well as one musician who reported doing "the stairs at work". One musician reported that their MSSs were due to a cycling accident resulting in "trauma related injuries". Two participants reported that it was the return to sport/exercise which led to their MSSs; one reported that the time off was due to illness. One participant specified that it was the amount of exercise that caused their MSSs; however, it is unclear whether they mean they had done too much or too little. Two musicians reported past events as the problem, one stating their current MSSs were due to "early gymnastics and sport" and the other stating that they had previously been injured running and never recovered.

A further 26 (12.2%) musicians reported that their MSSs were due to a lack of exercise or physical activity; specifically stretching, strength or resistance training, and relaxation exercises. Three musicians reported that their MSSs were specifically due to not stretching before or after their musical activity. One musician reported immobility as the cause of their MSSs, while another reported inactivity. Reported reasons for not exercising included a lack of time, pregnancy, and recent sickness.

7.4.3.4 Housework and child-minding
Five musicians reported that housework, including gardening and cleaning, were the cause of their MSSs. A further three musicians reported that their MSSs were due to child-care, with all reporting that manual handling of the child was the cause, and one also mentioned being used as a "play gym" by their children.

7.4.3.5 Sleeping
Sleeping issues were reported by 10.8% of musicians as the cause of their MSSs, including sleeping position, and a lack of sleep specifically.

7.4.3.6 General
The following reported MSS causes did not specify whether they related to a specific activity (e.g. musical activity, work/ study); hence, it is possible that the abovementioned activities are under-estimated as MSS causes. Within this section, the specific factors are reported.

Position/ posture
In addition to the musical position/ posture issues reported as causes of MSSs by 44 (20.7%) musicians (Section 7.4.3.1), posture more generally was reported by a further 62 (29.1%) musicians. Specific posture/position-related factors were back posture, hunching over, incorrect/poor posture, inattention to posture, and prolonged sitting.

Manual handling
In Section 7.4.3.1, it was reported that 29 (13.6%) musicians reported music-specific manual handling as the cause of their MSSs. A further 12 (5.6%) musicians reported manual handling tasks (not specific to musical activities) as the cause of their MSSs; four specified this involved backpacks or bags. One participant specified "loading trunk with low ceiling height", as the cause of their MSSs.

Movement/ muscle tension
In addition to the 42 (19.7%) musicians who reported that the cause of their MSSs was musical technique, movement and muscle tension while engaged in musical activities (Section 7.4.3.1), a further 14 (6.6%) reported the cause of their MSSs as movements or muscle tension, not specifically associated with musical activities.

Other behavioural factors
Other behavioural causes of MSSs were reported by eight musicians. Specific reported behaviours were "constant cracking", "grinding teeth at night/ when stressed", "not being able to rest", diet, and not doing anything to manage their MSSs when the symptoms started.

7.4.4 Psychosocial factors
Psychosocial factors were reported as the perceived cause of MSSs by 40 musicians (18.8%). The most common reported psychosocial factor was stress; reported by 31 (14.6%) participants. Four of these participants paired stress and tension, while one stated that they grind their teeth when stressed, which they believe led to their MSSs. Two participants attributed their stress to work, and another to concerts and auditions.

Two musicians reported anxiety led to their symptoms, and one each for depression, nervousness, and psychosomatic pain. One musician reported that pressure from others caused tense playing, thus leading to their MSSs. Lack of knowledge was also reported by one musician; however, they did not specify in which specific area they felt they lacked knowledge.

7.4.5 Other factors
A total of 21 (9.9%) musicians reported perceived causes of their MSSs that did not clearly fit into the above categories. These causes included physical impact, accidents, falls, tiredness, and tension (not specified as being muscle tension).

7.5 Discussion
This study contributes to our understanding of musicians' perceived causes of their MSSs, and is the first to investigate perceived causes of musicians' MSSs across the music industry. By using musician-driven (rather than researcher-driven) data collection strategies a comprehensive, unbiased list of perceived causes of MSSs from a diverse range of musicians was compiled (Appendix 1.7). The findings will be discussed in relation to the three research questions the following sections.

7.5.1 Preventable and/ or modifiable factors
All musicians reported at least one perceived cause of their MSSs that was likely preventable and/or modifiable. With 93.9% of participants reporting behavioural factors as one of the top three causes of their MSSs, it would indicate that musicians may struggle to address these factors in order to prevent their MSSs. Musicians may have little personal control over some of the reported factors. For instance, the duration and structure of musical activities may be dictated by management for larger groups, or other musicians in chamber music groups. In a performance setting, musicians will also have limited control over the structure and duration of the performance. The finding that musicians appear to view their MSSs as preventable suggests that research be directed towards understanding the enablers and barriers to address the most important preventable, perceived causes of musicians' MSSs, so that these can be addressed in interventions to reduce the burden of musicians' MSSs.

7.5.2 Musical causes

The majority of musicians (61.0%) reported at least one musical cause of their MSSs, with 58.4% of all symptomatic musicians reporting a behavioural aspect of their musical activity as the cause. These musical behaviours included posture/ position, technique, manual handling of instruments and/or equipment associated with musical activities, as well as the duration and/or structure of musical activities. Musical equipment itself was reported as a cause of MSSs by 14.6% of musicians, which is lower than the 39.7% of WRMSDs attributed to "other non-powered equipment" (including musical instruments) in the WCCs data analysis (Chapter 6). The specific musical equipment issues were using a footstool, using a drum stool, the piano pedal, using a neck strap or sling for playing saxophone, carrying/holding instruments, the size of the instrument, and sitting angle within the orchestra/ pit. These findings suggest that addressing elements of musical activity, including equipment, as potential risk factors for MSSs, focusing solely on musical strategies is unlikely to be sufficient in reducing the MSS burden; a more comprehensive, multifactorial approach is required.

7.5.3 Main perceived causes

The main perceived causes of musicians' MSSs identified in the present study related to musical activity (posture/ position, manual handling, technique, structure and/or duration of musical activity), posture/ position and manual handling more generally, performing physical activity or a lack of physical activity, issues with sleep, and stress. These main perceived causes of MSSs are similar to what has previously been reported[64, 65, 217, 224, 296], however the role of manual handling, physical activity (including a lack of physical activity), and sleep had not previously been identified as key perceived causes of musicians' MSSs.

A recent systematic review[199] of university music students' and professional musicians' MSSs stated that "no conclusion can be drawn regarding risk factors for musculoskeletal disorders in (pre-) professional instrumental musicians".[199(p 621)] However, they found evidence to support associations between gender, performance anxiety, instrument, higher number of orchestral hours, work-related stress and warming-up, and MSS outcomes, and consistent evidence of no association between sports/exercise, other work-related factors, and anthropometric factors, and MSS outcomes. In contrast with Baadjou et al.'s[199] findings, no musician in the present study reported performance anxiety as the cause of their MSSs, however stress, which may be closely related, was reported as the cause by 14.6% of musicians. Musicians also perceived doing physical activity (12.7%) or a lack of physical activity (12.2%) as a cause of their MSSs, which is in contrast with Baadjou et al.'s[199] review findings. This finding highlights the importance of considering the dose-response relationship between physical activity and MSS outcomes, which has not been adequately assessed in musicians. Baadjou et al.'s[199] findings are based on few studies; hence the evidence around musicians' MSSs is not strong enough to confidently conclude that musicians' perceptions of the cause of their MSS are consistent with the epidemiological evidence or not.

7.5.4 Future research

As discussed in Section 7.5.1, future research should investigate the enablers and barriers to behaviour changes that may reduce musicians' MSS prevalence to optimise future public health interventions into musicians' MSSs.

Future studies should also investigate the association between the factors reported in this study and MSSs outcomes in musicians. By confirming, through epidemiological research, the most important risk factors, interventions can be directed at addressing these factors, as well as dispelling any misconceptions held by musicians regarding their MSSs. For instance, 19.7% of musicians reported that poor technique or movements while performing their musical activity as one of the top three causes of their MSSs. There is currently insufficient evidence to determine whether such an association exists (Appendix 2.2), but holding such a belief may cause harm to musicians, due to both internal and external stigma associated with musicians' MSSs and the assumption that poor technique has caused the MSSs, thus potentially ignoring other relevant factors. As reported in Section 7.5.3, the reports of both too much physical activity and a lack or not enough physical activity as perceived causes of MSSs indicates that the dose-response relationship between physical activity and MSS outcomes should be investigated in future studies.

A range of instrument-specific issues were identified as perceived causes of MSSs. These issues included the use of neck straps/ slings for saxophonists, foot stools for guitarists, and drum stools for drummers. The equipment used by specific instrumentalists has not previously been examined as risk factors for MSSs (Appendix 2.2), however there have recently been a number of studies that have investigated the biomechanical impact of these equipment choices. These equipment choices have included shoulder rests for violinsts[462], instrument supports for saxophonists[463], trumpeters, trombonists and French horn players[464], and thumb-rest positions for clarinettists.[465] These studies indicate that the selection of specific equipment may influence biomechanical factors. Although the findings do not necessarily indicate that these equipment choices alter the risk of MSSs, they provide sufficient evidence to justify larger scale observational studies investigating the relationship between instrument-specific equipment choices/ instrument set-up and MSS outcomes. In doing so, advice provided to musicians regarding equipment choices may be effective in reducing the burden of musicians' MSSs.

Consistent with some of the perceived causes of MSSs reported in this study, the relationship between sitting time, time engaged in musical activity and stress (perceived causes identified in the present study), and MSS outcomes will be examined in Chapter 8. This analysis will lead to a better understanding the association between these perceived causes of MSSs and reported MSS outcomes in musicians, and may inform the development of interventions to reduce the burden of musicians' MSSs.

Because musician-driven data collection methods (i.e. open responses) were used in the present study, a comprehensive list of the most important perceived causes for musicians' MSSs was compiled (Appendix 1.7). This list may be used to develop questionnaire items of potential perceived causes for musicians to endorse in future studies. The most important factors identified were posture/ position (musical and non-musical), manual handling tasks (musical and non-musical), musical technique, duration and structure of musical activities, overuse/misuse, engaging in physical activity (non-musical), a lack of physical activity, and stress. Future studies utilising researcher-driven methods should ensure that these main factors are included in their questionnaire items.

Qualitative studies utilising in-depth interviews are also recommended to investigate musicians' perceived causes of their MSSs. These interviews may provide a more in-depth understanding of the causes of MSSs from the musicians' perspective than the current study, and should focus on the pathways linking various factors, as well as barriers to changing factors (e.g. behaviours) that the musicians believe led to their MSSs. Such a study may lead to the development of a conceptual framework from which path analysis could be used in quantitative studies to gain a better understanding of the relationship between factors leading to MSS outcomes. Coupled with the knowledge of barriers to change, the findings of such a path analysis would inform the development of interventions to reduce the burden of musicians' MSSs.

7.5.5 Conclusions

In the first study to comprehensively examine the perceived causes of musicians' MSSs in a diverse group of musicians, musicians largely attributed their MSSs to behavioural factors, including musical behaviours. All musicians reported at least one perceived cause that is likely preventable or modifiable, suggesting that musicians' MSSs are perceived to be preventable. Musicians themselves do not necessarily have control over all of the reported behavioural factors; hence the organisations that employ, train and support musicians may play an important role in the management of musicians' MSSs. Research should be directed towards the barriers and enablers relating to the behaviours identified as perceived causes of musicians' MSSs, and into the association between modifiable perceived causes and reported MSSs outcomes in epidemiological studies. In doing so, new strategies may be developed to address the burden of MSSs in musicians.

Key findings

- All participants reported at least one perceived cause that is likely modifiable and/or preventable, suggesting that musicians' MSSs are preventable.
- Behavioural factors were reported by 93.9% of musicians as perceived causes of MSSs:
  - 58.4% related to musical activity,
  - 12.7% physical activity,
  - 12.2% a lack of physical activity, and
  - 29.1% posture/ position (not specified as relating to musical activity).
- Biological factors were reported by 37.6% of musicians.
- Psychosocial factors were reported by 18.8% of musicians.
- External, physical factors were reported by 21.1% of musicians.
- Research should be directed towards the potential causes identified in this study, as possible risk factors for MSSs, and the barriers and enablers to changing the perceived behavioural causes of MSSs.

CHAPTER 8: MODIFIABLE PERSONAL FACTORS ASSOCIATED WITH MUSCULOSKELETAL SYMPTOM OUTCOMES

8.1 Introduction

The burden of musculoskeletal conditions in Australian university music students and professional musicians was established in Section B (Chapters 3-5) of this thesis, with the shoulder, wrist/ hand, neck, upper back, and lower back regions identified as priority regions for future research into musicians' musculoskeletal symptoms (MSSs). In order to reduce the identified burden, an understanding of the factors associated with MSS outcomes (e.g. presence and consequences) is required, as per van der Beek et al.'s[198] framework for the development and implementation of strategies to prevent work-related musculoskeletal disorders.

The study reported in this chapter examines the association between modifiable personal factors and MSS outcomes. The selection of the modifiable factors examined in this chapter was guided by gaps in the current evidence regarding musicians' MSSs (Chapter 1 and Appendix 2.2), musicians' perceived 'causes' of their MSSs (Chapter 7), and established risk factors for MSS outcomes in other populations (Chapter 1).

The research question for this chapter is: "is there an association between modifiable personal factors and MSS outcomes in Australian university music students and professional musicians?".

8.2 Background

Musculoskeletal disorders are the leading cause of musicians' workers' compensation claims (WCCs; Chapter 3), and musculoskeletal symptoms (MSSs) are experienced by the majority of musicians[48-52], including Australian university music students and professional musicians specifically (Chapter 4). In order to address the burden of musicians' MSSs the modifiable factors associated with MSS outcomes, specific to this population, should first be established.[198]

A recent systematic review[199] of risk factors for MSSs in university music students and professional musicians reported that high work-related stress levels and music performance anxiety were consistently associated with MSSs. However, these conclusions were made on the basis of few studies.[45, 222, 466, 467] Ultimately, Baadjou et al.[199] reported that they were unable to draw any conclusions regarding risk factors for musicians' MSSs. Baadjou et al.'s[199] review was limited in that it excluded studies of temporomandibular disorders, as well as marching band musicians and vocalists, and also appeared to exclude music teachers. Nonetheless, the findings of Baadjou et al.'s[199] review suggest a need to better understand the variables associated with musicians' MSS outcomes, in order to develop interventions to address the established MSS burden in musicians. The systematic mapping review (Chapter 1 and Appendix 2.2) revealed that much of the research into the association between potential risk factors and MSS outcomes in musicians has focused on non-modifiable factors. The present study focuses on modifiable factors, so that strategies to address the modifiable factors associated with MSS outcomes in musicians can be developed, to reduce the established burden of musculoskeletal conditions in musicians.

The present study investigates the association between BMI, typical daily sitting time, time engaged in musical activity, musical career satisfaction, musical social support, psychological distress and psychosocial stress, and MSS outcomes. Psychological distress and psychosocial stress are referred to as 'distress' and 'stress' respectively for the remainder of the chapter. These factors were selected based on the existing evidence of associations with MSS outcomes within the general population[111-118, 127, 130, 137, 150-155], musicians' perceived causes of their MSSs (Chapter 7), as well as gaps in the current evidence base for musicians' MSSs (Appendix 2.2). Psychological distress, which combines symptoms of anxiety and depression, was considered rather than anxiety and depression separately, as these conditions are often comorbid.[468] It is also anticipated that similar public health strategies would be recommended to address these conditions, and therefore a combined measure of psychological distress was appropriate.

The research question for this chapter is: "is there an association between modifiable personal factors and MSS outcomes in Australian university music students and professional musicians?".

The modifiable factors of interest were BMI, time spent sitting on a typical day, and time spent engaged in musical activity, as well as the self-reported levels of musical career satisfaction, musical social support, psychosocial stress, and psychological distress.

8.3 Methods

The methods for this research were reported in Chapter 2. The elements specific to Chapter 8 are described below. All musician participants were involved in the present study.

Elements of the questionnaire of relevance to the present chapter were demographic information, psychosocial factors, and MSS outcomes, as reported in Chapter 2. The psychosocial measures used were:

- the Patient Health Questionnaire-4 (PHQ-4)[370, 371] to measure psychological distress,
- Littman et al.'s[379] two-item stress questionnaire,
- the General Nordic Questionnaire for Psychological and Social Factors at Work (QPS_{Nordic})[378] support from co-workers sub-scale that was modified to specify support from other musicians, and
- the Michigan Organizational Assessment Questionnaire – Job Satisfaction Subscale (MOAQ-JSS)[377] that was modified for both students and workers, as well specifying that the ratings were for their musical career.

The MSS outcomes and data collection tools are summarised in Table 8.1, and the questionnaire is reported in full in Appendix 1.2, and summarised in Chapter 2.

Descriptive statistics were used to evaluate the overall sample, as well as the key sub-groups of musicians (females, males, university music students, professional employed musicians, and professional self-employed musicians). Descriptive statistics for the MSS outcomes were reported in Chapter 4, with the present chapter focusing on the association between modifiable personal factors and the MSS outcomes. Consistent with Chapters 4-5, pain intensity 'on average' was classified as mild (0-4) or moderate-severe pain (5-10)[413], while quartiles were used to analyse ratings of the emotional impact of MSSs and the impact of MSSs on daily life. For music-related musculoskeletal disorders (MRMDs) severity, interval-level w-scores from the Rasch analysis were used (Appendix 2.10). Unadjusted and adjusted regression analyses were performed, as reported in Chapter 2. Throughout Chapter 8, the default level of significance (5%) was used. Given the potential for multiple testing to influence results, the findings focus on identifying patterns of associations across MSS outcomes, rather than focusing on individual results.

Table 8.1: Musculoskeletal symptom outcomes and data collection tools used relevant to Chapter 8

Musculoskeletal symptom outcomes	Data collection tools used
The presence and location of MSSs in the last 12 months and 7 days	NMQ[67] modified for this study such that participants were asked whether they had experienced ache, pain or discomfort in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MSSs in the last 7 days, participants were also asked to indicate the laterality of their MSSs, and whether they had experienced their MSSs on most days for at least the last 3 months.
The presence and location of MRMDs in the last 12 months and 7 days	NMQ[67] modified to investigate MRMDs such that participants were asked whether they had experienced MRMDs in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MRMDs in the last 7 days, participants were also asked to indicate the laterality of their MRMDs, and whether they had experienced their MRMDs on most days for at least the last 3 months.
The intensity of pain on average in the last 7 days	Pain intensity on average was rated on a 11-point NRS, using the wording and anchors from the Brief Pain Inventory-Pain Intensity scale.[459]
The severity of MRMDs in the last 7 days	MRMD severity ratings at its worst and on average were rated on 11-point NRSs, with the anchors from the Brief Pain Inventory-Pain Interference scale.[459] The two scales were combined and transformed to w-scores as described in Chapter 2 and Appendix 2.10.
The impact of MSSs on daily life, the emotional impact of MSSs, and level of concern regarding MSSs in the last 7 days	Ratings were made on the consequences (impact on daily life), emotional impact, and concern scales of the Brief Illness Perception Questionnaire[407], which uses 11-point NRS. The scales asked about ache, pain or discomfort rather than illness.
The work/ study impact of MSSs in the last 12 months	Participants were asked whether they had made changes to their work/ study in the last 12 months due to MSSs, or had taken leave from work/ study in the last 12 months due to MSSs, with these items being based on the Extended NMQ[384] and enquiring as to whether the work/ study was musical or not. Participants were also asked whether they had claimed workers' compensation for their MSSs in the last 12 months for any work, and for musical work specifically.
The health professionals consulted for MSSs in the last 12 months	Participants were asked to indicate whether they had consulted the following health professionals for their MSSs in the last 12 months: medical professionals; physiotherapists or occupational therapists; psychologists or counsellors; personal trainers, Pilates instructors or yoga instructors; chiropractors, osteopaths, massage therapists, or Bowen therapists; naturopaths or homeopaths; Alexander technique practitioners, Feldenkrais practitioners and body mapping teachers; or other health professionals.
The self-management strategies used for MSSs in the last 12 months	Participants were asked to indicate the self-management strategies that they had tried for their MSSs in the last 12 months: heat or ice, medication, exercises or stretches, braces, strapping or taping, or other self-management strategies.
Discussing their MSSs with other musicians in the last 12 months	Participants were asked whether they had discussed their MSSs with other musicians in the last 12 months.
Current treatment for their MSSs	Participants were asked whether they were currently having treatment for their MSSs.

Notes: MSS: musculoskeletal symptom. NMQ: Nordic Musculoskeletal Questionnaire. MRMD: music-related musculoskeletal disorder (defined as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed"). NRS: numeric rating scale.

8.4 Results

A total of 317 musicians were included in the study. The median age was 25 years (interquartile range 20-46), and 55.4% of the sample were females. Demographic information is reported in Table 8.2.

8.4.1 Overall patterns

The overall patterns of associations between the modifiable personal factors and MSS outcomes are summarised in Tables 8.3-8.5. Table 8.3 reports the association between modifiable personal factors and MSS outcomes overall (i.e. in any body region), while Tables 8.4 and 8.5 report the associations with MSSs and MRMDs, respectively, in the combined and priority body regions. In these three tables, orange up arrows (↑) indicates a significant ($p<0.05$) adjusted odds ratio (AOR) >1, or adjusted beta coefficients >0. The blue down arrows (↓) indicates a significant AOR <1, or adjusted beta coefficient <0. The same colour coding is used throughout the results section.

Table 8.2: Demographic information for the musician sample (n=317)

	All musicians
Age in years (median, IQR)	25.0 (20.0-46.0)
Gender (%)	
Female	55.4
Male	44.3
Other	0.3
Body mass index (median, IQR)	24.3 (21.3-27.3)
Typical daily sitting time (%)	
<4 hours	20.6
4-8 hours	53.2
8+ hours	26.3
Socioeconomic status quartile[a] (%)	
1	24.1
2	24.4
3	24.4
4	27.0
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)
Hours worked in the last 7 days (median, IQR)	9.0 (0.0-20.0)
Age in years they started their musical activities (median, IQR)	8.0 (6.0-10.0)
Years of musical activity (median, IQR)	18.0 (12.0-38.0)
Amount of musical activity in the last 7 days (%)	
0-10 hours	36.1
10-20 hours	30.1
20 or more hours	33.9
Performed in the last 12 months (%)	90.3
Performed in the last 7 days (%)	56.0
Musical biomechanical exposure in the last 12 months (%)	
Singing/ woodwind/ brass	67.8
Singing	46.2
Brass	16.9
Woodwind	26.2
Flute	12.3
Reed	17.9
Saxophone	13.6
Upper string	14.5
Hands elevated at shoulder level to play	52.5
Repetitive elbow movement to play	74.9
Repetitive finger flexion/ extension to play	92.0
Repetitive finger adduction/ abduction to play	70.4
Repetitive foot movement to play	59.1
Musical biomechanical exposure in the last 7 days (%)	
Singing/ woodwind/ brass	58.5
Singing	35.5
Brass	13.2
Woodwind	21.2
Flute	8.7
Reed	15.6
Saxophone	11.5
Upper string	13.2
Hands elevated at shoulder level to play	42.0
Repetitive elbow movement to play	64.9
Repetitive finger flexion/ extension to play	88.4
Repetitive finger adduction/ abduction to play	64.4
Repetitive foot movement to play	48.2
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)
Social support score[b] (median, IQR)	48.0 (35.0-59.0)
Psychological distress score[b] (median, IQR)	40.0 (19.0-55.0)
Psychosocial stress score[b] (median, IQR)	25.0 (12.0-30.0)

Notes: IQR: interquartile range, [a]based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]using the W-scores derived from Rasch analyses (Appendices 2.11-2.14). For demographic information for the sub-groups, refer to Appendix 1.4.

Table 8.3: Summary of the significant associations (p<0.05) between the modifiable personal factors and musculoskeletal symptoms overall (i.e. in any body region) for musicians

	Sitting time						Musical time						Psychosocial stress						Psychological Distress						Musical career satisfaction						Musical social support					
	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS
Musculoskeletal symptoms																																				
Last 12 months										↑										↑		↑	↑													
Last 7 days	↑		↑	↑				↑						↑					↑		↑	↑	↑	↑	↓			↑								
Chronic[a]			↑											↑					↑				↑	↑	↓											
Chronic[a] of those with MSSs[b]																				↑			↑	↑												
Moderate-severe pain intensity[b]																			↑	↑											↓					
Music-related musculoskeletal disorders																																				
Last 12 months	↑		↑				↑	↑			↑						↑																			
Last 7 days			↑				↑	↑											↑				↑	↑												
Chronic[a]			↑																↑	↑			↑	↑										↓		
Chronic[a] of those with MRMDs[c]																																				
MRMDs severity ratings[c]									↓																						↓			↓		
Consequences																																				
Ratings of the impact of MSSs on daily life[b]									↑										↑	↑			↑								↓	↓	↓	↓		
Ratings of the emotional impact of MSSs[b]														↑					↑	↑	↑	↑	↑	↑									↓			
Leave from work/ study[d]																		↑	↑	↑		↑	↑													
Leave from musical work/study[d]																		↑	↑	↑			↑													
Changes to work/ study[d]																							↑													
Changes to musical work/ study[d]																							↑													
Consulted a health professional[d]										↑							↑																			
Engaged in self-management[d]							↑			↑													↑	↑												
Discussed their MSSs with another musician[d]							↑	↑		↑	↓										↑															
Current treatment[b]					↓															↑																

Notes: Orange up arrows (↑) indicate an adjusted odds ratio >1 or adjusted beta coefficient (for ratings) of >0. Blue down arrows (↓) indicate an adjusted odds ratio <1 or adjusted beta coefficient (for ratings) of <0. MSS: Musculoskeletal symptom, MRMD: music-related musculoskeletal disorder A: all musicians, M: male musicians, F: female musicians, S: student musicians, PE: professional employed musicians, PS: professional self-employed musicians. [a]chronic refers musculoskeletal symptoms or music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]of those reporting musculoskeletal symptoms in the last 7 days. [c]of those reporting music-related musculoskeletal disorders in the last 7 days. [d]of those reporting musculoskeletal symptoms in the last 12 months. Body mass index was omitted from the table above, as it was not associated with any of the musculoskeletal symptom outcomes after adjustment for confounders.

Table 8.4: Summary of the significant associations (p<0.05) between the modifiable personal factors and musculoskeletal symptoms by body region for musicians

	Body mass index						Sitting time						Musical time						Psychosocial stress						Psychological distress						Musical career satisfaction						Musical social support					
	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS
Last 12 months																																										
Combined regions																																										
Head/ orofacial																									↑	↑	↑	↑	↑	↑							↓			↓		
Upper limb																								↑	↑	↑			↑													
Neck/ trunk																									↑	↑		↑	↑	↑												
Lower limb																										↑																
Priority regions																																										
Neck		↓																							↑	↑	↑	↑	↑	↑												
Shoulder																↑									↑	↑		↑	↑	↑							↓			↓		
Wrist/ hand										↑									↑	↑	↑	↑																				
Upper back			↑		↑				↑														↑	↑		↑													↓			
Lower back																													↑	↑												
Last 7 days																																										
Combined regions																																										
Head/ orofacial															↑										↑		↑	↑	↑	↑										↓		
Upper limb																				↑					↑		↑	↑	↑	↑	↑			↑								
Neck/ trunk																							↑		↑	↑	↑	↑	↑	↑												
Lower limb																				↑																						
Priority regions																																										
Neck									↑	↑										↑					↑		↑	↑	↑	↑												
Shoulder																									↑	↑	↑	↑	↑	↑							↓					
Wrist/ hand					↓									↑						↑	↑		↑					↑						↑	↑							
Upper back																									↑				↑	↑												
Lower back																									↑		↑		↑	↑												

Notes: Orange up arrows (↑) indicate an adjusted odds ratio >1. Blue down arrows (↓) indicate a significant (p<0.05) adjusted odds ratio <1. A: all musicians, M: male musicians, F: female musicians, S: student musicians, PE: professional employed musicians, PS: professional self-employed musicians.

Table 8.5: Summary of the significant associations (p<0.05) between the modifiable personal factors and music-related musculoskeletal disorders by body region for musicians

	Body mass index						Sitting time						Musical time						Psychosocial stress						Psychological distress						Musical career satisfaction						Musical social support					
	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS	A	M	F	S	PE	PS
Last 12 months																																										
Combined regions																																										
Head/ orofacial								↓				↓					↑						↑	↑									↓						↓	↓		
Upper limb									↑				↑	↑			↑						↑	↑	↑																	
Neck/ trunk																	↑						↑	↑	↑																	
Lower limb																			↑	↑			↑																			
Priority regions																																										
Neck																	↑						↑	↑	↑														↓	↓		
Shoulder									↑				↑	↑			↑			↑	↑		↑	↑	↑												↓		↓	↓		
Wrist/ hand							↑		↑		↑		↑	↑			↑						↑	↑																		
Upper back	↑		↑						↑								↑				↑		↑	↑		↑																
Lower back																							↑	↑			↑												↓			
Last 7 days																																										
Combined regions																																										
Head/ orofacial												↓			↑															↑				↓			↓				↓	↓
Upper limb									↑				↑	↑			↑								↑	↑			↑	↑												
Neck/ trunk									↑	↑			↑										↑							↑												
Priority regions																																										
Neck													↑		↑		↑						↑		↑					↑										↓		
Shoulder													↑	↑	↑		↑								↑	↑			↑	↑										↓		
Wrist/ hand									↑					↑	↑		↑			↑										↑												
Upper back			↑		↑																		↑							↑										↓		
Lower back									↑														↑	↑															↓			

Notes: Orange up arrows (↑) indicate an adjusted odds ratio >1. Blue down arrows (↓) indicate a significant (p<0.05) adjusted odds ratio <1. A: all musicians, M: male musicians, F: female musicians, S: student musicians, PE: professional employed musicians, PS: professional self-employed musicians.

Overall, psychosocial factors were more commonly associated with MSS outcomes, compared with both the behavioural factors and BMI. Of these factors, distress was the variable most consistently associated with MSS outcomes, including MSS and MRMD prevalence, rating scales and taking leave from work/study due to MSSs. Other investigated factors were associated with some of the MSS outcomes, albeit in a less consistent manner, and in some cases only for particular sub-groups, as will be discussed in the following sections.

Statistically significant ($p<0.05$) findings after adjustment for potential confounders are reported for each of the modifiable personal factors in detail in the following sections, starting with BMI, followed by the behavioural factors, and concluding with the psychosocial factors. All findings with $p<0.10$ from the unadjusted and adjusted analyses are reported in Appendix 1.8.

8.4.2 Body mass index

Body mass index was not associated with any overall MSS outcomes (i.e. for any body region) for the whole sample, nor sub-groups. Body mass index was however associated with some MSS and MRMD outcomes in specific body regions, but the direction of the associations was inconsistent. For the overall sample, a higher BMI was associated with 12 month MRMDs in the upper back (AOR 1.061, 95% CI 1.007-1.118, p=0.026), and for males a higher BMI was associated with a lower 12 month neck MSS prevalence (AOR 0.908, 95% CI 0.835-0.988, p=0.026). In contrast, for females a higher BMI was associated with a higher prevalence of upper back MSSs in the last 12 months (AOR 1.131, 95% CI 1.033-1.240, p=0.008), and upper back MRMDs in the both the last 12 months (AOR 1.113, 95% CI 1.014-1.222, p=0.024) and the last 7 days (AOR 1.130, 95% CI 1.025-1.246, p=0.014). For employed professional musicians, a higher BMI was associated with a higher 12 month prevalence of upper back MSSs (AOR 1.080, 95% CI 1.003-1.163, p=0.041) and 7 day prevalence of upper back MRMDs (AOR 1.057, 95% CI 1.004-1.113, p=0.034), but a lower 7 day prevalence of wrist/ hand MSSs (AOR 0.894, 95% CI 0.812-0.984, p=0.022). There were no significant associations between BMI and any MSS outcome for university music students, nor self-employed professional musicians.

8.4.3 Typical daily sitting time

Higher levels of reported typical daily sitting time were associated with a higher 7 day prevalence of MSSs for all musicians, as well as amongst the sub-groups of females and students (Tables 8.6-8.7). Chronic MSSs was associated with typical daily sitting time for females only. Higher levels of typical daily sitting time were associated with a range of MRMD outcomes, particularly for female musicians (Tables 8.6-8.7). There were no associations between typical daily sitting time and the consequences of MSSs, nor any of the ratings (i.e. pain intensity, MRMD severity, emotional impact of MSSs, and impact of MSSs on daily life) for all musicians, and the sub-groups examined.

8.4.4 Time engaged in musical activity

Time engaged in musical activity (in the last 7 days) was more consistently associated with MRMDs compared with MSSs, both overall and in specific body regions (Tables 8.8-8.9). For the whole sample, musical activity time was associated with upper limb and neck/trunk MRMDs, as well as the neck, shoulder, and wrist/ hand specifically. Although there were inconsistencies in the findings across the sub-groups, associations between time engaged in musical activity and MRMD outcomes were more commonly associated with musical time, than with MSSs. Most associations between time engaged in musical activity and MRMD outcomes were significant for male musicians, and for employed professional musicians. There were no significant associations between time engaged in musical activity and MSS outcomes for self-employed musicians.

Table 8.6: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between typical daily sitting time, for all musicians, and stratified by gender

	All musicians	Male musicians	Female musicians
Musculoskeletal symptoms			
Last 12 months			
Priority regions			
Upper back			4-8: 6.108 (1.307-28.544), p=0.021* >8: 8.021 (1.562-41.198), p=0.013*
Last 7 days			
Overall	4-8: 2.304 (1.156-4.591), p=0.018* >8: 2.555 (1.141-5.725), p=0.023*		4-8: 5.589 (1.967-15.879), p=0.001** >8: 3.941 (1.227-12.663), p=0.021*
Chronic[a]			4-8: 5.120 (1.741-15.059), p=0.003** >8: 5.423 (1.668-17.631), p=0.005**
Combined regions			
Upper limb			4-8: 5.315 (1.829-15.444), p=0.002**
Priority regions			
Neck			4-8: 7.088 (2.239-22.442), p=0.001**
Music-related musculoskeletal disorders			
Last 12 months			
Overall	4-8: 2.002 (1.068-3.829), p=0.031* >8: 2.570 (1.236-5.343), p=0.012*		4-8: 2.619 (1.117-6.141), p=0.027* >8: 5.280 (1.896-14.704), p=0.001**
Combined regions			
Head/ orofacial		4-8: 0.267 (0.077-0.931), p=0.038* >8: 0.104 (0.017-0.639), p=0.015*	
Upper limb			>8: 4.661 (1.671-12.996), p=0.003**
Priority regions			
Shoulder			>8: 10.108 (2.703-37.804), p=0.001**
Wrist/ hand	>8: 2.948 (1.255-6.922), p=0.013*		>8: 7.887 (2.073-30.000), p=0.002**
Upper back			>8: 9.344 (2.102-41.527), p=0.003**
Last 7 days			
Overall			>8: 3.566 (1.336-9.516), p=0.011*
Chronic			4-8: 3.826 (1.287-11.377), p=0.016* >8: 4.186 (1.285-13.637), p=0.018*
Combined regions			
Upper limb			>8: 4.270 (1.461-12.482), p=0.008**
Neck/ trunk			>8: 4.482 (1.201-16.727), p=0.026*
Priority regions			
Wrist/ hand			4-8: 4.990 (1.069-23.286), p=0.041* >8: 6.183 (1.243-30.753), p=0.026*
Lower back			>8: 12.605 (1.444-110.021), p=0.022*

Notes: Reference group was <4 hours. [a]chronic musculoskeletal symptoms referred to musculoskeletal symptoms that were experienced on most days for at least the last 3 months. *p<0.050, **p<0.010, ***p<0.001

Table 8.7: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between typical daily sitting time for university music students, employed professional musicians and self-employed professional musicians

	Student musicians	Employed professional musicians	Self-employed professional musicians
Musculoskeletal symptoms			
Last 12 months			
Overall	4-8: 12.853 (2.036-81.137), p=0.007**		
Priority regions			
Wrist hand	4-8: 3.002 (1.060-8.506), p=0.039*		
Last 7 days			
Overall	4-8: 5.501 (1.967-15.382), p=0.001** >8: 4.756 (1.571-14.399), p=0.006**		
Priority regions			
Neck	4-8: 7.583 (1.636-35.147), p=0.010* >8: 6.310 (1.296-30.724), p=0.023*		
Music-related musculoskeletal disorders			
Last 12 months			
Combined regions			
Head/ orofacial			4-8: 0.228 (0.065-0.796), p=0.020* >8:0.044 (0.006-0.357), p=0.003**
Priority regions			
Wrist/ hand		>8: 4.555 (1.362-15.232), p=0.014*	
Last 7 days			
Combined regions			
Head/ orofacial			>8: 0.035 (0.002-0.615), p=0.002**
Neck/ trunk	>8: 3.844 (1.089-13.570), P=0.036*		
Consequences of musculoskeletal symptoms			
Current treatment[a]		>8: 0.214 (0.055-0.828), p=0.026*	

Notes: Reference group was <4 hours. [a]of the musicians who reported musculoskeletal symptoms in the last 7 days. *p<0.050, **p<0.010, ***p<0.001

Table 8.8: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between musical activity time for all musicians, and stratified by gender

	All musicians	Male musicians	Female musicians
Musculoskeletal symptoms			
Last 7 days			
Overall		10-20: 2.888 (1.099-7.587), p=0.031*	
Combined regions			
Head/ orofacial			>20: 3.091 (1.081-8.834), p=0.035*
Priority regions			
Wrist/ hand		10-20: 6.347 (1.834-21.968), p=0.004**	
		>20: 3.622 (1.008-13.017), p=0.049*	
Lower back		10-20: 3.093 (1.241-7.710), p=0.015*	
Music-related musculoskeletal disorders			
Last 12 months			
Overall	10-20: 2.287 (1.223-4.278), p=0.010*	10-20: 2.834 (1.164-6.897), p=0.022**	
	>20: 1..931 (1.032-3.612), p=0.039*		
Combined regions			
Upper limb	10-20: 2.013 (1.049-3.862), p=0.035*	10-20: 3.311 (1.236-8.868), p=0.017*	
	>2.304 (1.198-4.434), p=0.012*	>20: 3.012 (1.114-8.139), p=0.030*	
Priority regions			
Shoulder	>20: 3.059 (1.514-6.181), p=0.002**	>20: 2.843 (1.076-7.512), p=0.035*	
Wrist hand	10-20: 2.193 (1.064-4.518), p=0.033*	10-20: 10.042 (2.952-34.157), p<0.001***	
	>20: 2.366 (1.159-4.830), p=0.018*	>20: 4.510 (1.259-16.151), p=0.021*	
Last 7 days			
Overall	10-20: 2.075 (1.094-3.938), p=0.025*	10-20: 4.002 (1.564-10.241), p=0.004**	
	>20: 2.646 (1.392-5.030), p=0.003**		
Combined regions			
Head/ orofacial			10-20: 0.079 (0.007-0.849), p=0.036*
Upper limb	10-20: 2.609 (1.302-5.228), p=0.007**	10-20: 5.173 (1.782-15.018), p=0.003**	
	>20: 3.512 (1.759-7.013), p<0.001***	>20: 3.746 (1.202-11.672), p=0.023*	
Neck / trunk	>20: 2.858 (1.446-5.649), p=0.003**		
Priority regions			
Neck	>20: 3.117 (1.468-6.618), p=0.003**		>20: 7.569 (2.494-22.967), p=0.001***
Shoulder	>20: 3.745 (1.715-8.179), p=0.001**	10-20: 3.417 (1.042-11.204), p=0.043*	>20: 3.448 (1.175-10.116), p=0.024*
		>20 4.133 (1.185-14.423), p=0.026*	
Wrist/ hand		10-20: 6.242 (1.876-20.769), p=0.003**	
			>20: 3.402 (1.207-9.592), p=0.021*
Consequences of musculoskeletal symptoms			
Engagement in self-management[a]	10-20: 2.665 (1.052-6.753), p=0.039*		
Consulted musicians[a]	10-20: 2.938 (1.257-6.864), p=0.013*	10-20: 4.346 (1.042-18.130), p=0.044*	
	>20: 2.992 (1.304-6.866), p=0.010*	>20: 5.304 (1.303-21.591), p=0.020*	

Notes: Reference group was <10 hours. [a]among those that reported musculoskeletal symptoms in the last 12 months. *p<0.050, **p<0.010, ***p<0.001

The only rating for which musical activity time was associated was MRMD severity for females, with those who reported engaging in 10-20 hours of musical activity in the last week reported lower MRMD severity w-scores than those who engaged in <10 hours (adjusted beta coefficient -23.635, 95% CI -40.011-7.259, p=0.005). In contrast, compared with musicians who engaged in <10 hours of musical activity in the last week, musicians who engaged in 10-20 hours of musical activity (AOR 3.651, 95% CI 1.196-11.145, p=0.025) and >20 hours of musical activity (AOR 3.542, 95% CI 1.206-10.404, p=0.020) both reported higher ratings of the impact of MSSs on daily life.[jjj] Musical activity time was associated with engaging in self-management strategies for MSSs, and discussing MSSs with other musicians (Table 8.8-8.9).

Table 8.9: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between musical activity time for university music students and employed professional musicians

	Student musicians	Employed professional musicians
Musculoskeletal symptoms		
Last 12 months		
Overall	>20: 8.368 (1.450-48.297), p=0.018*	
Priority regions		
Shoulder	10-20: 4.092 (1.511-11.080), p=0.006**	
	>20: 3.321 (1.319-8.360), p=0.011*	
Music-related musculoskeletal disorders		
Last 12 months		
Overall		>20: 3.306 (1.037-7.957), p=0.008**
Combined regions		
Head/ orofacial		>20: 4.440 (1.382-14.262), p=0.012*
Upper limb		10-20: 3.267 (1.269-8.412), p=0.014*
		>20: 4.179 (1.648-10.598), p=0.003**
Neck/ trunk		10-20: 3.360 (1.345-8.388), p=0.009**
		>20: 4.024 (1.649-9.820), p=0.002**
Priority regions		
Neck		10-20: 3.268 (1.203-8.877), p=0.020*
		>20: 4.772 (1.737-13.112), p=0.002**
Shoulder		10-20: 2.963 (1.072-8.190), p=0.036*
		>20: 5.803 (2.120-15.890), p=0.001**
Wrist/ hand		10-20: 3.769 (1.297-10.951), p=0.015*
		>20: 5.436 (1.933-15.290), p=0.001**
Upper back		10-20: 3.789 (1.365-10.517), p=0.011*
		>20: 5.034 (1.877-13.494), p=0.001**
Last 7 days		
Overall		
Combined regions		
Upper limb		10-20: 5.104-1.722-15.129), p=0.003**
		>20: 9.473 (3.199-28.052), p<0.001***
Neck/ trunk		
Priority regions		
Neck		>20: 6.857 (2.082-22.588), p=0.002**
Shoulder		>20: 11.268 (2.783-45.616), p=0.001**
Wrist/ hand		>20: 4.760 (1.526-14.849), p=0.007**
Consequences of musculoskeletal symptoms		
Leave from musical study/ work[a]		
Consulted a health professional[a]	>20: 2.947 (1.084-8.015), p=0.034*	
Engaged in self-management[a]	>20: 4.834 (1.391-16.801), p=0.013*	
Consulted other musicians[a]	>20: 4.373 (1.646-11.620), p=0.003**	10-20: 0.299 (0.111-0.805), p=0.017*
		>20: 0.315 (0.105-0.941), p=0.039*

Notes: Reference group was <10 hours. [a]among those that reported musculoskeletal symptoms in the last 12 months. There were no statistically significant associations between musical activity time and musculoskeletal symptom outcomes for self-employed musicians; hence, they were not reported in the table above. *p<0.050, **p<0.010, ***p<0.001

8.4.3 Stress

Stress was not associated with MSS or MRMD overall outcomes for the whole sample of musicians. Stress was however associated with MSSs or MRMDs in specific body regions, particularly MSSs in the wrist/ hand in the last 12 months. Additionally, stress was associated with some MSS overall outcomes for male and professional musicians (Tables 8.10-8.11). In addition to the associations reported in Tables 8.10-8.11, stress levels were also associated

[jjj]For this analysis, the ratings of the impact of musculoskeletal symptoms on daily life were dichotomised using a median cut-point and analysed using binary logistic regression, as the parallel lines assumption was violated when quartiles were analysed using ordered logistic regression.

with the emotional impact of MSSs for male musicians (adjusted beta coefficient 0.035, 95% CI 0.000-0.074, p=0.049). There was an association between higher levels of stress and consulting a health professional for employed musicians, and taking leave from work/ study for self-employed musicians (Table 8.11).

Table 8.10: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between psychosocial stress and musculoskeletal symptom outcomes, and stratified by gender

	All musicians	Male musicians	Female musicians
Musculoskeletal symptoms			
Last 12 months			
Priority regions			
Wrist/ hand	1.042 (1.021-1.064), p<0.001***	1.057 (1.023-1.093), p=0.001**	1.030 (1.003-1.058), p=0.030*
Last 7 days			
Overall		1.034 (1.001-1.068), p=0.041*	
Chronic[a]		1.052 (1.017-1.089), p=0.004**	
Combined regions			
Upper limb		1.042 (1.009-1.076), p=0.012*	
Lower limb		1.046 (1.005-1.088), p=0.027*	
Priority regions			
Neck		1.042 (1.006-1.078), p=0.021*	
Wrist/ hand		1.503 (1.167-1.936), p=0.002**	1.030 (1.001-1.060), p=0.039*
Music-related musculoskeletal disorders			
Last 12 months			
Combined regions			
Lower limb	1.032 (1.004-1.060), p=0.026*	1.065 (1.013-1.119), P=0.014*	
Priority regions			
Shoulder		1.046 (1.010-1.083), P=0.012*	0.971 (0.943-0.999), p=0.042*
Upper back			0.959 (0.928-0.991), p=0.011*
Last 7 days			
Priority regions			
Wrist/ hand		1.046 (1.003-1.090), P=0.036*	

Notes: [a]chronic musculoskeletal symptoms referred to symptoms that were present on most days for at least the last 3 months. *p<0.050, **p<0.010, ***p<0.001

8.4.6 Distress

Distress appears to be the most important modifiable personal risk factor for MSS outcomes, for all sub-groups analysed (Tables 8.12-8.13). For the whole sample, distress was associated with MSSs and MRMDs in any region in the last 7 days, and chronic MSSs/MRMDs. Distress was also associated with MSSs in most body regions (for the whole sample), for the last 12 months and 7 days. Among the symptomatic musicians, distress was associated with taking leave, as well as other consequences, particularly for employed musicians (Tables 8.12-8.13). Of the musicians who reported MSSs in the last 7 days, there was a significant association between distress and moderate-severe pain ratings for all musicians (AOR 1.022, 95% CI 1.001-1.044, p=0.042) and male musicians (AOR 1.050, 95% CI 1.009-1.093, p=0.016) specifically. Distress was also associated with the emotional impact of MSSs among all (symptomatic) musicians, and all sub-groups of musicians. Furthermore, distress was associated with ratings of the impact of MSSs on daily life among all (symptomatic) musicians, and males specifically (Table 8.14).

Table 8.11: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between psychosocial stress and musculoskeletal symptom outcomes for university music students, employed professional musicians and self-employed professional musicians

	Student musicians	Employed professional musicians	Self-employed professional musicians
Musculoskeletal symptoms			
Last 12 months			
Combined regions			
Upper limb			1.083 (1.026-1.143), p=0.004**
Priority regions			
Wrist/ hand	1.043 (1.014-1.073), p=0.003**		
Upper back		1.034 (1.005-1.065), p=0.023*	1.041 (1.004-1.080), p=0.030*
Last 7 days			
Combined regions			
Neck/ trunk		1.040 (1.005-1.077), p=0.024*	
Priority regions			
Wrist/ hand		1.041 (1.008-1.074), p=0.014*	
Music-related musculoskeletal disorders			
Last 12 months			
Overall		1.044 (1.012-1.007), p=0.007**	
Combined regions			
Head/ orofacial		1.054 (1.016-1.095), p=0.006**	1.061 (1.015-1.110), p=0.009**
Upper limb		1.050 (1.015-1.085), p=0.003**	1.043 (1.006-1.081), p=0.024*
Neck/ trunk		1.074 (1.040-1.113), p<0.001***	1.067 (1.027-1.109), p=0.001**
Lower limb		1.040 (1.002-1.079), p=0.038*	
Priority regions			
Neck		1.072 (1.035-1.110), p<0.001***	1.067 (1.026-1.109), p=0.001**
Shoulder		1.063 (1.025-1.102), p=0.001**	1.064 (1.023-1.106), p=0.002**
Wrist/ hand		1.042 (1.008-1.077), p=0.014*	1.041 (1.005-1.078), p=0.023*
Upper back		1.036 (1.002-1.070), p=0.035*	1.056 (1.107-1.095), p=0.004**
Lower back		1.057 (1.023-1.091), p=0.001**	1.063 (1.025-1.102), p=0.001**
Last 7 days			
Combined regions			
Neck/ trunk		1.042 (1.010-1.074), p=0.010*	
Priority regions			
Neck		1.045 (1.008-1.082), p=0.015*	
Upper back		1.041 (1.001-1.083), p=0.047*	
Lower back		1.060 (1.021-1.101), p=0.003**	1.053 (1.000-1.108), p=0.049*
Consequences of musculoskeletal symptoms			
Leave from work/ study[a]			1.078 (1.023-1.135), p=0.005**
Leave from musical work/ study[a]			1.066 (1.008-1.127), p=0.026*
Consult a health professional[a]		1.040 (1.007-1.075), p=0.019*	

Notes: [a]of those who reported musculoskeletal symptoms in the last 12 months. *p<0.050, **p<0.010, ***p<0.001

Table 8.12: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between psychological distress and musculoskeletal symptom outcomes, and stratified by gender

	All musicians	Male musicians	Female musicians
Musculoskeletal symptoms			
Last 12 months			
Overall		1.038 (1.002-1.076), p=0.039*	
Combined regions			
Head/ orofacial	1.028 (1.011-.046), p=0.001**	1.033 (1.008-1.058), p=0.009**	1.022 (1.001-1.044), p=0.044*
Upper limb	1.028 (1.006-1.051), p=0.013*	1.042 (1.012-1.072), p=0.005**	
Neck/ trunk	1.032 (1.012-1.052), p=0.002**	1.036 (1.009-1.064), p=0.009**	
Lower limb		1.030 (1.006-1.054), p=0.015*	
Priority regions			
Neck	1.041 (1.022-1.060), p<0.001***	1.031 (1.008-1.056), p=0.010*	1.038 (1.012-1.064), p=0.003**
Shoulder	1.038 (1.019-1.057), p<0.001***	1.039 (1.014-1.065), p=0.002**	
Upper back		1.030 (1.005-1.056), p=0.017*	
Last 7 days			
Overall	1.030 (1.012-1.048), p=0.001**		1.043 (1.013-1.074), p=0.004**
Chronic[a]	1.029 (1.013-1.046), p=0.001**		
Chronic+[b]		1.041 (1.009-1.074), p=0.013*	
Combined regions			
Head/ orofacial	1.033 (1.013-1.053), p=0.001**		1.042 (1.013-1.071), p=0.004**
Upper limb	1.035 (1.019-1.053), p<0.001***		1.029 (1.005-1.053), p=0.019*
Neck/ trunk	1.033 (1.016-1.049), p<0.001***	1.024 (1.002-1.047), p=0.035*	1.039 (1.016-1.063), p=0.001**
Priority regions			
Neck	1.033 (1.016-1.050), p<0.001***		1.051 (1.025-1.077), p<0.001***
Shoulder	1.032 (1.015-1.049), p<0.001***	1.039 (1.014-1.064), p=0.002**	1.033 (1.009-1.057), p=0.006**
Upper back	1.018 (1.001-1.035), p=0.040*		
Lower back	1.018 (1.002-1.034), p=0.028*		1.029 (1.007-1.051), p=0.009**
Music-related musculoskeletal disorders			
Last 12 months			
Combined regions			
Upper limb	1.021 (1.005-1.037), p=0.012*		
Neck/ trunk	1.023 (1.006-1.039), p=0.006**		
Priority regions			
Neck	1.018 (1.002-1.034), p=0.029*		
Shoulder	1.023 (1.006-1.041), p=0.009**		
Upper back		1.034 (1.009-1.060), p=0.007**	
Lower back			1.028 (1.002-1.053), p=0.031*
Last 7 days			
Overall	1.018 (1.002-1.034), p=0.025*		
Chronic[a]	1.028 (1.009-1.046), p=0.003*	1.035 (1.007-1.064), p=0.014*	
Combined regions			
Upper limb	1.025 (1.008-1.043), p=0.004**	1.045 (1.016-1.074), p=0.002**	
Priority regions			
Neck	1.025 (1.006-1.045), p=0.010*		
Shoulder	1.022 (1.002-1.042), p=0.028*	1.045 (1.014-1.078), p=0.005**	
Consequences from musculoskeletal symptoms			
Leave from work/ study[c]	1.030 (1.010-1.050), p=0.003**	1.054 (1.017-1.092), p=0.004**	
Leave from musical work/study[c]	1.030 (1.008-1.052), p=0.006**	1.056 (1.014-1.099), p=0.008**	
Current treatment[d]		1.036 (1.004-1.070), p=0.028*	

Notes: [a]Chronic refers to musculoskeletal symptoms/music-related musculoskeletal disorders experienced on most days for at least the last 3 months. [b]Chronic+ refers to chronic musculoskeletal symptoms among those reporting these outcomes in the last 7 day only. [c]of those reporting musculoskeletal symptoms in the last 12 months. [d]of those reporting musculoskeletal symptoms in the last 7 days. *p<0.050, **p<0.010, ***p<0.001

Table 8.13: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between psychological distress and musculoskeletal symptom outcomes for university music students, employed professional musicians and self-employed professional musicians

	Student musicians	Employed professional musicians	Self-employed professional musicians
Musculoskeletal symptoms			
Last 12 months			
Overall	1.045 (1.002-1.091), p=0.041*	1.055 (1.010-1.103), p=0.017*	
Combined regions			
Head/ orofacial	1.037 (1.015-1.060), p=0.001**	1.029 (1.007-1.052), p=0.008**	1.056 (1.021-1.091), p=0.001**
Upper limb		1.038 (1.004-1.074), p=0.030*	
Neck/ trunk	1.025 (1.000-1.050), p=0.049*	1.063 (1.020-1.107), p=0.004**	1.060 (1.013-1.110), p=0.012*
Priority regions			
Neck	1.026 (1.005-1.048), p=0.014*	1.063 (1.035-1.093), p<0.001***	1.077 (1.035-1.121), p<0.001***
Shoulder	1.029 (1.006-1.053), p=0.014*	1.057 (1.028-1.086), p<0.001***	1.038 (1.007-1.071), p=0.017*
Lower back		1.025 (1.004-1.046), p=0.021*	1.027 (1.000-1.054), p=0.049*
Last 7 days			
Overall	1.026 (1.002-1.050) , p=0.032*	1.048 (1.020-1.007), p=0.001**	1.039 (1.006-1.073), p=0.019*
Chronic[a]		1.049 (1.025-1.074), p<0.001***	1.041 (1.013-1.070), p=0.004**
Chronic+[b]		1.037 (1.010-1.065), p=0.007**	1.032 (1.002-1.063), p=0.037*
Combined regions			
Head/ orofacial	1.030 (1.006-1.055), p=0.014*	1.025 (1.000-1.050), p=0.049*	1.044 (1.012-1.077), p=0.007**
Upper limb	1.031 (1.009-1.053), p=0.005**	1.044 (1.021-1.068), p<0.001***	1.034 (1.006-1.063), p=0.018*
Neck/ trunk	1.024 (1.003-1.046), p=0.027*	1.040 (1.013-1.067), p=0.003**	1.040 (1.012-1.069), p=0.005**
Priority regions			
Neck	1.022 (1.001-1.044), p=0.039*	1.045 (1.021-1.070), p<0.001***	1.057 (1.027-1.088), p<0.001***
Shoulder	1.027 (1.005-1.049), p=0.016*	1.051 (1.026-1.077), p<0.001***	1.043 (1.013-1.074), p=0.005**
Wrist/ hand	1.033 (1.010-1.056), p=0.005**		
Upper back		1.027 (1.003-1.052), p=0.025*	1.034 (1.004-1.065), p=0.026*
Lower back		1.031 (1.009-1.053), p=0.005**	1.026 (1.000-1.053), p=0.048*
Music-related musculoskeletal disorders			
Last 7 days			
Overall		1.027 (1.005-1.050), p=0.016*	1.040 (1.013-1.068), p=0.004**
Chronic[a]		1.034 (1.011-1.058), p=0.004**	1.049 (1.019-1.079), p=0.001**
Combined regions			
Head/ orofacial			1.047 (1.005-1.090), p=0.028*
Upper limb		1.030 (1.006-1.054), p=0.015*	1.044 (1.014-1.075), p=0.004**
Neck/ trunk			1.037 (1.009-1.067), p=0.010*
Priority regions			
Neck			1.049 (1.017-1.082), p=0.002**
Shoulder		1.036 (1.008-1.066), p=0.013*	1.048 (1.014-1.083), p=0.006**
Wrist/ hand			1.038 (1.007-1.071), p=0.018*
Upper back			1.034 (1.002-1.067), p=0.035*
Consequences of musculoskeletal symptoms			
Leave from work/ study[c]	1.031 (1.004-1.060), p=0.025*	1.047 (1.019-1.075), p=0.001**	
Leave from musical work/study[c]		1.052 (1.021-1.083), p=0.001**	
Changes to work/ study[c]		1.036 (1.006-1.066), p=0.018*	
Changes to musical work/ study[c]		1.034 (1.001-1.069), p=0.043*	
Self-management[c]		1.064 (1.022-1.108), p=0.003**	1.051 (1.001-1.103), p=0.047*

Notes: [a]Chronic refers to musculoskeletal symptoms/music-related musculoskeletal disorders experienced on most days for at least the last 3 months. [b]Chronic+ refers to chronic musculoskeletal symptoms among those reporting these outcomes in the last 7 day only. [c]of those reporting musculoskeletal symptoms in the last 12 months. *p<0.050, **p<0.010, ***p<0.001

Table 8.14: Adjusted beta coefficients (95% confidence intervals) for the significant (p<0.05) associations between psychological distress and ratings of the impact of musculoskeletal symptoms on daily life, and the emotional impact of musculoskeletal symptoms in the last 7 days, for all musicians, males, females, employed professionals and self-employed professionals specifically.

	All musicians	Male musicians	Female musicians	Employed professional musicians	Self-employed professional musicians
Impact of musculoskeletal symptoms on daily life	0.026 (0.009-0.042), p=0.002**	0.047 (0.018-0.076), p=0.001**		0.023 (0.001-0.046), p=0.044*	
Emotional impact of musculoskeletal symptoms	0.041 (0.024-0.058), p<0.001***	0.044 (0.017-0.072), p=0.002**	0.034 (0.012-0.057), p=0.003**	0.043 (0.019-0.067), p<0.001***	0.054 (0.025-0.084), p<0.001***

Notes: Ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. There were no significant associations for university music students; hence, they were omitted from the table above. *p<0.050, **p<0.010, ***p<0.001

8.4.7 Musical career satisfaction

Musical career satisfaction was sporadically associated with MSS outcomes across the musician groups, with variability in the direction of the associations. For all musicians, higher levels of musical career satisfaction were associated with a lower prevalence of chronic MSSs (AOR 0.953, 95% CI 0.912-0.995, p=0.029), but a higher 7 day prevalence of upper limb MSSs (AOR 1.038, 95% CI 1.005-1.073, p=0.022). For female musicians, the only MSS outcome associated with musical career satisfaction was head/orofacial MRMDs in the last 12 months (AOR 0.941, 95% CI 0.890-0.995, p=0.031); there were no associations for males. For university music students, the direction of associations was also mixed. Higher levels of musical career satisfaction were associated with a higher 7 day prevalence of MSSs overall (AOR 1.058, 95% CI 1.015-1.103, p=0.008), in the upper limb region (AOR 1.065, 95% CI 1.021-1.112, p=0.004), and in the wrist/ hand region (AOR 1.089, 95% CI 1.029-1.151, p=0.003). In contrast, higher levels of musical career satisfaction were associated with lower 7 day prevalence of head/orofacial MRMDs (AOR 0.889, 95% CI 0.830-0.951, p=0.001) among music students. There were no associations between the levels of musical career satisfaction and MSS outcomes for self-employed professional musicians, however for employed professional musicians higher levels of musical career satisfaction were associated with a higher 7 day prevalence of wrist/ hand MSSs (AOR 1.066, 95% CI 1.003-1.134, p=0.038). There were no significant associations between satisfaction and any ratings made, across all musicians, and sub-groups of musicians.

8.4.4 Musical social support

All significant associations between musical social support and any MSS outcomes indicated a protective effect of higher levels of musical social support (Table 8.15). Reported levels of musical social support were not associated with MSSs and MRMDs overall (i.e. in any body region) in both the last 12 months and 7 days in all musicians, and any of the sub-groups. For students, higher levels of musical social support had a protective effective against chronic MRMDs. Musical social support was also associated with MSSs and MRMDs in some body regions; however, there was little consistency across the sub-groups of musicians (Table 8.15).

Among symptomatic musicians, higher levels of social support from musicians were associated with a lower prevalence of moderate-severe pain for all musicians (AOR 0.982, 95% CI 0.966-0.999, p=0.042), but not for any sub-groups of musicians. Higher levels of social support from musicians were also associated with lower MRMD severity w-scores and ratings of the impact of MSSs on daily life among symptomatic musicians, particularly for students (Table 8.16). For symptomatic student musicians, higher levels of social support were also associated with a lower ratings of emotional impact of MSSs[kkk] (AOR 0.974, 95% CI 0.953-0.996, p=0.020).

8.5 Discussion

This is the first study to investigate the association between modifiable personal factors and MSS outcomes across all types of Australian university music students and professional musicians. Psychological distress was the most prominent factor associated with MSS outcomes, with some evidence indicating that further research into social support, stress, time engaged in musical activity, and typical daily sitting time is warranted. In the following sections, the findings of the present study are discussed within the context of the existing literature, and provide recommendations for interventions and future research.

[kkk]In this analysis, the emotional impact ratings were dichotomised with a median cut-point and analysed using binary logistic regression, as the parallel lines assumption was violated when the ratings were analysed as quartiles using ordered logistic regression

Table 8.15: Adjusted odds ratios (95% confidence intervals) for the significant (p<0.05) associations between musical social support and the prevalence of musculoskeletal symptoms and music-related musculoskeletal disorders, for all musicians, and females, university music students, employed professionals and self-employed professionals specifically

	All musicians	Female musicians	Student musicians	Employed professional musicians	Self-employed professional musicians
Musculoskeletal symptoms					
Last 12 months					
Combined regions					
Head/ orofacial	0.981 (0.967-0.995), p=0.007**		0.977 (0.958-0.996), p=0.016*		
Priority regions					
Upper back		0.978 (0.961-0.996), p=0.016*			
Shoulder	0.981 (0.968-0.994), p=0.006**		0.972 (0.952-0.992), p=0.006**		
Last 7 days					
Combined regions					
Head/ orofacial			0.976 (0.955-0.998), p=0.033*		
Priority regions					
Shoulder	0.986 (0.973-0.999), p=0.042*				
Music-related musculoskeletal disorders					
Last 12 months					
Combined regions					
Head/ orofacial		0.973 (0.949-0.998), p=0.032*	0.972 (0.949-0.995), p=0.019*		
Priority regions					
Neck		0.980 (0.962-0.997), p=0.022*	0.975 (0.957-0.993), p=0.006**		
Shoulder	0.979 (0.965-0.993), p=0.004**	0.977 (0.957-0.996), p=0.020*	0.973 (0.955-0.992), p=0.006**		
Lower back		0.968 (0.947-0.989), p=0.004**			
Last 7 days					
Overall					
Chronic[a]			0.978 (0.958-0.999), p=0.042*		
Combined regions					
Head/ orofacial	0.974 (0.953-0.995), p=0.018*			0.956 (0.926-0.987), p=0.006**	0.949 (0.912-0.986), p=0.008**
Priority regions					
Neck			0.978 (0.956-1.000), p=0.048*		
Shoulder			0.973 (0.951-0.995), p=0.016*		
Upper back			0.973 (0.950-0.996), p=0.024*		
Lower back		0.972 (0.948-0.997), p=0.027*			

Notes: [a]Chronic refers to music-related musculoskeletal disorders experienced on most days for at least the last 3 months. There were no statistically significant associations for male musicians; hence, they were omitted from the table above. *p<0.050, **p<0.010, ***p<0.001

Table 8.16: Adjusted beta coefficients (95% confidence intervals) for the significant (p<0.05) associations between musical social support and the severity of music-related musculoskeletal disorders, and the level of impact of musculoskeletal symptoms on daily life for all musicians, males and university music student specifically

	All musicians	Male musicians	Student musicians
Severity of MRMDs[a]	-0.243 (-0.477- -0.009), p=0.042*		-0.661 (-0.972- -0.034), p<0.001***
Impact of MSSs on general life[b]	-0.020 (-0.032- -0.007), p=0.003**	-0.025 (-0.046- -0.003), p=0.027*	-0.026 (-0.045- -0.007), p=0.006**

Notes: MRMD: music-related musculoskeletal symptom. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days, with w-scores used for regression analyses (Appendix 2.10). [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days, with ratings categorised as quartiles for analysis. There were no statistically significant associations between musical social support and ratings for females nor professional musicians; hence, these groups were omitted from the table above. *p<0.050, **p<0.010, ***p<0.001

8.5.1 The main factor to address: psychological distress

Psychological distress was the most commonly associated factor for MSS outcomes across all sub-groups, including the target group identified in Chapter 4 – self-employed musicians. The previous evidence of an association between distress, anxiety and depression, and MSS outcomes in musicians is mixed[45, 181, 214, 227, 261, 307], which may potentially be attributable to differences in the populations investigated, the specific 'exposures' (e.g. anxiety), differences in the specific MSS outcomes, and the measures used for both the exposure and outcome. The present study provides a more complete analysis of sub-groups of musicians (e.g. by gender and student/professional status), with a range of MSS outcomes, including the consequences of MSSs. The present study identified an association between distress and MSS outcomes - across all sub-groups and across a range of MSS outcomes - in the only study of musicians' MSSs where the measures used had undergone modern psychometric testing. This study therefore provides the most valid, and comprehensive examination of the association between distress and MSS outcomes in musicians and has identified that a significant association is present.

Given the cross-sectional nature of the study, the direction of the association between the distress and MSS outcomes (including MRMD) could not be established. However, there is evidence that distress and pain are often comorbid in the general population[469, 470], and longitudinal studies of other populations suggest a bidirectional relationship between pain, and anxiety and/or depression[471-473] (the components of psychological distress). Although not designed to determine the direction of association, triangulation of the findings reported in Chapters 4 (emotional impact of MSSs) and 7 (perceived causes of MSSs), and the present chapter tend to suggest a bidirectional relationship between psychosocial factors and MSS outcomes.

The associations between psychological distress and MSS outcomes support the recommendation that the vicious cycle of these health problems needs to be broken. Compared to the wider population, higher levels of distress are experienced by both university music students[192] and professional musicians.[191] In Australia specifically, mental health has also been identified as a problem for professional musicians, with 64% reporting that they had been diagnosed with a mental illness.[III] [56] Furthermore, both mental health and musculoskeletal disorders are priority areas for Safe Work Australia[6], and are two of the top three causes of years lived with disability globally.[1] Addressing musicians' distress is therefore recommended to reduce the level of condition in and of itself, but also the MSS burden.

Musicians should be made aware of the association between distress and MSS outcomes. The findings of the same survey used in the present chapter, suggest that a minority (6.0%) of musicians with MSSs have sought treatment from psychologists or counsellors in the last 12 months for their MSSs. These health professionals therefore appear to be under-utilised for pain management. Understanding the relationship between psychosocial factors, such as distress, and MSS outcomes - as well as the important role that psychologists and counsellors may play in management of MSSs - may therefore lead to an increased utilisation of these services.

[III]Recalculated from the numbers reported by van den Eydne et al.'s[56] report, combining 'musicians' and 'singers', with non-respondents excluded from the denominator

A recent qualitative study[56] of Australian professional musicians indicated that, to address the mental health issues among professional musicians, strategies were required to improve three key areas: the level of social support between musicians, resilience training, and access to health professionals who are aware of the unique challenges faced by musicians. Through improving mental health, we would anticipate a reduction in the burden of MSSs for musicians.

8.5.2 Other factors to consider

There was also evidence to suggest an association between typical daily sitting time, musical activity time, levels of musical social support and levels of psychosocial stress, and MSS outcomes, as will be described in the following sections. The evidence for an association between these modifiable personal factors and MSS outcomes was less consistent than the associations for distress. Some of the associations that were detected may have been due to multiple testing; hence, the discussion below focuses on the patterns that emerged, rather than specific outcomes.

8.5.2.1 Typical daily sitting time

Typical daily sitting time was associated with a range of MSS outcomes, particularly for female musicians. The associations between sitting time and MSS outcomes has not previously been investigated in musicians[mmm], although evidence from other populations suggests such an association.[117, 127] Of the symptomatic musicians within this present investigation, 8% reported that prolonged sitting time was one of the top three causes of their MSSs (Chapter 7), indicating some level of awareness of this potential problem within the musician population. The differences in the associations for males and females specifically may be due to physiological differences; however, it is also possible that there are biases in the self-reporting of typical daily sitting time between genders.

Confidence intervals were wide for many of the associations, particularly in the sub-group analyses, which is likely due to small sample sizes, and may have led to Type 2 errors. Nonetheless, the associations identified in this study indicate that future research into the association between sitting time and MSS outcomes for musicians should be further investigated, with larger samples of musicians. Given the potential for both recall and self-reporting bias, future research should consider the use of objective measures of sitting time to provide a more valid exposure measure.[474-476]

8.5.2.2 Musical activity time

Although 12.2% of musicians with MSSs reported that the duration and/or structure of their musical activities was one of the top three causes of their MSSs in the last 7 days (Chapter 7), there was no association between musical time and MSS prevalence. There was, however, an association between musical time and MRMDs, particularly among professional musicians. Baadjou et al.'s[199] systematic review into the risk factors for MSS outcomes suggested that the findings of previous studies into the relationship between time engaged in musical activity and MSS outcomes were inconsistent. As suggested by the findings of this study, the inconsistent findings reported by Baadjou et al.[199] may relate to differences in the specific MSS outcome investigated.

It is possible that musical activity was associated with MRMDs but not MSSs, because of differences in musicians' ability to detect differences in their musical abilities. Musicians performing at a higher level (and more likely to be engaging in more than 20 hours of musical activity per week) may be more sensitive to changes in their musical abilities due to MSSs, such that musicians who spend more time engaged in musical activity are more likely to

[mmm]Based on the systematic mapping review (Appendix 2.2), the update systematic search (Chapter 1), and targeted searches of the literature published prior to 2017

endorse MRMD questionnaire items. These musical impairments might not be detectable to audiences or even other musicians. Importantly, as with the associations between sitting time and MSS outcomes, the 95% CIs were wide, which may have resulted in Type 2 errors. It is therefore possible that, with a larger sample size, some of the statistically significant associations in the unadjusted analyses may have remained significant after adjustment for confounders.

The current evidence is insufficient to recommend that restrictions be placed on the time engaged in musical activity; however, the findings of this study suggest that more valid measures of both musical activity time and MRMDs may be required. Musical activity time could be examined using diaries; however, the benefit of this approach would need to be weighed against the added burden this strategy would place on musicians. Longer questionnaires to examine MRMD severity may be required (as discussed in Appendix 2.10). There is only one existing measure of the impact of MSSs on musical activities: the Disability of the Arm, Shoulder and Hand Questionnaire's performing arts module.[324, 477] This measure examines the impact that MSSs have on musical activity, however the scale focuses on the upper limb, is only applicable to instrumentalists[324, 477], and has not undergone modern psychometric testing. A comprehensive measure of MRMDs should, therefore, be developed which is applicable to all body regions, and to all types of musicians. Using these measures and a larger sample of musicians would provide more valid information regarding the association between musical activity time and MSS outcomes.

8.5.2.3 Stress

Stress was associated with some MSS outcomes; however, this was mainly when considering specific body regions, particularly for professional musicians. Previous evidence of an association between stress and MSS outcomes was scant, with one study[478] investigating the association between stress and pain in percussionists, and the other[211] focusing on symptoms of temporomandibuar joint dysfunction in professional symphony orchestra musicians. The present study is therefore the most comprehensive study to date of the association between stress and MSS outcomes in univeristy music students and professional musicians, and therefore also likely to be the most generalisable.

Stress was identified as one of the main perceived causes of MSSs in Chapter 7, with 14.6% of musicians reporting that stress was one of the three main causes of their MSSs. This finding appears inconsistent with the findings of this chapter, which may relate to musicians labelling symptoms of distress as stress in their free-text responses. Given that chronic stress can lead to anxiety and/or depression (the components of psychological distress)[479], a reduction in stress could potentially result in improvements in both MSS outcomes and psychological distress.

8.5.2.4 Musical social support

The finding that musical social support was not associated with MSS prevalence is consistent with the existing evidence[232] (albeit support at work, rather than from musicians more generally). The present study did, however, find an association between musical social support and pain intensity, MRMD severity, the emotional impact of MSSs, and the impact of MSSs on daily life, in at least one sub-group of musicians. Musical social support is therefore an important consideration for altering the experience of MSSs, and as indicated above, musicians have suggested that improving social support from other musicians would help to address their poor mental health.[56] Future studies should also consider developing questionnaires to specifically examine the level of social support from other musicians, as discussed in Appendix 2.14.

8.5.3 Factors with little evidence of an association

Musical career satisfaction and BMI were not associated with many of the MSS outcomes investigated in this study, which is consistent with the existing evidence of musicians.[192, 212, 214, 226, 262, 292, 293, 306, 480, 481] Musical career satisfaction was not generally associated with MSS outcomes for musicians. The associations that were identified may simply be due to multiple testing, as directions of associations were inconsistent, and there were relatively few associations detected. Had a more conservative level of significance been used (e.g. $p<0.01$), most of these associations would not have been considered statistically significant.

8.5.8 Conclusion

In this research, distress was identified as an important factor associated with MSS outcomes. To reduce the burden of MSSs in Australian university music students and professional musicians, psychological distress should be addressed, in view of its association with a range of MSS outcomes. Musicians should be made aware of the association between psychosocial factors, particularly distress, and MSS outcomes (as well as the role psychologists play in addressing both psychosocial issues and pain itself). There was some evidence to support an association between stress, social support, musical time and sitting time and some MSS outcomes, warranting further investigation. Research should be directed towards establishing effective strategies to reduce distress in university music students and professional musicians, in order to minimise the burden of musculoskeletal conditions in this population.

Key points:

- Psychological distress was the most commonly associated factor for both MSS and MRMD outcomes.
- There was some evidence to suggest that stress, time engaged in musical activity, sitting time and support from other musicians may be associated with MSS outcomes, warranting further research into these factors.
- It is recommended that:
  - Strategies to reduce distress be developed, evaluated and implemented in organisations which train, employ and support musicians;
  - That musicians be made aware of the association between these psychosocial factors and MSS outcomes; and
  - That future studies use more comprehensive measures of distress, stress, musical social support and MRMD severity, use diaries to determine musical activity time, and objective measures of sitting time, and investigate both MSSs and MRMDs as outcomes.

CHAPTER 9: ASSOCIATION BETWEEN PSYCHOSOCIAL ORGANISATIONAL FACTORS AND MUSCULOSKELETAL SYMPTOM OUTCOMES

9.1 Introduction

In Chapter 8, the associations between modifiable personal factors and musculoskeletal symptom (MSS) outcomes were investigated, whereas in the present chapter the associations between psychosocial organisational factors and MSS outcomes are examined.

Until now, only one study[212] has investigated the association between psychosocial organisational factors and MSS outcomes in musicians.[nnn] Kaufman-Cohen et al.[212] (who based their study on the job-demands-control model[355]) found no association between the elements of job-demand-control and various MSS outcomes in professional symphony orchestra musicians. The present study focuses on the effort-reward imbalance (ERI) model[354] which proposes that an imbalance between effort and reward at work results in occupational stress and in turn various adverse health outcomes[482], including MSSs.[359] It is proposed that the imbalance between effort and reward is a more important risk factor than effort and reward as individual items.[357]

The research question for this study is: “Is there an association between psychosocial organisational factors and MSS outcomes?”.

9.2 Background

The prevalence of MSSs among professional musicians is high[52], including in Australian professional musicians (Chapter 4), and musculoskeletal disorders account for the majority of musicians’ workers’ compensation claims and the majority of claim costs (Chapter 3). Despite this established burden, the risk factors for musicians’ MSSs have not adequately been investigated[199]; with few studies investigating psychosocial organisational factors (Appendix 2.2).

Psychosocial organisational factors, including occupational stress, may play an important role in the development of MSSs and their consequences. There are two prevailing models of occupational stress: the ERI model[354], and the job-demand-control model.[355] These models have been described as complementary[358], with a recent study finding that there was little value in investigating both models.[483] Only one study[212] of musicians’ MSS outcomes has investigated either of these models. Kaufman-Cohen et al.[212] investigated the association between elements of the job-demand-control model and MSS outcomes, finding that there was no significant association. Kaufman-Cohen et al.’s[212] findings, as well as the conclusion that the ERI model may be more appropriate for white collar workers[356] led to the selection of the ERI model as the basis of the present study.

Based on the notion of social reciprocity, the ERI model proposes that high effort and low reward may have a role in the emergence of some health conditions.[358] ‘Effort’ can be considered in terms of time pressure, interruptions/ disturbances, and increasing demand over time, and ‘reward’ in terms of job security, esteem and promotion opportunities. The ERI model hypotheses that: The combination of high effort and low reward will be a more important risk factor for illness then either factor individually; 2. Overcommitment is associated with adverse health outcomes; and 3. That those with both ERI and overcommitment may have the highest risk of adverse health outcomes.[357] In the present study, only the first hypothesis (i.e. not overcommitment) was investigated, given that

[nnn]Based on the systematic mapping review (Appendix 2.2), the update systematic search (Chapter 1), and a targeted search of the literature published before 2017.

previous evidence suggests that overcommitment is not as important as ERI when considering MSS outcomes.[359]

In addition to the ERI variables, the association between specific elements of safety climate and MSS outcomes was explored. The specific elements of interest were perceptions of the workplaces' communication and prioritisation of OHS, as well as the degree to which the individual is involved in OHS within the workplace. These are elements of safety climate that are of relevant to musicians and MSS outcomes, and have the potential to be modified within the organisation.

The research question addressed in this chapter is: "Is there an association between psychosocial organisational factors and MSS outcomes?".

The psychosocial organisational factors of interest were ERI (and its components: effort, reward, job security, promotion opportunities, esteem), and three safety climate factors (the organisation's communication and prioritisation of occupational health and safety (OHS), and the individual's involvement in OHS at work).

9.3 Methods

Chapter 2 outlined the overall methods of this research. Here the elements of the methods, specific to the study presented in this chapter are reported.

The study population for this study was musicians who were currently employed as a performing musician, or instrumental or singing teacher. Musicians who were only self-employed were excluded.

The questionnaire (Appendix 1.2) used is described in full in Chapter 2. This chapter draws on the data from the Short ERI Questionnaire[380] and Whysall's[382] modification of the Safety Climate Assessment Questionnaire[381], for the psychosocial organisational factors of interest. Participants were asked to only respond to these items with regards to their main musical employer. These measures, like all those used in this project, were analysed using the w-scores derived from the Rasch analysis (Chapter 2, and Appendices 2.15-2.16). The MSS outcomes and the data collection tools used are summarised in Table 9.1. Pain intensity ratings (on average) were classified as mild (0-4) or moderate-severe (5-10)[413], and the ratings for the impact of MSSs on daily life and the emotional impact of MSSs were analysed as binary variables, using a median cut-point.[ooo] The music-related musculoskeletal disorder (MRMDs) severity ratings were transformed into interval-level w-scores, as per the Rasch analysis (Appendix 2.10).

Unadjusted and adjusted regressions were conducted, as per the methods reported in Chapter 2. Within the present study, three analysis types were conducted: 1) included ERI as a dichotomous variable, determined using Siegrist et al.'s[358] proposed formula, with a cut-point at one[358], 2) effort and reward w-scores, and 3) effort, job security, esteem, and promotion opportunities w-scores. The analysis was not stratified by gender, owing to the relatively small sample size.

[ooo]A median cut-point was used instead of quartiles given the relatively small number of participants, and the parallel lines assumption for ordered logistic regression being violated when analysed as quartiles.

Table 9.1: Musculoskeletal symptom outcomes and data collection tools used relevant to Chapter 9

Musculoskeletal symptom outcomes	Data collection tools used
The presence and location of MSSs in the last 12 months and 7 days	NMQ[67] modified for this study such that participants were asked whether they had experienced ache, pain or discomfort in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MSSs in the last 7 days, participants were also asked to indicate the laterality of their MSSs, and whether they had experienced their MSSs on most days for at least the last 3 months.
The presence and location of MRMDs in the last 12 months and 7 days	NMQ[67] modified to investigate MRMDs such that participants were asked whether they had experienced MRMDs in the last 12 months or 7 days in the head, orofacial, neck, shoulder, elbow, wrist/ hand, upper back, chest/ abdomen, lower back, hip/ thigh, knee, and ankle/ foot regions. For MRMDs in the last 7 days, participants were also asked to indicate the laterality of their MRMDs, and whether they had experienced their MRMDs on most days for at least the last 3 months.
The intensity of pain on average in the last 7 days	Pain intensity on average was rated on a 11-point NRS, using the wording and anchors from the Brief Pain Inventory-Pain Intensity scale.[459]
The severity of MRMDs in the last 7 days	MRMD severity ratings at its worst, and on average were rated on 11-point NRSs, with the anchors from the Brief Pain Inventory-Pain Interference scale.[459] The two scales were combined and transformed to w-scores as described in Chapter 2 and Appendix 2.10.
The impact of MSSs on daily life, the emotional impact of MSSs, and level of concern regarding MSSs in the last 7 days	Ratings were made on the consequences (impact on daily life), emotional impact, and concern scales of the Brief Illness Perception Questionnaire[407], which uses 11-point NRS. The scales asked about "ache, pain or discomfort" rather than "illness".
The work/ study impact of MSSs in the last 12 months	Participants were asked whether they had made changes to their work/ study in the last 12 months due to MSSs, or had taken leave from work/ study in the last 12 months due to MSSs, with these items being based on the Extended NMQ[384] and enquiring as to whether the work/ study was musical or not. Participants were also asked whether they had claimed workers' compensation for their MSSs in the last 12 months for any work, and for musical work specifically.
The health professionals consulted for MSSs in the last 12 months	Participants were asked to indicate whether they had consulted the following health professionals for their MSSs in the last 12 months: medical professionals; physiotherapists or occupational therapists; psychologists or counsellors; personal trainers, Pilates instructors or yoga instructors; chiropractors, osteopaths, massage therapists, or Bowen therapists; naturopaths or homeopaths; Alexander technique practitioners, Feldenkrais practitioners or body mapping teachers; or other health professionals.
The self-management strategies used for MSSs in the last 12 months	Participants were asked to indicate the self-management strategies that they had tried for their MSSs in the last 12 months: heat or ice, medication, exercises or stretches, braces, strapping or taping, or other self-management strategies.
Discussing their MSSs with other musicians in the last 12 months	Participants were asked whether they had discussed their MSSs with other musicians in the last 12 months.
Current treatment for their MSSs	Participants were asked whether they were currently having treatment for their MSSs.

Notes: MSS: musculoskeletal symptom. NMQ: Nordic Musculoskeletal Questionnaire. MRMD: music-related musculoskeletal disorder (defined as "pain, weakness, lack of control, numbness, tingling, or other symptoms that have interfered with the musician's ability to do their musical activity at the level to which they are accustomed"). NRS: numeric rating scale.

9.4 Results

Of the 110 musicians who were included in the organisational factors analysis (i.e. those who were currently employed as musicians, and who completed at least one item for the organisational factors), 48.2% were female. The median age was 44 years (interquartile range 31-54; Table 9.2). Musicians indicated that their main musical employers were orchestras (16.4%), opera companies (14.5%), military bands (32.7%), 'other' performance organisations (7.3%), education departments/ universities (13.6%), and 'other' education organisations (14.5%). The prevalence and profile of MSSs for the employed musicians included in this study are reported in Appendix 1.9. The type of employment (e.g. casual, contract) could not be determined for 28 musicians who did not report the type of employment for the specific organisation. Of the musicians whose employment type with their main musical employer was available, 37.8% were permanent, 19.5% contract, 25.6% reservists, and 17.1% casual.

There was consistency in the findings across the three types of analysis (Tables 9.3-9.4). Regarding overall MSS outcomes (i.e. relating to MSSs and MRMDs in any body region), there were similarities between the three analyses with regards to the outcomes for which ERI or effort were associated. Analysis 3 (effort, security, promotion and esteem) provides the most information and the findings reported in the following section relate to this analysis. Findings from Analyses 1 and 2 are reported in Appendix 1.9.

9.4.2 Effort

The psychosocial organisational factor associated with the most MSS outcomes was effort (Table 9.5). Effort was also associated chronic MRMDs among the whole sample (adjusted odds ratio (AOR) 1.033, 95% confidence interval (CI) 1.010-1.057, p=0.006), and only including musicians who reported MRMDs in the last 7 days (AOR 1.052, 95% CI 1.005-1.102, p=0.028).

9.4.2 Reward sub-scales

Ratings of perceived promotion opportunities at work were associated with two outcomes. There was a significant association between lower perceived promotion opportunities and engagement in self-management strategies among musicians with MSSs in the last 12 months (AOR 0.923, 95% CI 0.855-0.995, p=0.038), and with lower ratings of the impact of MSSs on daily life in the last 7 days (AOR 0.947, 95% CI 0.901-0.996, p=0.035).

Higher levels of perceived job security were associated with a higher 12 prevalence of MSSs in the upper limb (AOR 1.111, 95% CI 1.029-1.200, p=0.007), and the shoulder region specifically (AOR 1.088, 95% CI 1.019-1.151, p=0.010). In contrast, higher levels of perceived job security were associated with a lower 7 day prevalence of lower back pain (AOR 0.942, 95% CI 0.899-0.987, p=0.012). Levels of esteem were not significantly associated with any of the MSS outcomes.

9.4.3 Safety climate sub-scales

Higher personal involvement in OHS was associated with a lower 12 month prevalence of lower back MSSs (AOR 0.977, 95% CI 0.963-0.992, p=0.003), but a higher 12 month prevalence of upper back MRMDs (AOR 1.028, 95% CI 1.006-1.049, p=0.011). Higher perceived prioritisation of OHS within an organisation was associated with a lower 12 month prevalence of neck MSSs (AOR 0.989, 95% CI 0.978-1.000, p=0.044). Where musicians perceived a higher prioritisation of OHS, a higher proportion of musicians discussed their MSSs with other musicians (AOR 0.975, 95% CI 0.957-0.993, p=0.006). Communication was associated with taking leave from work/ study (AOR 1.013, 95% CI 1.001-1.024, p=0.026) and engagement in self-management (AOR 1.029, 95% CI 1.006-1.052, p=0.014) of MSSs in the last 12 months. There was a strong correlation (0.794) between communication and prioritisation ratings; hence, the two variables were not included within the same models.

9.5 Discussion

In the first study to investigate the association between elements of ERI and safety climate, and MSS outcomes in employed musicians, the importance of effort as an organisational factor associated with the presence of MRMDs was identified. Elements of safety climate were rarely associated with any of the MSS outcomes investigated.

9.5.1 Effort

Effort was identified as an important factor associated with MRMDs, but not the presence of MSSs itself. This finding mirrors our earlier finding (Chapter 8) that time spent engaged in musical activity was generally associated with MRMD findings only, not MSSs. The three elements of 'effort' included in the Short ERI questionnaire used in this study include having time pressure, interruptions/ disturbances, and increasing demand over time. Of these three factors, addressing time pressure is likely the most practical change that could be made for performing musicians, in particular. For performance musicians the repertoire is generally decided well in advance of performances; hence, the sheet music may be made available to musicians earlier, thus reducing the time pressure at work.

Table 9.2: Sample demographics for the employed musicians (n=110)

Characteristic	
Age in years (median, IQR)	44.0 (31.0-54.0)
Female (%)	48.2
Body mass index (median, IQR)	25.3 (23.0-27.5)
Typical daily sitting time (%)	
<4 hours	25.5
4-8 hours	52.7
8+ hours	21.8
Socioeconomic status[a] (%)	
1	26.4
2	25.5
3	21.8
4	26.4
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-4.0)
Number of employers in the last 7 days (median, IQR)	2.0 (1.0-2.0)
Hours worked in the last 7 days (median, IQR)	20.0 (8.0-39.0)
Education main musical employer (%)	28.2
Current university music study (%)	15.3
Age (year) they started their musical activities (median, IQR)	8.0 (6.0-10.0)
Years of musical activity (median, IQR)	34.0 (24.0-44.0)
Amount of musical activity in the last 7 days (%)	
0-10 hours	31.8
10-20 hours	33.6
20 or more hours	34.6
Performed in the last 12 months (%)	95.4
Performed in the last 7 days (%)	61.3
Musical biomechanical exposures in the last 12 months (%)	
Singing/ woodwind/ brass	74.3
Singing	41.9
Brass	21.0
Woodwind	30.5
Flute	14.3
Reed	21.0
Saxophone	15.2
Upper string	12.3
Hands elevated at shoulder level to play	57.6
Repetitive elbow movement to play	68.6
Repetitive finger flexion/ extension to play	89.5
Repetitive finger adduction/ abduction to play	55.2
Repetitive foot movement to play	34.0
Musical biomechanical exposures in the last 7 days (%)	
Singing/ woodwind/ brass	65.4
Singing	30.6
Brass	18.7
Woodwind	25.2
Flute	12.2
Reed	15.9
Saxophone	11.2
Upper string	12.3
Hands elevated at shoulder level to play	53.3
Repetitive elbow movement to play	60.6
Repetitive finger flexion/ extension to play	86.3
Repetitive finger adduction/ abduction to play	46.2
Repetitive foot movement to play	34.0
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)
Social support score[b] (median, IQR)	48.0 (35.0-59.0)
Psychological distress score[b] (median, IQR)	33.0 (19.0-46.0)
Psychosocial stress score[b] (median, IQR)	25.0 (5.0-25.0)
Effort-reward imbalance (%)	40.4
Effort score[b] (median, IQR)	42.0 (34.0-64.0)
Reward score[b] (median, IQR)	54.0 (45.0-59.0)
Job security score[b] (median, IQR)	30.0 (21.0-30.0)
Promotion score[b] (median, IQR)	32.0 (25.0-43.0)
Esteem score[b] (median, IQR)	59.0 (41.0-93.0)
Communication score[b] (median, IQR)	122.0 (88.0-122.0)
Involvement score[b] (median, IQR)	56.0 (44.0-87.0)
Prioritisation score[b] (median, IQR)	105.0 (71.0-105.0)

Notes: IQR: interquartile range. [a]quartiles (for all musicians in this research, not just employed professionals) according to the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]using w-scores from the Rasch analyses (Chapter 2; Appendices 2.10-2.16).

Table 9.3: Summary of significant associations (p<0.05) between organisational, psychosocial factors and musculoskeletal symptom outcomes overall (i.e. in any body region) for employed musicians

	ERI	Effort		Promotion	Communication			Prioritisation		
Analysis	1	2	3	3	1	2	3	1	2	3
Musculoskeletal symptoms										
Last 7 days										
Chronic[a]	↑									
Chronic+[b]	↑									
Music-related musculoskeletal disorders										
12 months	↑	↑	↑							
7 days	↑	↑	↑							
Chronic[a]	↑	↑	↑							
Chronic+[b]	↑	↑	↑							
Consequences of musculoskeletal symptoms in the last 12 months										
Leave from work/study							↑			
Engage in self-management				↓	↑	↑	↑			↓
Consulting a musician								↓	↓	↓
Musculoskeletal symptom ratings for the last 7 days										
Impact of musculoskeletal symptoms on daily life				↓						

Notes: Orange up arrows (↑) indicate a significant adjusted odds ratio of >1 or an adjusted beta coefficient of >0 (for ratings), and blue down arrows (↓) indicate a significant adjusted odds ratio of <1, or an adjusted beta coefficient of <0 (for ratings). ERI: effort-reward imbalance. Analysis 1 included effort-reward imbalance, the safety climate variables and potential confounders, Analysis 2 included effort and reward, the safety climate variables, and potential confounders, Analysis 3 included effort, job promotion opportunities, esteem, and job security. [a]chronic referred to musculoskeletal symptoms/ music-related musculoskeletal disorders that were experienced on most days for at least the last 3 months, with all musicians included in the denominator. [b]chronic+ referred to musculoskeletal symptoms/ music-related musculoskeletal disorders that were experienced on most days for at least the last 3 months, with only symptomatic musicians included in the denominator. There were not significant associations between reward, esteem, job security, and involvement, and any of the overall musculoskeletal symptom outcomes, and have therefore been omitted from the table above.

Table 9.4: Summary of significant associations (p<0.05) between organisational, psychosocial factors, and musculoskeletal symptoms and music-related musculoskeletal disorders in specific body regions

	ERI	Effort		Security	Prioritisation			Involvement		
Analysis	1	2	3	3	1	2	3	1	2	3
Musculoskeletal symptoms										
Last 12 months										
Combined regions										
Upper limb				↑						
Priority regions										
Neck					↓	↓	↓			
Shoulder				↑						
Lower back								↓	↓	↓
Last 7 days										
Combined regions										
Head/ orofacial	↑									
Priority regions										
Lower back		↑		↓						
Music-related musculoskeletal disorders										
Last 12 months										
Combined regions										
Head/ orofacial	↑									
Upper limb	↑	↑	↑							
Lower limb	↑	↑	↑							
Priority regions										
Wrist/ hand	↑	↑	↑							
Upper back								↑	↑	↑
Lower back	↑	↑	↑							
Last 7 days										
Collapsed regions										
Upper limb		↑	↑							
Neck/ trunk	↑									
Lower limb	↑	↑	↑							
Priority region										
Lower back	↑	↑	↑							

Notes: Orange up arrows (↑) indicate a significant adjusted odds ratio of >1, and blue down arrows (↓) indicate a significant adjusted odds ratio of <1. ERI: effort-reward imbalance. Analysis 1 included effort-reward imbalance, the safety climate variables and potential confounders, Analysis 2 included effort and reward, the safety climate variables, and potential confounders, Analysis 3 included effort, job promotion opportunities, esteem, and job security. There were not significant associations between reward, job promotion opportunities, and esteem, and any of the overall musculoskeletal symptom outcomes, and have therefore been omitted from the table above.

Table 9.5: Adjusted odds ratio (95% confidence intervals) for the significant (p<0.05) associations between perceived effort and music-related musculoskeletal disorders in the last 12 months and 7 days among employed musicians

	12 months	7 days
Overall	1.032 (1.010-1.055), p=0.004**	1.031 (1.011-1.051), p=0.002**
Combined regions		
Upper limb	1.030 91.009-1.051), p=0.006**	1.025 (1.002-1.048), p=0.032*
Lower limb	1.023 (1.002-1.044), p=0.035*	1.030 (1.002-0.058), p=0.035*
Priority regions		
Wrist/ hand	1.028 (1.008-1.048), p=0.006**	
Lower back	1.019 (1.002-1.037), p=0.025*	1.038 (1.013-1.063), p=0.003**

Note: *p<0.050, **p<0.010, ***p<0.001

9.5.2 Reward sub-scales

In contrast with the ERI model, reward and the reward subscales were not generally found to be associated with MSS outcomes for musicians. While some associations between MSS outcomes and promotion opportunities and job security were observed, these associations may be the result of multiple testing. This unexpected finding may also relate to musicians being driven by different rewards to the general workforce. Musicians have been described as 'subjective careerists'[56]; that is they have a 'calling' or are internally driven to participate in their career[484], in contrast with 'objective careerists' who are driven by external factors like job security, position, and salary[56] (core elements of the reward component of the ERI questionnaires). This distinction may explain why elements of reward were not an important factor for musicians, as the rewards examined in the ERI model focus on 'objective careerists'. It may be that musicians rewards are more personal, for instance being pleased with a performance, or overcoming the technical challenges of a piece. Musicians may also derive reward from influences external to the organisation they work for, such as the audience's applause, or a positive review of their performance. These rewards are not captured within the ERI questionnaires, which may indicate that musician-specific questionnaires are required, however this would arguably no longer be an organisational factor, given the rewards are external to the organisation. Nonetheless, further development of the concepts of effort and reward within the context of 'subjective careerists', like musicians, may be warranted.

9.5.3 Aspects of safety climate

For the elements of safety climate, there was strong correlation between communication and prioritisation of OHS was identified for musicians, which may indicate that communication of OHS within a workplace may lead to individuals perceiving the workplace has a high prioritisation of OHS. Regarding the presence of MSSs or MRMDs, the only association was for neck MSSs in the last 12 months and high prioritisation of OHS, while higher ratings of involvement were associated with higher 12 month prevalence of MRMDs in the upper back, and lower 12 month prevalence of MSSs in the lower back. Musicians with MSSs who engaged in self-management strategies or who took leave from work or study were more likely to report higher levels of workplace communication regarding OHS. It is possible that open communication regarding OHS creates a safe environment for musicians to manage their MSSs. Communication may have also included leave policies, as well as education of musicians regarding self-management strategies for MSS.

9.5.4 Future directions

Because effort was identified as an important factor associated with the presence of MRMDs, the development of a musician-specific effort and reward questionnaire may be warranted. Musicians and their employers should be involved in focus groups to develop such a questionnaire so that effort and reward may be conceptualised in a way that is specific to musicians, leading to a more appropriate measure of effort and reward for this population. It is also possible that musicians gain reward from sources beyond the organisation (e.g. audiences), which may also be appropriate to include in future research of musicians' MSS outcomes.

It is also recommended that future studies consider musicians' multiple employers when examining the relationship between organisational factors and health outcomes, including MSS outcomes. To achieve this, musicians could be asked to complete the questionnaire items for each of their employers, and the scores weighted according to the hours worked for each employer. The utility of such an approach would, however, first need to be established.

9.5.5 Conclusions

In the first study to investigate ERI and safety climate elements in employed musicians, the role of perceived effort in the presence of MRMDs and ratings of the impact of MSSs was identified. The present study indicates that effort may be an important factor to consider in future research, justifying the development of musician specific measures of effort and reward. Future work into the organisational factors related to MSS outcomes in musicians is warranted.

Key findings

- The findings of this study indicate that effort was the most important organisational factor in terms of MSS outcomes for musicians.
- Reward was not associated with any MSS outcomes, and reward subscales and elements of safety climate were only sporadically associated with MSS outcomes.

SUMMARY OF SECTION C

The preventability of the burden of musculoskeletal conditions in Australian university music students and professional musicians was investigated in Section C. The key findings of Chapters 6-9 support the notion of preventability, as indicated in Figure C. Minimising psychological distress would lead to a reduction in the burden of musicians' musculoskeletal conditions.

Is the burden of musculoskeletal conditions among Australian university music students and professional musicians preventable?

What were the reported mechanisms and agencies for musicians' musculoskeletal disorder workers' compensation claims?

Chapter 6: Workers' compensation claims data

- Body stressing was reported the mechanism for:
  - 88% of musculoskeletal disease claims,
  - 62% of musculoskeletal injury claims, and
  - 82% of upper limb musculoskeletal claims.
- "Other equipment" (including musical instruments) was the reported agency for:
  - 40% of all musculoskeletal claims, and
  - 51% of upper limb musculoskeletal claims.

What do musicians' who reported experiencing MSSs in the last 7-days believe caused their MSSs?

Chapter 7: Survey data

- All musicians with MSSs reported modifiable or preventable factors.
- 94% listed a behavioural factor:
  - Aspects of musical activity (58%):
    - Posture/ position (31%), and
    - Technique/ muscle use (22%),
  - General posture (30%),
  - Manual handling (15%),
  - Lack of physical activity (13%), and
  - Physical activity/ exercise (15%).
- 38% listed a biological factor.
- 19% a psychosocial factor:
  - Stress (15%)

What is the association between modifiable, personal factors and MSS outcomes among musicians?

Chapter 8: Survey data

- Psychological distress was associated with MSSs and MRMDs in the majority of body regions, for most groups of musicians.
- Social support was associated with the impact of MSSs.
- There was some evidence suggesting an association between stress, sitting time, and time engaged in musical activity and MSS outcomes.

What is the association between organisational, psychosocial factors and MSS outcomes among professional employed musicians?

Chapter 9: Survey data

- Occupational effort was associated with:
  - MRMDs in any body region, and most specific body regions.
- Involvement, priority, communication, reward, job security, promotion opportunities, esteem were not associated with most MSS outcomes.

Yes

Figure C: Summary of findings to answer the question "Is the burden of musculoskeletal conditions among Australian university music students and professional musicians preventable?"

Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder

SECTION D:
Discussion and recommendations

Section D (Chapter 10) is the discussion and recommendations section. It brings together the findings of Sections B and C to answer the central research question "is there a preventable burden of musculoskeletal conditions in Australian university music students and professional musicians?". The findings of this research are discussed within the context of the existing evidence base for both musicians and the general population. Evidence-based recommendations are drawn from this research to guide future research and practice.

CHAPTER 10: GENERAL DISCUSSION

10.1 Introduction

This thesis addresses musculoskeletal conditions, which are one of the leading causes of years lived with disability globally[1] and a priority area identified by Safe Work Australia[6], in an under-investigated population: university music students and professional musicians. Musculoskeletal symptoms (MSSs) may have a devastating impact on musicians, with some musicians even stopping playing[450] or changing careers due to MSSs.[61, 62] It is therefore critical to establish the extent, profile and preventability of the burden of MSSs for musicians. For these reasons, this thesis was designed to answer the central research question "Is there a preventable burden of musculoskeletal conditions for Australian university music students and professional musicians?". The findings suggest that the answer is yes, and the thesis contributes significant original findings to help address the identified burden.

An analysis of workers' compensation claims (WCCs) data is presented, with musculoskeletal disorders (MSDs) identified as the most common and costly type of claim for musicians (Chapter 3) – thereby justifying a focus on the prevention and management of MSDs for professional musicians to decrease the societal cost of this burden. The work presented here appears to be the first such analysis. Importantly, the survey work also informing the conclusions and recommendations, includes a range of university music students and professional musicians (e.g. popular, jazz, opera), rather than focusing on classical/orchestral musicians as has been the case in the majority of past studies (Chapter 1 and Appendix 2.2). The importance of this lies in the generalisability of recommendations across all groups of musicians, because expenditure to address MSSs may otherwise be inappropriately targeted.

Additionally, in reviewing the literature to develop the questionnaire (Chapter 2 and Appendix 2.5) it became clear that the data collection tools and MSS outcomes varied considerably in the published research. To ensure that the questionnaire used in the research presented in this thesis did not contribute to the heterogeneity of MSS data collection tools and outcomes, recommendations were developed based on the most commonly used data collection tools and outcomes, and the broader evidence base (Chapter 2 and Appendix 2.5). The survey results describe the extent, severity, and consequences of MSSs (Chapter 4) that are consistent with existing knowledge, but more generalisable for the reasons discussed above. It also identifies psychological distress as the most important modifiable factor associated with MSS outcomes (Chapter 8), and further research should therefore develop interventions to target psychological distress in musicians.

The findings of this thesis support the notion that there is a significant MSS burden in musicians, and that this burden is likely preventable, with particular attention to reducing psychological distress. As evidence emerges regarding the association between modifiable factors and MSS outcomes for musicians, research needs to shift towards intervention studies, and if found to be safe and effective, more widespread implementation. Strategies to address psychological distress and other modifiable factors associated with MSS outcomes should not be restricted to workplace interventions, because the majority of Australian musicians are either self-employed or freelance.[21] Indeed, self-employed musicians, particularly those who are both employed and self-employed, appear to have the highest burden of MSSs (Chapter 4), further supporting this notion. The proportion of self-employed or freelance musicians is increasing[21, 54], and this trend is likely to continue with increasing financial pressure in the sector, making it all the more important to have interventions that are not restricted to the workplace.

The thesis has provided a rigorous approach to analysing the key issues discussed above, and a summary of the evidence base supporting the argument is presented chapter by chapter in Figures 10.1 and 10.2 below for ease of reference. The key findings are then discussed in Section 10.2, followed by future directions in 10.3, and the conclusion in 10.4.

10.2 Key findings

This section is presented in two parts: the burden of MSSs is discussed in Section 10.2.1, and the preventability of the burden in Section 10.2.2.

10.2.1 There is a burden of musculoskeletal symptoms among musicians

Drawing upon the findings of the analyses of the WCCs data, and the questionnaire survey, it will be argued that there is a preventable burden of musculoskeletal conditions in Australian university music students and professional musicians.

10.2.1.1 Evidence from workers' compensation claims data

For professional musicians, the burden is evident from the WCCs data where most claims (69.8%) and the majority of the costs of claims (77.8%) related to work-related musculoskeletal disorders (WRMSDs; Chapter 3). Owing to the lack of a valid denominator, the incidence of WRMSD claims could not be established (Chapters 2-3). While it has been suggested that professional orchestral musicians under-utilise workers' compensation, this is reportedly due to the majority of musicians choosing not to claim as the injury was not deemed bad enough to take time off from work.[64] Although WCCs are likely the 'tip of the iceberg' it may be argued that claimed conditions are the most important to address with public health strategies, given their severity and burden. Workers' compensation claims have previously threatened the viability of Australia's orchestras[451], hence the burden of WRMSDs for the music industry is clear. In the following sections, the findings from the questionnaire survey are discussed to provide a more complete picture of the extent and burden of musicians' conditions.

10.2.1.2 Evidence from survey findings

Prevalence and body regions

Given the limitations of the WCCs data (Chapter 3), the findings of the WCCs data analysis were supplemented with a targeted questionnaire survey that included university music students (i.e. pre-professional musicians) and professional musicians (performers and teachers) from two Australian states. Consistent with the existing literature regarding the prevalence of MSSs among university music students and professional musicians[52], 90.1% of musicians reported MSSs in the last 12 months, and 72.1% in the last 7 days (Chapter 4). Musculoskeletal symptoms were most commonly experienced in the neck, shoulder, wrist/ hand, upper back, and lower back regions, and this finding was consistent across most sub-groups of musicians (Chapter 4). This finding is also consistent with the WCCs data where most MSD claims were for the upper limb region (Chapter 3).

Unlike much of the existing evidence base[63, 182-184, 202, 207, 287, 298], musicians did not report a higher prevalence of MSSs than other populations; indeed there was no significant difference between music and reference groups for the 12 month and 7 day MSS prevalence overall (i.e. in any body region; Chapter 5). University music students did, however, report a significantly higher prevalence of MSSs in the wrist/ hand region compared with science students. The differences between the existing evidence and the findings of this thesis may be due to differences in the populations investigated (both the musician and reference groups), specific MSS outcomes investigated, data collection tools used and, and statistical analyses conducted (as discussed in Chapter 5).

Is there a burden of musculoskeletal conditions among Australian university music students and professional musicians?

What proportion and cost of employed musicians' workers' compensation claims were due to musculoskeletal disorders?

What is the profile of these claims?

(Chapter 3: Workers' compensation claims data)

- 70% of all musicians' compensation claims were for musculoskeletal disorders.
- 60% of musculoskeletal disorder claims were for injuries.
- 50% of musculoskeletal disorder claims were for the upper limb.
- 66% of musculoskeletal disease claims were for the upper limb.
- 78% of the cost of all claims were for musculoskeletal disorders.
- 58% of the cost of musculoskeletal disorder claims were for injuries.
- 50% of the cost of musculoskeletal disorder claims were for upper limb conditions.

What is the prevalence and profile of musculoskeletal symptoms among professional and university student musicians?

Which group of musicians has the highest burden?

(Chapter 4: Survey data)

- 90% of musicians reported MSSs in the last 12 months, 72% in the last 7 days.
- Over half the musicians with MSSs reported impaired musical activity due to MSSs (last 12 months, and 7 days).
- Of those with MSSs in the last 12 months,
  - 65% consulted a health professional,
  - 22% took leave from work/study, and
  - 16% made changes to work/ study.
- Of those with MSSs in the last 7 days,
  - 96% reported an impact on their general lives,
  - 81% reported an emotional impact, and
  - 49% had chronic MSSs.
- The most commonly affected regions for MSS and MRMD were the neck, shoulder, wrist/ hand, upper back and lower back, across most sub-groups.
- There were some differences in the prevalence and profile of MSS outcomes across sub-groups of musicians, suggesting that self-employed musicians should be prioritised.

How does the prevalence and profile of MSS differ between musician and reference groups?

(Chapter 5: Survey data)

- There was no significant differences in the overall 12 month and 7 day prevalence of MSSs between the music and reference groups.
- Compared with science students, music students had:
  - a higher prevalence of wrist/ hand MSSs in the last 12 months and 7 days,
  - higher ratings of emotional impact of MSSs, and
  - a higher proportion of symptomatic musicians making changes to work/study due to MSSs.
- The only outcome where professional musicians had a higher MSS outcome prevalence or rating was in the gender-stratified analysis:
  - A higher proportion of symptomatic female professional musicians rated their pain intensity as moderate-severe in the last 7 days, compared with female university staff

Yes

Figure 10.1: Summary of findings to answer the question "Is there a burden of musculoskeletal conditions among Australian university music students and professional musicians?"
Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder

Is the burden of musculoskeletal conditions among Australian university music students and professional musicians preventable?

What were the reported mechanisms and agencies for musicians' musculoskeletal disorder workers' compensation claims?

Chapter 6: Workers' compensation claims data

- Body stressing was reported the mechanism for:
    - 88% of musculoskeletal disease claims,
    - 62% of musculoskeletal injury claims, and
    - 82% of upper limb musculoskeletal claims.
- "Other equipment" (including musical instruments) was the reported agency for:
    - 40% of all musculoskeletal claims, and
    - 51% of upper limb musculoskeletal claims.

What do musicians' who reported experiencing MSSs in the last 7-days believe caused their MSSs?

Chapter 7: Survey data

- All musicians with MSSs reported modifiable or preventable factors.
- 94% listed a behavioural factor:
    - Aspects of musical activity (58%):
        - Posture/ position (31%), and
        - Technique/ muscle use (22%),
    - General posture (30%),
    - Manual handling (15%),
    - Lack of physical activity (13%), and
    - Physical activity/ exercise (15%).
- 38% listed a biological factor.
- 19% a psychosocial factor:
    - Stress (15%)

What is the association between modifiable, personal factors and MSS outcomes among musicians?

Chapter 8: Survey data

- Psychological distress was associated with MSSs and MRMDs in the majority of body regions, for most groups of musicians.
- Social support was associated with the impact of MSSs.
- There was some evidence suggesting an association between stress, sitting time, and time engaged in musical activity and MSS outcomes.

What is the association between organisational, psychosocial factors and MSS outcomes among professional employed musicians?

Chapter 9: Survey data

- Occupational effort was associated with:
    - MRMDs in any body region, and most specific body regions.
- Involvement, priority, communication, reward, job security, promotion opportunities, esteem were not associated with most MSS outcomes.

Yes

Figure 10.2: Summary of findings to answer the question "Is the burden of musculoskeletal conditions among Australian university music students and professional musicians?"
Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder

The findings of the survey (Chapters 4-5) indicate that to reduce the prevalence of MSSs in musicians, the neck, upper back, lower back, shoulder and wrist/ hand regions should be targeted.

Consequences and implications

Musculoskeletal symptoms are not of themselves an indicator of the burden of MSSs, but are necessary for such a burden to occur. This section focuses on the consequences of MSSs, as an indicator of their burden. The majority of the 90.1% of musicians who reported MSSs in the last 12 months reported that their musical activities were impaired because of MSSs (62.5%), while a similar proportion sought treatment for their MSSs (65.1%). Leave from work/study for MSSs was only taken by 21.5% of symptomatic musicians in the last 12 months, however this still represents a significant burden when considering that, at least for performers, this may have an immense impact on the ensembles they work within (Appendix 2.3). The personal impact of MSSs for musicians was explored for the last 7 days, where, of the 72.1% of musicians who reported MSSs:

- 96.4% reported that MSSs impacted their daily activities,
- 91.4% reported that they were concerned about their MSSs,
- 80.5% reported that they were emotionally impacted by their MSSs,
- 55.0% reported that their musical activities were impaired by MSSs, and
- 49.3% reported that they had experienced MSSs on most days for at least the last 3 months.

Musicians may have a poorer prognosis of MSSs and may be at increased risk of developing chronic pain syndromes compared with non-musicians. Neurological differences between musicians and non-musicians, the greater importance of psychosocial factors (e.g. distress where professional musicians have a higher prevalence than the general working population[191]) may contribute to a poorer prognosis for musicians with MSSs (see Appendix 2.1 for a comprehensive review). Given the complexity of chronic pain, multidisciplinary treatment is often indicated[111], arguably making chronic pain more costly to treat than acute pain. The longer-term burden of musicians' MSSs therefore needs to be considered beyond what has been reported within this thesis, to include the future burden that the current evidence suggests could result.

There were no significant differences between musician and reference groups regarding chronic MSSs, however this does not necessarily indicate that musicians' risk of transitioning from acute to chronic MSSs is no greater than that of the general population, as there are some issues unique to musicians. Musicians, particularly those who are performing, must be able to perform highly specific and perfectly timed movements; hence, the ability to continue working at the level required is arguably more threatened by MSSs. The 'healthy worker effect'[461] might therefore play a bigger role for musicians than for non-musicians, which may have influenced this comparison.

Compared with university science students, a higher proportion of symptomatic university music students made changes to work/study in response to their MSSs. Additionally, music students rated the emotional impact of their MSSs higher than the science students did (Chapter 5). The competitive nature of the music industry[55], as well as musicians' passion for music[56] may explain why MSSs have a greater emotional impact on music students compared with science students. Finding differences in the university student comparison, but not the professional musician comparison, may suggest a 'healthy worker effect'[461]; hence, these outcomes require further investigation in university music students. There were no significant differences regarding the consequences of MSSs between professional musicians and university staff.

Sub-groups of musicians

One of the key differences between this research and other recent studies of musicians' MSSs was the inclusion of all types of university music students and professional musicians (Chapter 1 and Appendix 2.2). In doing so, the MSS outcomes of different groups of musicians could be compared (Chapter 4). There were some significant differences identified between groups of musicians, however these may be the result of multiple testing given the large number of outcomes investigated. There was, however, a consistent pattern in the results that indicated that self-employed musicians, particularly those who are both self-employed and employed, may be at particular risk compared with those who are only employed. No studies identified in the systematic mapping review (Appendix 2.2), nor update search (Chapter 1), reported MSS outcomes for self-employed musicians, much less compared these outcomes with employed musicians. With 86% of Australian professional musicians working in a freelance or self-employed capacity[21] addressing the burden of MSSs in self-employed musicians is vital. These musicians do not have the protections of organisational occupational health and safety (OHS) policy, nor access to paid sick leave or workers' compensation. A more comprehensive examination of MSSs in self-employed musicians, including additional factors such as role conflict, is therefore warranted. To date, self-employed musicians have not been investigated in public health interventions to manage musicians' MSSs; a clear evidence gap (Appendix 2.4). Targeting self-employed musicians is likely to be more difficult than targeting those employed by musical organisations, but highlights the important role of universities and the organisations that support musicians (e.g. unions) in preventing and managing musicians' MSSs.

10.2.1.3 Overall summary of the burden of musicians' musculoskeletal conditions

This thesis, and the discussion presented above, establishes that there is a burden of MSSs for university music students and professional musicians as indicated through two lines of evidence - WCCs data and a questionnaire survey - and is consistent with the existing evidence base. The most important body regions to address were the shoulder, wrist/ hand, neck, upper back and lower back. Self-employed musicians appear to have a greater burden of MSSs, and warrant further investigation.

With the range of consequences for musicians including the impact on musical activity, daily life, and emotional wellbeing, there may also be potential for a future burden of MSSs in the form of chronic pain syndromes. The relatively high proportion of musicians with MSSs experiencing psychological distress, and the neurological differences between musicians and non-musicians discussed earlier, could further contribute to such an adverse outcome.

10.2.2 The burden of musculoskeletal symptoms is likely preventable

Having identified that there is a burden of MSSs for university music students and professional musicians, the preventability of the burden was considered. All musicians with MSSs reported at least one modifiable or preventable cause of their MSSs, indicating that musicians believe that their MSSs are preventable (Chapter 7). The following discussions focus on the strongest line of evidence; the analysis of the association between modifiable factors and MSS outcomes (Chapters 8-9), and is supplemented by musicians' perceptions of the causes of their MSSs (Chapter 7) and the reported mechanisms and agencies for MSD WCCs (Chapter 6).

10.2.2.1 Addressing psychological distress should be prioritised

To have the greatest impact on the burden of musicians' MSS psychological distress must be considered. Across most groups of musicians, including self-employed musicians, psychological distress was the factor most frequently associated with MSS outcomes, including MSS consequences (Chapter 8). The existing evidence of the association between psychological distress or its components (symptoms of anxiety and depression) and MSS outcomes is largely mixed[45, 181, 192, 214, 227, 229, 261, 292, 307, 480], with Baadjou et al.[199] reporting that there was consistent evidence of no association between trait anxiety (an element of distress) and MSS outcomes. Baadjou et al.'s [199] finding was based on only two studies[45, 466]; hence it was important to reconsider psychological distress. No WRMSD WCCs for musicians were reported to be the result of any psychosocial factor (Chapter 6), while only three musicians reported anxiety or depression as one of the three main causes of their MSSs (Chapter 7). It is however possible that some of the 14.6% of musicians who reported stress as one of the three causes of their MSSs, were in fact referring to symptoms of anxiety or depression (Chapter 7). Nonetheless, the important association between distress and musculoskeletal conditions may be under-recognised among musicians.

Owing to the cross-sectional study design, the direction of the association between psychological distress and MSS outcomes could not be established in the current study. The finding that 80.5% of musicians felt emotionally impacted by their MSSs (Chapter 4), and that a number of musicians reported that anxiety, depression or stress (which may relate to distress) were some of the main causes of their MSSs (Chapter 7) suggests that the relationship between distress and MSS outcomes identified in Chapter 8 is bidirectional. While these findings may indicate that prospective cohort studies may be of value, prospective studies[471-473] with the general population have failed to determine the direction of the relationship between psychosocial factors and MSS outcomes, and the public health recommendation remains the same: both distress and MSSs need to be addressed to prevent a feedback loop developing.

Psychological distress is likely modifiable, however multiple strategies may be required. The prevalence of psychological distress is reportedly higher in professional musicians than in the general population[191], and student musicians reportedly have poorer mental health than the general population.[192] Further, poor mental health has been identified as a prominent health issue in Australian musicians specifically.[56, 485] As discussed in Chapter 1, the comorbidity of mental health issues and MSSs is associated with poorer quality of life[486, 487], higher levels of impairment[486], and increased risk of chronic pain syndromes developing.[111, 488, 489] In addressing psychological distress for musicians, there is an opportunity to address two of the largest health issues for musicians simultaneously, thus reducing in the burden of both prominent health conditions.

10.2.2.2 Other factors to consider

Although the results were not as consistent as for psychological distress, the findings of Chapter 8 suggest that the MSS burden could be reduced by decreasing stress, improving social support, and decreasing both musical activity and sitting time.

There was some evidence to suggest an association between stress and MSS outcomes. Stress was reported as one of the three top causes of MSSs by 14.6% of musicians (Chapter 7). Addressing stress is also likely to impact upon distress, as chronic stress can lead to anxiety and/or depression (the components of psychological distress)[479]; hence stress reduction strategies should be explored as strategies to reduce distress, and the burden of MSSs in musicians.

Social support from other musicians specifically was investigated as a factor associated with MSSs for the first time in the current research. Lower levels of social support from other musicians were associated with a higher impact of MSSs, both in terms of their daily lives and the impact on musical activity. Ensuring that strategies are in place to encourage social support among these more vulnerable musicians (e.g. self-employed, teachers and/or symptomatic) will be an important step in reducing the burden of MSSs. Importantly, musicians who were self-employed and employed by teaching organisations reported the lowest levels of social support from other musicians (Appendix 1.4). These musicians are less likely to have ongoing, regular contact with other musicians, thus potentially leading to lower levels of musical social support. There was however no association between social support and MSS outcomes for self-employed musicians (Chapter 8). The lack of an association may relate to there being little variation in the social support scores, supporting the need for longer measures of musical social support for use in future research (discussed further in Section 10.3.1.2).

While modifiable, the time spent engaged in musical activity may be a challenging factor to address. Individuals may have little personal control over the time engaged in musical activity, and there is a potential trade-off where reducing time spent engaged in musical activity may also have a negative impact upon musical ability. The current study identified an association between more time engaged in musical activity and music-related musculoskeletal disorder (MRMD) outcomes, but not MSSs themselves nor other MSS consequences (Chapter 8). These findings do not provide sufficient evidence to restrict musicians' time engaged in musical activity. It is possible that musicians who engaged in more musical activity are more sensitive to changes in their musical abilities, and were therefore more likely to report MRMDs. The impairment of musical activity reported by musicians themselves might not necessarily be evident to audiences and potentially not even other musicians. If this is the case, a reduction in musical activity may have a greater detrimental impact on the musician, and the fear-avoidance behaviour this may promote may also have greater implications, including the development of chronic pain (Appendix 2.1). As will be discussed further in Section 10.3.1.2, more comprehensive measures of MRMDs are required, and data regarding musical activity time might be more accurately collected using diaries.

Regarding musicians' perceived causes of their MSSs only 12.2% of symptomatic musicians attributed their MSSs to the duration and/or structure of their musical activities (Chapter 7). In total however, 59.2% reported at least one musical behavioural cause for their MSSs, and for most of these factors (e.g. posture, technique) one could argue that there is an element of dosage associated with the reported factor (Chapter 7). Musical time should not be ruled out as a potential risk factor for MSS outcomes, however at this stage the evidence is not strong enough for firm recommendations to be made, owing to the potential adverse effects.

The findings of Chapter 8 also suggest that more time spent sitting may be associated with poorer MSS outcomes, particularly for female musicians. This association had not previously been explored; hence, self-reported exposure data was appropriate in the present studies. Given the identified association, future studies should use objective measures of sitting time to obtain more accurate and sensitive exposure data[474-476], thus improving our understanding of the potential association between sitting time and MSS outcomes in musicians (as will be discussed further in Section 10.3.1.2).

10.2.2.3 Organisational factors might not be that important

There was little evidence in support of the association between perceived reward at work (including the sub-scales job security, esteem and promotion opportunities), the communication, involvement and prioritisation of OHS at work, and MSS outcomes (Chapter 9). There was evidence in support of an association between perceived work effort and the presence of MRMDs only. This finding is therefore similar to that of musical time, despite adjustment for musical time in the analyses. It is possible that when MSSs impair musical activity (i.e. a MRMD is present) musicians' work is more difficult; thus increasing the perception of work effort, rather than effort necessarily leading to MRMDs. The cross-sectional nature of this research meant it was not possible to determine the direction of the association, although evidence from other populations suggests a bidirectional relationship between effort-reward imbalance (ERI) and MSS outcomes.[473] Further insights into the relationship between psychosocial organisational factors and MSS outcomes may also be gained through a gender-stratified analysis, which was not conducted in this study owing to the relatively small sample size. Nonetheless, this research highlights the potentially important role of effort as a factor associated with MRMD.

The findings of this study indicate that the ERI model does not apply to musicians' MSSs, as the MSS outcomes were only associated with effort, and not reward. This finding may relate to the drivers of musicians work, and how they may differ from the general working population. Musicians have been described as 'subjective careerists'[56]; that is they have a 'calling' or are internally driven to participate in their career.[484] In contrast, 'objective careerists' are driven by external factors like job security, position, and salary[56] (elements prominent in the reward component of ERI). This distinction may explain why reward was not an important factor for musicians, as the rewards examined in the ERI model focus on 'objective careerists'. Musicians' work rewards may be more personal, for instance being pleased with a performance, or overcoming the technical challenges of a piece. Musicians may also derive reward from external influences beyond the organisation they work for, such as the audience's applause, or review of their performances. These rewards are not captured within the ERI questionnaires. Nonetheless, further development of the concepts of effort and reward within the context of 'subjective careerists', like musicians, may be warranted (as will be discussed further in Section 10.3.2). The findings of this study also highlight the importance of investigating the components of ERI, not just ERI itself, in any study examining the relationship between ERI and any health issue, in order to provide more targeted recommendations regarding potential interventions.

10.2.2.4 Overall summary of the preventability of musicians' musculoskeletal conditions

Based on the analysis of musicians' perceived causes of their MSSs (Chapter 7), the reported agencies and mechanisms for musculoskeletal disorder claims (Chapter 6), and the association between modifiable factors and MSS outcomes (Chapters 8-9), it can be concluded that musicians' musculoskeletal conditions are likely preventable. With distress being the most important factor associated with MSS outcomes, and all musicians reporting at least one (of three) likely modifiable or preventable factor as one of the top three causes of their MSSs, there are two lines of evidence supporting this conclusion.

Having established that there is a preventable burden of musculoskeletal conditions for musicians, recommendations and implications of these findings will be discussed in the following sections.

10.3 Recommendations

There is a burden of musculoskeletal conditions for musicians and it is likely preventable. Based on the key findings of the research, as discussed in Section 10.2, the main recommendations and implications from this thesis are discussed in the following section. This section has two main parts: a discussion regarding future research directions (Section 10.3.1), and how the factors associated with MSS outcomes may be addressed (Section 10.3.2) in order to ultimately reduce the burden of musculoskeletal conditions for musicians.

10.3.1 Future research

The foundation work for this thesis has provided a number of recommendations regarding the future research (Chapter 1 and Appendix 2.2), as well as the most appropriate MSS outcomes to investigate and data collection tools to use (Chapters 2 and Appendix 2.5). Furthermore, the research itself has led to new recommendations to guide future research. These recommendations will be discussed in four main sections: prioritisation of research topics (Section 10.3.1.1), improving data collection (Section 10.3.1.2), considering higher-level study designs (Section 10.3.1.3), and improving the sample size and response rate (Section 10.3.1.4). These recommendations are discussed within the context of the limitations of this research, which provides a foundation for future work.

10.3.1.1 Prioritising future research

Recommendations for prioritising future research into musicians' MSSs were based on the findings of this thesis. These recommendations are summarised in Table 10.1, and are discussed in the following sections.

The systematic mapping review (Appendix 2.2) identified a number of gaps in the current evidence base, resulting in a series of recommendations. Researchers planning investigations into musicians' MSSs should carefully consider what the planned study would add to the current evidence base. For instance, the majority of studies of professional musicians were of orchestral musicians; hence, one would have to question the value of yet another prevalence study in this population specifically, unless unique outcomes were being investigated.

Under-investigated groups of musicians

The research presented in this thesis partially addresses a number of recommendations derived from the systematic mapping review, including investigating the music industry as a whole, comparing sub-groups of musicians, comparing musicians and reference groups, and investigating the association between modifiable factors and MSS outcomes. The research provided new evidence regarding the prevalence and profile of MSSs in under-investigated groups of musicians (e.g. military band musicians, opera singers); however in some instances the sample sizes were small (discussed further in Section 10.3.1.3). Research into the prevalence and profile of these under-investigated groups may still be warranted. This is particularly true internationally, but also for some groups within Australia. For instance, the military bands in the Australian states investigated are reservist (part-time) bands, which means the full-time military band musicians have not been investigated. Furthermore, there were too few participants working in some ensemble types (e.g. musical theatre, professional jazz bands) to report these sub-groups of musicians separately. Nationwide studies may yield sufficient sample sizes to investigate these sub-groups of musicians specifically.

Body regions to target

The analysis of the survey data indicated that the most commonly affected body regions for MSSs and MRMDs were the neck, shoulder, wrist/ hand, upper back and lower back overall, and for most sub-groups of musicians (Chapter 4). Furthermore, the upper limb region accounted for the majority of musicians' MSD WCCs (Chapter 3). These findings indicate that future research, particularly into the risk factors and interventions for musicians' musculoskeletal conditions, should be directed at the upper limb and spinal regions.

Investigating modifiable risk factors

There should be a shift towards determining the modifiable factors associated with MSS outcomes, particularly the consequences of MSSs. Such studies, like those presented in Chapters 8-9, would provide a solid foundation for intervention studies to reduce the MSS burden (discussed further in Section 10.2.2). Where possible, studies should investigate sub-groups of musicians, and stratify the analyses by gender. In Chapter 8, the association between modifiable factors and MSS outcomes was investigated, with analyses specific to sub-groups of musicians (i.e. males and females, university music students, employed professional musicians and self-employed musicians). Through undertaking such an analysis, differences in the associations between modifiable factors and MSS outcomes were identified.

For instance, musical activity time was associated with MSS outcomes in employed musicians, but not self-employed musicians, and sitting time associated with MSS outcomes in females but not males. As self-employed musicians were identified as a priority group in Chapter 4, owing to the higher prevalence and ratings of MSS outcomes, further research into the specific modifiable risk factors for MSS outcomes in this population are recommended. Given the higher burden, and that the majority of musicians working in a self-employed/freelance capacity[21], targeting self-employed musicians would be expected have the greatest impact in reducing the MSS burden for musicians.

Investigating the components of the effort-reward imbalance model

In the first study of the association between ERI and MSS outcomes in musicians, the association between ERI and its components (perceived effort, reward, job security, promotion opportunities and esteem) and MSS outcomes were investigated (Chapter 9). For musicians, while ERI was associated with MSS outcomes, the association appeared to be driven by the effort component, as reward not associated with any of the MSS outcomes. It is therefore recommended that any study investigating ERI should consider the components of ERI, as well as ERI itself, allowing for more targeted interventions to be developed; thus improving the likelihood success.

10.3.1.2 Data collection for exposures and musculoskeletal symptom outcomes

The recommendations to improve data collection of both exposures and MSS outcomes are summarised in Table 10.2, and described in the following sections.

Workers' compensation claims data

This thesis includes the first study to investigate WCCs data for musicians. There were a number of unavoidable challenges encountered in this analysis. These challenges included the lack of a valid denominator (population size for eligible musicians), reporting behaviour potentially influencing the data (e.g. not claiming for fear that disclosure would threaten job opportunities), data not available specifically for music teachers (who were considered private tutors), the type of musician (e.g. orchestral, opera) not being available, and only a minority of professional musicians being eligible for workers' compensation (as discussed in Chapter 3). Despite these limitations, the WCCs data analysis provided valuable insights into musicians' WRMSDs (Chapters 3 and 6). To overcome the limitations of these data, findings should be triangulated with other sources of data, including survey data. Such an approach was adopted in this thesis, combining the valuable insights provided by the WCCs data analysis (Chapters 3 and 6), with the survey findings. This was a powerful combination in terms of identifying the burden of musculoskeletal conditions, and it is therefore recommended that WCCs data and other surveillance methods for MSS outcomes be considered for studies of musicians internationally.

Data collection regarding musical activity

As discussed in Chapter 8, musical exposure diaries may provide more valid data for determining the potential association between time engaged in musical activity and MSS outcomes, compared with the 7 day recall approach used in the present study. In response to the feedback from musicians during the pilot testing of the questionnaire, time categories were used for data collection rather than an open-ended response, as difficulties were reported in recalling the number of hours. A diary should address this problem; however, the added burden of an exposure diary may reduce the response rate and compliance of participants, hence the potential advantages and disadvantages of this approach would have to be considered.

Table 10.1: Recommendations for the prioritisation of research into musicians' musculoskeletal conditions, with supporting evidence

Recommendations	Supporting evidence
1. The prevalence and profile of MSS outcomes should continue to be investigated in the music industry as a whole, and for non-orchestral professional musicians and non-classical university music students	The systematic mapping review (Appendix 2.2) and update search (Chapter 1) identified that no recent study had investigated the music industry as a whole, instead mainly focusing on university classical music students and/or professional orchestral musicians, leaving non-classical university music students, and non-orchestral musicians. The research presented in Chapter 4 partially fills this evidence gap; however, the sample size for some sub-group analyses may have been too small; hence further research is required, including beyond Australia.
2. The modifiable factors associated with MSS outcomes should be investigated for the music industry as a whole, and for non-orchestral professional musicians and non-classical university music students	The systematic mapping review (Appendix 2.2) and update search (Chapter 1) identified that no recent study had investigated the music industry as a whole, instead mainly focusing on university classical music students and/or professional orchestral musicians, leaving non-classical university music students, and non-orchestral musicians. Non-modifiable factors were most commonly investigated in the existing evidence base. The research presented in Chapters 8 and 9 partially fills this evidence gap; however, the sample size for some sub-group analyses may have been too small; hence further research is required, including beyond Australia.
3. Workers' compensation claims for musicians should be investigated to determine the burden and profile of musculoskeletal conditions	No study to date had reported analysis of workers' compensation claims for musicians' musculoskeletal disorders (based on the systematic mapping review (Appendix 2.2), update search (Chapter 1), and targeted searches of the literature published before 2007. The research presented in Chapter 3 partially fills this evidence gap, however similar studies should also be conducted outside of Australia.
4. The prevalence and profile of MSS outcomes should be compared between different types of musicians (e.g. students and professionals, orchestral and military band)	Few studies have compared the prevalence and profile of MSSs between different types of musicians, and those that have focused on specific instruments (Chapter 1, Appendix 2.2). The research presented in Chapter 4 partially filled this evidence gap, however the sample size for some sub-group analyses may have been too small; hence further research is required, including beyond Australia.
5. The prevalence and profile of MSS outcomes should be compared between musicians and reference groups	Few studies have compared the prevalence and profile of MSS outcomes between musicians and reference groups. Previous studies have used inappropriate reference groups, not accounted for potential confounders and/or not used valid data collection methods (Chapter 1, Appendix 2.2). The research presented in Chapter 5 partially filled this evidence gap; however this study should be replicated internationally.
6. The prevalence and profile of MSS outcomes should be compared between musicians internationally	No study has compared the prevalence and profile of musicians' MSS outcomes internationally (Chapter 1, Appendix 2.2). Through using consistent methods of data collection (Recommendations 10-18; Appendix 2.5) international analyses may be conducted cost-effectively through a systematic reviews and meta-analyses.
7. The association between modifiable factors and MSS outcomes (including the consequences) should be investigated	Studies that have investigated the factors associated with MSS outcomes have focused on non-modifiable factors, with few modifiable factors having been investigated (Chapter 1, Appendix 2.2). The research presented in Chapters 8-9 partially addresses this recommendation, however larger scale studies with improved measures are required to confirm the findings of this research.
8. Public health interventions, based on our understanding of the modifiable factors associated with MSS outcomes, should be developed to prevent and manage MSSs, and their safety and effectiveness should be examined.	No public health intervention for musicians' MSS outcomes has been found to be safe and effective (Chapter 1, Appendix 2.4).
9. Future research into the risk factors and interventions for MSSs should focus on the neck, shoulder, wrist/ hand, upper back and lower back	Musculoskeletal disorders for which musicians most commonly claimed workers' compensation was the upper limb region (Chapter 3) and the most common regions in which musicians reported MSSs and MRMDs were the neck, shoulder, wrist/ hand, upper back and lower back (Chapter 4).
	(continued)

Recommendations	Supporting evidence
10. For the investigation of potential risk factors, sub-groups of musicians should be considered, particularly self-employed musicians	The association between modifiable factors and MSS outcomes was investigated for sub-groups of musicians in Chapter 8, and differences by gender, and musician type (e.g. student, employed, and self-employed musicians) were identified. Self-employed musicians should be prioritised given their higher prevalence and ratings for MSS outcomes (Chapter 4).
11. Investigations into the association between ERI and MSS outcomes should consider ERI, as well as the components of ERI (perceived effort, reward, job security, promotion opportunities, and esteem).	The association between ERI and its sub-components and MSS outcomes was investigated in Chapter 9, where perceived effort was associated with a number of MSS outcomes, but reward was not. The identified association between ERI and MSS outcomes was therefore driven by effort.
12. Barriers and enablers to behaviour change to reduce MSSs should be explored	All musicians reported at least one likely modifiable or preventable factor that they believe caused their MSSs, with 94% reporting at least one behavioural factor (Chapter 7). The barrier and enablers to change therefore need to be understood, so that strategies can be implemented to support suggested changes. This topic has not been adequately addressed in the previous research (Appendix 2.2).

Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder, ERI: effort-reward imbalance

Table 10.2: Recommendations regarding data collection for future research into musicians' musculoskeletal conditions, with supporting evidence

Recommendations	Supporting evidence
1. The use of diaries to record musical activity time should be considered, and weighted against the increased burden this may place on participants, which may result in a lower level of participation.	Associations between the time engaged in musical activity and the presence and severity of MRMDs were detected (Chapter 8), however this finding was reliant on self-reported recall of the previous 7 days. Diaries would be expected to improve the validity of the exposure measure. The association detected in this study indicates that more comprehensive studies of this topic, including the use or more rigorous data collection methods, would be warranted.
2. The use of objective measures of sitting time	Associations between self-reported typical daily sitting time and a range of MSS outcomes were detected (Chapter 8), particularly for females. The findings of this research indicate that more rigorous studies of this topic are warranted; hence, objective measures of sitting time should be considered in future research.
3. A musician-specific measure of Effort-Reward Imbalance should be develop(d and tested for future studies into musicians' health	Association between effort and MRMD outcomes were identified, however the questionnaire was not designed specifically for musicians, who may have different types and expectations of effort and reward compared with the general working population (Chapter 9).
4. Musicians' perceptions regarding the causes of their MSSs should be investigated using musician-driven methods. Where this is not possible, the development of lists of perceived causes to endorse should be based upon the findings of Chapter 7.	Studies reporting the percentage of musicians who report various perceived risk factors or causes of their MSSs have used researcher-driven methods (Appendix 2.5). The research presented in Chapter 7 reported musicians' perceived causes of their MSSs, collected using musician-driven methods. Some of the most commonly reported factors had not been included in the questionnaires using researcher-driven methods, highlighting the importance of the musician-driven approach. Where musician populations are similar to that of the research presented in Chapter 7, questionnaire items (lists of causes) may be developed based on this research.
5. Workers' compensation claims data and other surveillance data should be considered as data sources for studies into musicians' MSSs	Despite the limitations of the workers' compensation claims data (described in Chapters 2-3), the analysis of these data strengthened the findings of this research, through providing an additional line of (consistent) evidence with the questionnaire survey data.
6. The NMQ[67] be used to collect data on the presence and body region of MSS, however the addition of the head, orofacial and chest/ abdominal regions may be required	The NMQ[67] was the most commonly used method of data collection for determining the presence and body region of MSSs in musicians (Appendix 2.5). The NMQ[67] has been used with a range of populations[394, 490, 491], and is valid and reliable.[67, 384, 396-398] The NMQ[67] does not include items for the head, orofacial and chest/ abdominal regions; hence these may be added for studies of musicians.
7. The regions of the NMQ[67] should be investigated, with the addition of the head, orofacial and chest/ abdominal regions	Even when the NMQ[67] was not used, the most commonly investigated regions for MSS outcomes in musicians were the neck, shoulder, elbow, wrist/ hand, upper back, lower back, hip/ thigh, knee and ankle/ foot (Appendix 2.5). The investigation of these body regions would also allow for comparison with a range of other populations.[394, 490, 491]
8. A modified version of the NMQ[67] be used to collect data regarding the presence of MSS that impair musical activity, with Zaza et al.'s[68] definition of playing-related musculoskeletal disorders substituted for ache, pain or discomfort. Where studies include non-instrumental musicians, the term 'music-related' should be used and the definition altered to include all musical activities rather than just playing an instrument.	The most commonly used definition to determine the musical impairment from MSSs was Zaza et al.'s[68] definition of playing-related musculoskeletal disorders (Appendix 2.5). This definition was developed through focus groups with musicians and health professionals who worked with musicians with MSSs.[68] A modified version of the NMQ[67] to incorporate this definition instead of ache, pain or discomfort has been used previously.[295, 400]
	(continued)

Recommendations	Supporting evidence
9. The 11-point NRS should be used to rate MSS intensity and frequency, and the consequences of MSS	The 11-point NRS and VAS were both often used to measure the intensity and frequency of MSSs, and MSSs that impaired musical activity in studies of musicians (Appendix 2.5). The NRS was recommended for cross-sectional studies over the VAS as it is often preferred[401-403, 492, 493] and used more often in other populations for pain intensity.[494] The NRS has been recommended for pain intensity ratings[401] and is valid and reliable for pain intensity in other populations.[403]
10. The anchors "no pain" to "pain as bad as you can imagine" should be used when asking participants to rate their pain intensity.	For pain intensity ratings in studies of musicians, there was little consistency in the anchors used (Appendix 2.5). For pain intensity in other populations "no pain" to "pain as bad as you can imagine" have been recommended.[401] One study of musicians used these anchors[218], with others using similar anchors.[206, 261, 495]
11. Pain intensity rating should be made for pain "on average"	Aggregate measures (e.g. combining ratings of pain at its worst, on average and at its least) have been found to improve the validity of pain intensity rankings[403-406], with two studies of musicians using this approach.[218, 293] In this study Rasch analysis identified that this was not a valid approach (Appendix 2.9). It is therefore recommended that pain intensity 'on average' only be used, as it has been found to be valid.[412]
12. For prevalence, recall periods of 12 months and/or 7 days are recommended	For the prevalence of MSSs, the most commonly used recall periods with musicians were 12 months, 7 days and current, however 'current' may pose issues with validity and reliability (Appendix 2.5). In the general population it has been suggested that prevalence periods should not exceed 12 months to reduce memory decay.[496] The use of 7 day and 12 month outcomes would allow comparison with other populations.[394, 490, 491]
13. A 7 day recall period is recommended for ratings of pain intensity and MRMD severity	For ratings, the most commonly used recall period was 7 days with musicians (Appendix 2.5). The validity of MRMD severity recall over 7 days in musicians has not been examined. For pain, however, 7 day recall of the level of pain intensity has been found to be valid[412, 497-499] and reliable[499], as have ratings of pain interference.[500] It has been reported that 7 day recall periods are not considered difficult for most people.[497] For the general population, recall periods for pain intensity should not exceed 3 months[403], and interference ratings should not exceed 1 month to improve validity.[500]
14. The development of more comprehensive measures of MRMDs should be developed and tested using Rasch analysis	As the factors associated with MRMD differed in some cases to those of MSS (Chapters 8-9), further research into MRMD is warranted. The presence of MRMD was associated with musical activity time, but not MSS, which may indicate that musicians who engage in more musical activity are more sensitive to changes in their musical abilities due to MSS. Further, the Rasch analysis of the measure of MRMD severity used (Appendix 2.10) indicated that there were some issues with this measure (e.g. local dependency), and measures with more items are less likely to encounter such issues.

Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder, NMQ: Nordic Musculoskeletal Questionnaire, NRS: numeric rating scale, VAS: visual analogue scale

Sitting time

In the survey questionnaire participants were asked to self-report their typical daily sitting time. The finding that there was a significant association between sitting time and MSS outcomes, particularly for female musicians (Chapter 8), justifies the use of objective (more resource intensive) measures of sitting time in future research. Objective measures of sitting time would provide a more valid measure[474-476]; and thus more rigorous findings to guide the development of interventions to reduce the burden of musicians' MSSs. Using objective measures would also inform whether the gender-specific findings regarding the association between sitting time and MSS outcomes related to differences in self-reporting of sitting time, or differences in their MSS response to sitting time.

Effort-reward imbalance measures

Perceived work effort was associated with MSS outcomes, while reward was not. This finding may relate to musicians being 'subjective careerists'[56] (as discussed in Section 10.3.1); hence the rewards included in the Short ERI Questionnaire might not be applicable to musicians. The development of a musician-specific ERI questionnaire is therefore recommended. This questionnaire should be developed through focus groups with musicians and their employers to ascertain the most relevant aspects of effort and reward to this population. Similar approaches may be required with other occupational groups that could be described as 'subjective careerists'.

Musculoskeletal symptom outcomes

One of the strengths of the research presented in this thesis was the use of standardised measures, where possible, that had been most frequently used in studies of musicians' MSSs, as recommended by the review of outcomes and data collection tools (Appendix 2.5). The recommendations from this review have been integrated into Table 10.2. Adherences with these recommendations in future studies would maximise the comparability of individual studies, both between different types of musicians, but also internationally. Meta-analyses of comparable data regarding musicians' MSS outcomes would provide insight into the generalisability of study findings across different types of musicians, temporally and geographically; thus addressing Recommendation 6 (Table 10.1) in a cost-effective manner.

As discussed earlier, more comprehensive measures of MRMDs may be required. Zaza et al.'s[68] definition of playing-related musculoskeletal disorders was modified for this study to include singing, conducting and being a drum major as musical activities of interest. This definition of playing-related musculoskeletal disorders[68] has been commonly used in research into musicians' MSSs (Appendix 2.5), and was developed through focus groups with professional musicians and health professional who had treated musicians.[68] In this study participants were asked to rate their MRMD severity at its least, on average, and at its worst for the last 7 days, and w-scores for this measure were derived from the Rasch analysis (Appendix 2.10). The Rasch analysis revealed some issues with this measure (e.g. local dependency), indicating that longer, more comprehensive measures are required. The only existing measure available that focuses on musical impairment of MSSs is the performing arts/sports module of the Disability of the Arm, Shoulder and Hand (DASH) questionnaire.[477, 501] The DASH performing arts module is only applicable to instrumentalists, and to MSSs in the upper limb[477, 501]; hence it was not appropriate for this study. It is recommended that a measure of MRMDs be developed that, like the DASH, incorporates scales for different ways in which MSSs may impair musical activity. Such a measure should be developed through focus groups with musicians, and then be subjected to Rasch analysis to determine its utility.

Research into perceived causes

With the exception of Bragge et al.'s[296] study, all recent studies[64, 65, 217, 224, 252] that reported the percentage of musicians reporting specific perceived causes of their MSSs used 'researcher-driven' methods of data collection (i.e. asking musicians to endorse causes listed in the questionnaire; Chapter 1). Chapter 7 reports the most comprehensive study of the perceived causes of musicians' MSS to date, as the whole music industry was investigated (e.g. not a specific instrument), musician-driven data collection methods were used, and all perceived causes listed by musicians were reported. By using musician-driven data collection methods new perceived causes, such as engagement in physical activity, were identified that had been omitted from previous lists. In addition, instrument- or ensemble-specific issues were identified (e.g. props for opera musicians, footwear for military band musicians), which may be the focus of future studies into these groups specifically. The findings of this study may be used to develop a list of potential causes to endorse, however an 'other' option should always be available with participants asked to specify the cause. While this has been an option in previous studies, the causes specified have not been reported. When considering smaller groups of musicians, including those not prominent in the present study (e.g. those in musical theatre), musician-driven methods may still be appropriate.

10.3.1.3 Considering higher-level study designs

The questionnaire survey component of the research represented cross-sectional data. A cross-sectional design was selected because it is appropriate and practical for investigating the prevalence of outcomes, and the associations between a range of exposures and outcomes.[363] One of the limitations of cross-sectional studies is that the direction of association cannot be established. This issue was discussed earlier with regards to the association between investigated modifiable factors (e.g. psychological distress and perceived work effort), and MSS outcomes. As associations were identified between a range of modifiable factors (e.g. distress, perceived work effort) and MSS outcomes were identified, future research may consider conducting longitudinal studies investigating the relationship between these variables. Longitudinal studies would represent higher levels of evidence[502], particularly in terms of establishing causation, however the value of these studies in guiding public health recommendations would have to be weighed against the additional resource costs. Previous research with other populations suggests the associations between anxiety and/or depression[471-473] and ERI[473], and MSS outcomes, for instance, are bidirectional. There is also some evidence to suggest that findings regarding the association between psychosocial factors and low back pain are similar whether cross-sectional nor longitudinal study designs are used.[364] These findings suggest that the public health recommendations would remain the same: distress should be addressed to reduce the burden of MSSs; hence, where the aim of the research is to guide the development of public health interventions through establishing risk factors, cross-sectional designs still may provide a more cost-effective approach.

10.3.1.4 Sample size and representativeness

Epidemiological research relies on having an adequate sample size to address the research question, and the sample should be representative of the population, so that the findings are generalisable. In this section, these two elements are discussed.

Sample size

Sample size is an important consideration for epidemiological research. In this research, the sample size obtained exceeded the estimated sample size for some elements; however, it may have been insufficient in others. Although the sample size was sufficient to answer the central research question, findings specific to some sub-groups of musicians may have been underpowered. For instance, the sample size may have been insufficient to detect smaller differences in some of the musician sub-group comparisons. These smaller differences are however unlikely to alter public health recommendations, nor therefore, the conclusions of the thesis.

Sample representativeness

All epidemiological studies should aim to be generalisable to the population of interest, and this is achieved through obtaining a representative sample. Having a higher proportion of the population participating has traditionally been thought to improve the generalisability of study findings, although recent evidence suggests that this is not always the case.[503] To determine the representativeness of the sample, the characteristics of the sample and population should be compared, where appropriate data are available. In the present study, no such data were available for the groups recruited from, nor the population of university music students and professional musicians more generally. Based on data regarding professional musicians (including music teachers) from the 2011 Census of Population and Housing[58], it appears that females may have been over-represented in the musician sample. However, as there has been a dramatic increase in the proportion of professional musicians working in a freelance/ self-employed capacity between 2009 and 2016[21, 54], these 2011 statistics cannot be assumed to reflect the current demographic. Additionally, there may have been differences in the distribution of the types of musicians (e.g., student musicians may have been over-represented). To address these concerns analyses were stratified by gender, and by musician type, where possible. As indicated in this study there are few differences between different sub-groups of musicians (Chapter 4), and the prevalence estimates are similar to those reported in previous studies[52], indicating that any potential issues with the representativeness of the sample are unlikely to have influenced the prevalence estimates.

Sampling bias

Sampling bias is another important consideration in epidemiological research, especially self-selection bias when calling for volunteer participants. It has been suggested that musicians with MSSs may be more likely to participate given their likely interest in the topic.[60] Conversely, those who have experienced MSS may be reluctant to share their experiences due to fear of being found out, and having to think about difficult parts of their lives.[60] As the findings of this research (Chapter 4) were similar to previous reports of comparable MSS outcomes[52], it is argued that self-selection was not a significant problem in this research.

Improving sample size and representativeness

Future research should, nonetheless, try to maximise sample representativeness, and adequacy of the sample size. While a number of strategies were employed in this research to maximise participation (Chapter 2), as outlined above the sample size was likely insufficient for some of the specific elements of the study. However, this study has now provided prioritised MSS outcomes for future research (Chapter 4), hence the questionnaires used in future research of musicians' MSS outcomes may be shortened. Using shorter questionnaires are anticipated to improve recruitment and participation, because they constitute a lesser impost on participants' time.

The particularly poor response from orchestral musicians (estimated to be approximately 20%) may indicate a broader issue: 'survey fatigue', with the increase in calls for participation in studies resulting in lower response rates.[503] The orchestras have been involved in a range of studies as part of the Sound Practice project[227, 453] over the last 10 years, including a comprehensive questionnaire survey investigating MSSs, hearing loss and psychological health.[224] This may have led to a reluctance to be involved in yet another study. The option of obtaining data from the Sound Practice project[227, 453], and using the same questionnaire[347] with non-orchestral musicians was considered for this research; thus reducing the additional burden on the orchestral musicians. However, this option was not pursued for two main reasons. Firstly, the survey was conducted in 2009 and numerous interventions have been implemented with this population since[227, 453] that may have led to changes in the MSS outcomes, hence the findings of the 2009 study might not reflect the current burden of MSSs. Secondly, the questionnaire[347] used in the Sound Practice project[227, 453] had no evidence of validity and reliability, did not allow for comparison with many other studies of musicians or non-musicians, and did not cover the outcomes and exposures of interest in the present study; hence the decision was made not to use this questionnaire.

The relatively poor response rate for orchestral musicians highlights an important point that may be applicable in other areas of health research. With response rates continuing to decline, and 'survey fatigue' being identified as part of the problem[503], coordinated efforts across institutions are required to ensure that there is not unnecessary replication of studies, and that future studies may not be hampered due to 'survey fatigue' in a population that has already been involved in research. Registration of protocols, as is commonly done with systematic reviews[504] and randomised controlled trials[505], may avoid researchers unknowingly replicating studies with the same groups. In relatively small populations, like professional musicians, 'survey fatigue' may also have implications for obtaining adequate sample sizes.

10.3.2 Addressing the factors associated with musculoskeletal symptom outcomes

The specific implications of the findings of this research the analysis of WCCs data and the questionnaire survey data are presented in this section, with the recommendations summarised in Table 10.3. There are three main factors to address: decreasing distress, improving social support from other musicians, and developing resources for musicians regarding exercises/ stretches to manage MSSs. These three aspects will be addressed in the following sections. With all factors it is important that interventions extend beyond specific workplaces, given that the majority of professional musicians work in a freelance or self-employed capacity[21], and that musicians working in a self-employed capacity appear to have a greater burden of MSSs than employed musicians (Chapter 4). To date, the studies that have investigated public health interventions for musicians' MSS have focused on organisations (e.g. university music students, and employed musicians; Appendix 2.5). This approach is appropriate to first test an intervention prior to wider implementation, however the transferability of the interventions to a broader target group must also be considered. For instance, if an intervention such as an exercise program is usually scheduled around rehearsals (e.g., in lunch breaks, or immediately after rehearsals) and is held on site, would compliance and the effectiveness be expected to be the same for freelance/self-employed musicians?

Table 10.3: Recommendations to reduce the burden of musicians' musculoskeletal symptoms, with supporting evidence

Recommendations		Supporting evidence
1.	Develop, evaluate and implement strategies to reduce psychological distress	Distress was associated with the presence and consequences of MSSs (Chapter 8).
2.	Develop, evaluate and implement strategies to improve social support between musicians	Social support was associated with the general impact of MSSs, and the severity of MRMDs. (Chapter 8)
3.	Develop, evaluate and implement resources to assist musicians in safety and effectively perform exercises/ stretches to address their MSSs	80% of musicians who reported MSSs in the last 12 months reported performing exercises/ stretches to manage their MSSs (Chapter 4)
4.	Strategies to address MSS outcomes in musicians should be appropriate for and available to self-employed musicians	Self-employed musicians appear to have a higher burden of MSSs than employed musicians (Chapter 4), and the majority of musicians in Australian are self-employed or freelance.[21]

Notes: MSS: musculoskeletal symptom, MRMD: music-related musculoskeletal disorder

10.3.2.1 Addressing psychological distress

One of the key findings of this research was the association between psychological distress and many MSS outcomes, including the consequences of MSSs (Chapter 8). As distress is another major health problem for musicians[56, 191, 192, 485] interventions aimed at reducing distress may result in the reduction of the two main health problems for musicians.

Strategies that could be applied to the music industry as a whole (i.e. not within specific organisations) include the promotion of individual strategies to prevent and manage stress and distress, such as physical exercise, avoiding drugs (including alcohol), having a balanced diet and meditation. In addition, musicians should be equipped with the skills to ask for help when needed, as well as the skills to assist others. Mental health care services already available to most musicians should also be promoted, not only as a way of managing distress/ stress, but also MSSs. These services may include the mental health help line through Support Act, Employee Assistance Programs, university student counselling, and Medicare funded psychologist consultations. Details of these services, as well as their potential role in pain management, should be added to existing occupational health and safety policies for organisations training and employing musicians, which appears to be overlooked in some current policies (e.g., for the Australian orchestras[506]). Musicians might not realise that they are anxious or depressed; hence, the use of self-screening tools may also be beneficial.

Within the organisations that employ musicians, psychological stressors should be identified and addressed. Such an investigation was beyond the scope of the research presented in this thesis, however some psychological stressors have been identified within the qualitative literature on professional orchestral musicians' MSSs, and include concurrent scheduling[254], performance stress[254], the stigma associated with MSSs[194], and being concerned about their MSSs.[194] In order to reduce the stigma associated with MSSs, similar strategies to those now used to destigmatise mental illness may be adapted, including improving knowledge about the risk factors for MSSs (e.g. MSSs are not simply a sign of poor technique), developing an awareness around how common MSSs are, and that MSS experiences differ between people and over time (e.g. not all back pain is the same). Where possible using personal stories to open lines of communication and develop an understanding among musicians regarding what it is like to experience debilitating and/or chronic MSSs may also be beneficial.

Involving musicians in the decision making regarding the scheduling of rehearsals and performances may also be beneficial in reducing workplace stressors. The duration and structure of musical activities was identified as a perceived cause of musicians' MSSs (Chapter 7), providing further support for increasing musicians' involvement in such decision-making. This may be particularly important for musicians working across multiple groups, and who are both self-employed and employed – the priority group identified in Chapter 4.

10.3.2.2 Musical social support

The research provides some evidence of the role of social support from other musicians in the consequences of MSSs; particularly the ratings of MRMD severity and the general impact of MSSs. Social support may be improved through strengthening existing networks within the music industry. For instance, there are a number of groups for musicians in Australia, including the Australian Double Reed Society, and the Australian String Association. With the exception of the Music Teachers' Association, anecdotally these groups focus on younger student musicians, rather than university music students and professional musicians. These groups could provide a valuable source of social support for musicians, particularly those who are more vulnerable to isolation (e.g. self-employed, teachers), and may include support specifically for those with health problems, as well as mentoring programs for less experienced professional musicians and for university music students. One of the issues with the existing groups is that not all instrument groups are addressed, and musicians might not feel comfortable discussing their MSSs with musicians who they are competing with (e.g. same instrument). The amalgamation of the instrument/singing-specific groups among university music students and professional musicians, even if just for the purpose of strengthening social networks and providing health education, may provide a solution to this barrier.

10.3.2.3 Resources regarding exercises/ stretches to manage musculoskeletal symptoms

An important finding of this research was that most musicians with MSSs have engaged in self-management strategies, with exercises and stretches being the most commonly used strategy (Chapter 4). As these musicians are already engaged in these behaviours it is important that the exercises they are performing are both safe and effective. Resources to assist musicians in self-managing their MSSs with targeted exercises should therefore be developed and evaluated. Chan et al.[246] recently investigated the effectiveness of an exercise program delivered via digital video device for the prevention and management of MSSs; however, there was little evidence of its effectiveness and compliance was poor. Rather than an exercise program as such, the resources recommended here would be for a specific body region, along with advice regarding when treatment from a health professional may be sought. If found to be safe and effective these resources should be disseminated to all musicians, in order to reduce the burden of musicians' musculoskeletal conditions.

10.4 Conclusion

This thesis undertook to expand and improve on the evidence base for there being a MSS burden in musicians, and establish to what extent this burden could be prevented. Because MSDs are the main type of WCCs, there is a clear indication for effective interventions to be developed both to decrease the adverse effect on musicians, as well as the societal impost on the health budget.

A particular outcome from the work presented was the revelation that university music students and professional musicians carry a high prevalence of MSSs (72.1% in the last 7 days), and that most of them experience negative consequences, including musical impairment, and impact on daily living and emotional wellbeing. The present research provides the most comprehensive examination of this problem to date and, importantly, demonstrated the generalisability of the problem for a broader group of musicians than has traditionally been researched.

If we are to develop group-specific interventions, further research will be required, but subject to two important guiding principles. Firstly, most of the existing evidence did not adequately report on the MSS outcomes nor data collection tools used, with heterogeneity of outcomes and data collection tools also identified. Standardised data collection tools need to be used to make the evidence base rigorous enough to support recommendations for intervention and future research. Secondly, there needs to be a shift from research aimed at understanding the extent and profile of the MSS problem, towards a focus on modifiable risk factors and ultimately intervention studies.

In terms of such future, targeted research, the work presented here identifies psychological distress as a priority area for intervention studies, because of its association with both MSSs and MSS consequences. Interventions within specific workplaces may be part of the solution, however given that the majority of musicians are working in a freelance or self-employed capacity, more far-reaching interventions are also required. Organisations that train and support musicians are likely to provide an important platform for such interventions. Importantly, these approaches are likely to become essential with increasing financial pressure in the sector. By strengthening existing support networks, and capitalising upon existing subsidised treatment options, distress and ultimately the MSS burden for musicians should decrease.

Music is an integral part of every civilization, and a sense of wellbeing and identity are inextricably linked to both its production and consumption. Anything that can be done to support this contribution to community health should be explored in the context of cost-effective interventions, and the hope is that this thesis has contributed significantly to position us to do so.

APPENDIX 1: SUPPLEMENTARY MATERIAL

Appendix 1 includes the supplementary material for Chapters 1-9.

A1.1 Supplementary material for Chapter 1

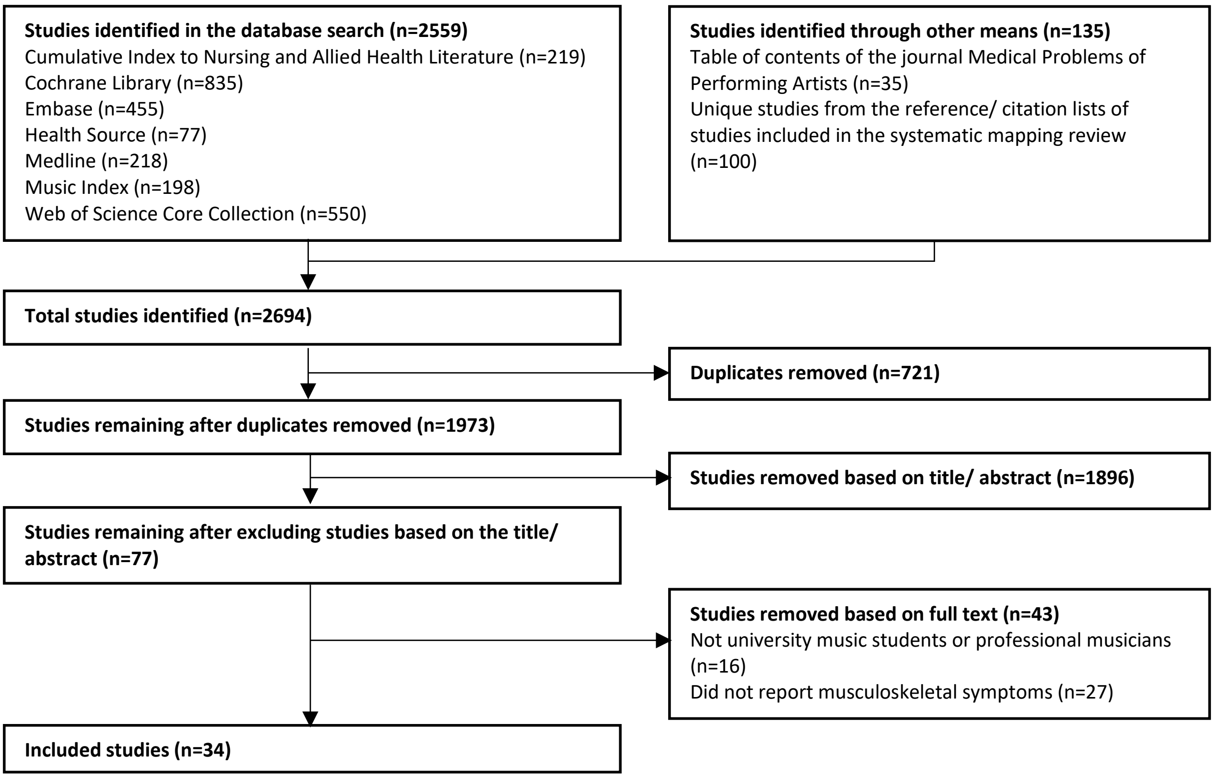


Figure A1.1: Flow chart for study inclusion/ exclusion for the update systematic search

A1.2 Supplementary material for Chapter 2

A1.2.1 Ethics approvals[ppp]

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

LEVEL 7, 115 GRENFELL STREET
THE UNIVERSITY OF ADELAIDE
SA 5005 AUSTRALIA

TELEPHONE +61 8 8313 5137
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EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

21 December 2015

Professor D Pisaniello
School: School of Public Health

Dear Professor Pisaniello

ETHICS APPROVAL No: **H-2015-279**

PROJECT TITLE: **Musculoskeletal disorders in under-investigated occupational groups: A case study in the music industry**

The ethics application for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Health Sciences) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* involving no more than low risk for research participants. You are authorised to commence your research on **21 Dec 2015**.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely,

Sabine Schreiber
Secretary, Human Research Ethics Committee
Office of Research Ethics, Compliance and Integrity

[ppp]Only the initial approvals have been included. Approvals for amendments and extensions are available upon request.

JOINT HEALTH COMMAND

Australian Defence Human Research Ethics Committee
CP3-6-036, Campbell Park Offices, PO Box 7912, Canberra BC ACT 2610

2016/1083761

DHRC/OUT/2016/R26592318

19 July 2016

Prof Dino Pisaniello
Professor of Public Health
The University of Adelaide

Copy: Ms Jessica Stanhope

Dear Prof Pisaniello

Protocol number: LREP 16-006
Project title: 'Musculoskeletal disorders in under-investigated occupational groups: A case study in the music industry'

Thank you for submitting the above research project for ethical review. In accordance with paragraphs 5.1.18 through 5.1.21 of the National Statement on Ethical Conduct in Human Research, your research was reviewed by the Joint Health Command Low Risk Ethics Panel. It has been determined that your research meets the criteria for low risk research as outlined in the National Statement at paragraph 2.1.6. Please retain this letter with your records as confirmation of institutional assessment and approval.

Your protocol has been allocated LREP Protocol Number 16-006 and this number must be quote in all correspondence. Your protocol has been approved under the low risk parameters for a period of three years from 14 July 2016 to 13 July 2019. If your research is to continue beyond this period, an extension is to be sought in writing.

The nominated participating sites in this project are:

- Keswick Barracks (South Australia)
- Warradale Barracks (South Australia)

Note: If additional sites are engaged prior to the commencement of, or during the research project, the Coordinating Principal Investigator is required to notify the JHC-LREP. Notification of withdrawn sites should also be provided to the JHC-LREP in a timely fashion.

The approved documents include:

Document	Version	Date
Health Research Ethical Review Assessment		18 Jul 16
JHC-LREP Application for ethics approval of low risk research involving people	1.2	14 Jul 16

Document	Version	Date
Email to Defence members seeking volunteers		18 Jul 16
Interview Schedule	1.2	18 Jul 16
Interview Schedule: Management	1.2	18 Jul 16
Interview Participant Information Sheet	1.3	18 Jul 16
Interview Consent Form	1.3	18 Jul 16
Questionnaire – Information Sheet	1.3	18 Jul 16
Musicians' Musculoskeletal Health Questionnaire		18 Jul 16

Approval of this project from JHC-LREP is subject to the following conditions being met:

- The Principal Investigator will immediately report anything that might warrant review of ethical approval of the project.
- The Principal Investigator will notify the JHC-LREP of any event that requires an amendment/modification to the protocol or other project documents and submit any required amendments.
- The Principal Investigator will submit any necessary reports related to the safety of research participants in accordance with JHC-LREP policy and procedures.
- The Principal Investigator will report to the JHC-LREP six monthly and notify JHC-LREP when the project is completed at all sites in the specified formats.
- The Principal Investigator will notify the JHC-LREP if the project is discontinued at a participating site before the expected completion date, with reasons provided.
- The Principal Investigator will notify the JHC-LREP of any plan to extend the duration of the project past the approval period listed above and will submit any associated required documentation.
- The Principal Investigator will notify the JHC-LREP of their inability to continue and indicate the name of and contact information for a replacement.
- The return of the Principal Investigators Assurance (Attachment A) signed by all Principal Investigators.

This letter constitutes ethical approval only. This project cannot proceed at any site until separate research governance authorisation has been obtained from the CEO or Delegate of the institution under whose auspices the research will be conducted and any relevant data access approvals are obtained.

Principal Investigators Assurance
The attached Principal Investigators Assurance Form is to be signed by the Principal Investigator, formatted in PDF and returned to the DHRC at health.research@defence.gov.au **before the project commences** (Attachment A).

Progress Reports
In accordance with HLTHMAN Volume 23 paragraph 5.3, DHRC requires you to provide six-monthly progress reports on your project to be submitted to DHRC in PDF form to health.research@defence.gov.au. Progress reports are due on 1 June and 1 December each year. Your first progress report will be due **1 December 2016.**

Amendments to your protocol
If your protocol requires any amendments, DHRC approval must be sought through completion of the attached Approval Protocol Amendment Form. To ensure efficient and effective review by the DHRC, please ensure your submission:

a. includes details of all amendments required;
b. ensure any relevant documents have been attached; and
c. save your submission and all attachments as **one single, PDF document** and attach to an email to health.research@defence.gov.au.

When considering amendments to your protocol, you should be aware that changes may also change the associated risk level. If that occurs, your research must cease until such time as you receive the appropriate ethical review and approval.

We wish you well with your research and look forward to your progress reports. If you have any queries, please do not hesitate in contacting DHRC on tel: (02) 6266 3470.

Yours sincerely

Terri Davis
Chair, Joint Health Command Low Risk Ethics Panel
A/Director Defence Health Research

Attachment:
A. Principal Investigators' Assurance Form

The Directorate for Health Research Coordination reviews research and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007).*

A1.2.2 Information sheets[qqq]

A.1.2.2.1 Information sheet for non-defence musicians

THE UNIVERSITY of ADELAIDE

Musculoskeletal disorders in selected occupational groups
A case study in the music industry

We are exploring musculoskeletal disorders in musicians. These disorders include pain, weakness, pins and needles, and numbness.

As part of this research, we are inviting South Australian musicians who are employed as performers (instrumental, vocal and/or conducting), instrumental, or vocal teachers, and university music students and staff, as well as members of the Musicians' Union of Australia and Music Teachers' Association of South Australia to participate.

It is anticipated that this research may lead to recommendations which will help reduce the frequency musculoskeletal symptoms and the impact of these symptoms for musicians, and potentially other occupational groups. There will be no direct benefits for participants.

Other than the time taken to complete this questionnaire, there are no foreseeable risks or harms.

The questionnaire is available online from https://www.surveymonkey.com/r/Musculoskeletal_MusiciansUnion or by scanning the QR code below. If you would prefer to complete a paper version of this questionnaire, please contact Jessica Stanhope (jessica.stanhope@adelaide.edu.au, Ph: 08 8313 1985) so that this can be sent to you. Please only complete the questionnaire once. The questionnaire takes approximately 15-20 minutes to complete, and those who complete and submit the questionnaire by June 10, 2016 will go into a **DRAW FOR A $250 GIFT CARD, OR ONE OF FIVE $50 GIFT CARDS.** To go into the draw you must provide an email address or phone number must be provided. This will be removed from the questionnaire as soon as possible, to protect your anonymity.

Who is conducting the research?
This research is being conducted by Jessica Stanhope. This research will form the basis for the degree of PhD at the University of Adelaide under the supervision of Prof. Dino Pisaniello, Prof. Philip Weinstein and Dr. Rebecca Tooher.

Confidentiality and privacy
Once you complete the questionnaire, it will be collected by one of the researchers. All contact details provided will be removed from the questionnaire as soon as possible, and only the research team will have access to this. Following the prize draw all contact details supplied for this purpose will be destroyed. The contact details of participants wanting a summary of the research findings will be destroyed once these findings have been provided.

All electronic data will be stored on The University of Adelaide's server in password protected folders. Only the research team will have access to this data. Paper questionnaires will be stored securely within a locked filing cabinet, in a locked office within The University of Adelaide. These will also be scanned, and all data will be entered onto the computer to allow for analysis, and will be stored on The University of Adelaide's server in password protected folders. All data will be retained for five years following publication.

It is anticipated that results will be presented at conferences, in published papers, and within a PhD thesis. All data will be aggregated so that the identity of participants cannot be determined; thus protecting your privacy and confidentiality.

1

[qqq]The information sheets were customised for the target group

Consent and complaints
Participation in this project is completely voluntary. By completing and returning the questionnaire you are providing consent to be involved in the study. As this is an anonymous survey, you will not be able to withdraw your data once it has been submitted, unless you have provided your contact details for participating in future research, in which case you will only be able to withdraw up until data analysis has commenced. Non-participation or withdrawal from the study will not impact upon study or employment.

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2015-279). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. Contact the Human Research Ethics Committee's Secretariat on phone +61 8 8313 6028 or by email to hrec@adelaide.edu.au. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

Returning your paper questionnaire
Paper questionnaires can be returned via the supplied reply-paid envelope.

Future research
As part of this project it is anticipated that interviews will be conducted with musicians. If you indicate your interest in participating in these interviews on the final page of the questionnaire, you may be conducted by the research team at a later date. A gift voucher will be offered to those participating in the interviews.

If you have any questions regarding the project, please contact one of the researchers.
Jessica Stanhope, PhD candidate, Ph: 08 8313 1985, jessica.stanhope@adelaide.edu.au
Prof. Dino Pisaniello, Professor of Public Health, Ph: 08 8313 3571, dino.pisaniello@adelaide.edu.au
Prof. Philip Weinstein, Head of the School of Biological Sciences, Ph: 08 8313 6222, philip.weinstein@adelaide.edu.au
Dr. Rebecca Tooher, Senior Lecturer, Ph: 08 8313 1316, rebecca.tooher@adelaide.edu.au

A1.2.2.2 Information sheet for musicians from the Australian Defence Force

THE UNIVERSITY of ADELAIDE

Musculoskeletal disorders in selected occupational groups

A case study in the music industry

We are exploring musculoskeletal disorders in musicians. These disorders include pain, weakness, pins and needles, and numbness.

As part of this research, we are inviting South Australian musicians who are employed as **performers (instrumentalists, vocalists and/or conductors),** instrumental, or vocal teachers, and university music students and staff, as well as members of the Musicians' Union of Australia and Music Teachers' Association of South Australia to participate.

It is anticipated that this research may lead to recommendations which will help reduce the frequency musculoskeletal symptoms and the impact of these symptoms for musicians, and potentially other occupational groups. There will be no direct benefits for participants.

Other than the time taken to complete this questionnaire, there are no foreseeable risks or harms.

If you are interested in participating, please complete the attached questionnaire.

The questionnaire takes approximately 15-20 minutes to complete.

Who is conducting the research?
This research is being conducted by Jessica Stanhope. This research will form the basis for the degree of PhD at the University of Adelaide under the supervision of Prof. Dino Pisaniello, Prof. Philip Weinstein and Dr. Rebecca Tooher.

Confidentiality and privacy
Once you complete the questionnaire, it will be collected by one of the researchers. All contact details provided will be removed from the questionnaire as soon as possible, and only the research team will have access to this. The contact details of participants wanting a summary of the research findings will be destroyed once these findings have been provided.

The paper questionnaires will be stored securely within a locked filing cabinet, in a locked office within The University of Adelaide. These will also be scanned, and all data will be entered onto the computer to allow for analysis. The scanned questionnaires and data will be stored on The University of Adelaide's server in password protected folders. Only the research team will have access to this data. All data will be retained for five years following publication.

It is anticipated that results will be presented at conferences, in published papers, and within a PhD thesis. All data will be aggregated so that the identity of participants cannot be determined; thus protecting your privacy and confidentiality.

THE UNIVERSITY of ADELAIDE

Consent and complaints
Participation in this project is completely voluntary. By completing and returning the questionnaire you are providing consent to be involved in the study. Participation in this research is entirely voluntary; there is no obligation to take part in the study, and if you choose not to participate there will be no detriment to your career or future health care; you may withdraw at any time up until data analysis has commenced with no detriment to your career or to your future health care. Withdrawal of survey data will only be possible for those who have provided their contact details for participating in future research, as other data cannot be identified.

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2015-279) and the Joint Health Command Low-Risk Ethical Review Panel (protocol number LREP 16-006). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. Contact The University of Adelaide Human Research Ethics Committee's Secretariat on phone +61 8 8313 6028 or by email to hrec@adelaide.edu.au. if you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant. Alternatively, you may prefer to contact
Director, Defence Health Research
Chair, Joint Health Command Low Risk Ethics Panel
CP3-6-031
PO Box 7911
CANBERRA BC ACT 2610
AUSTRALIA
Telephone: 0477 330 020
Email: health.research@defence.gov.au

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

Returning your paper questionnaire

Questionnaires can be returned to Jessica Stanhope directly, via the supplied reply-paid envelope, or by placing your completed questionnaire in the box marked 'Musicians Musculoskeletal Health Questionnaire'.

Future research
As part of this project it is anticipated that interviews will be conducted with musicians. If you indicate your interest in participating in these interviews on the final page of the questionnaire, you may be conducted by the research team at a later date.

If you have any questions regarding the project, please contact one of the researchers.
Jessica Stanhope, PhD candidate, Ph: 08 8313 1985, jessica.stanhope@adelaide.edu.au
Prof. Dino Pisaniello, Professor of Public Health, Ph: 08 8313 3571, dino.pisaniello@adelaide.edu.au
Prof. Philip Weinstein, Head of the School of Biological Sciences, Ph: 08 8313 6222, philip.weinstein@adelaide.edu.au
Dr. Rebecca Tooher, Senior Lecturer, Ph: 08 8313 1316, rebecca.tooher@adelaide.edu.au

A1.2.2.3 Information sheet for the reference groups

THE UNIVERSITY of ADELAIDE

Musculoskeletal disorders in selected occupational groups
A case study in the music industry

We are exploring the musculoskeletal disorders in musicians. These disorders include pain, weakness, pins and needles, and numbness.

As part of this research, we would like **university students and staff** to complete the attached questionnaire to use as a comparison group for musicians, to allow us to determine whether musicians are different to the general population. Only those aged 18 years or older are eligible to participate. ***If you are also currently studying music, employed as a musician, or a member of the Musicians' Union of Australia or the Music Teachers' Association of South Australia please complete the musicians' questionnaire, do not complete this questionnaire.*** Please contact the research team if you are unsure which questionnaire you should complete.

It is anticipated that this research may lead to recommendations which will help reduce the prevalence of musculoskeletal symptoms and the impact of these symptoms for musicians, and potentially other occupational groups. There will be no direct benefits for participants.

Other than the time taken to complete this questionnaire, there are no foreseeable risks or harms.

The questionnaire can be accessed at https://www.surveymonkey.com/r/Musculoskeletal_BiologicalSciences or by scanning the QR code below. If you would prefer to complete a paper version of this questionnaire, please contact Jessica Stanhope (jessica.stanhope@adelaide.edu.au, Ph: 08 8313 1985) so that this can be sent to you. Please only complete the questionnaire once. The questionnaire takes approximately 5-10 minutes to complete, and those who complete and submit the questionnaire by June 10, 2016 will go into a **DRAW FOR A $250 GIFT CARD, OR ONE OF FIVE $50 GIFT CARDS.** To go into the draw an email address or phone number must be provided. This will be removed from the questionnaire as soon as possible, to protect your anonymity.

Who is conducting the research?
This research is being conducted by Jessica Stanhope. This research will form the basis for the degree of PhD (Public Health) at the University of Adelaide under the supervision of Prof. Dino Pisaniello, Prof. Philip Weinstein and Dr. Rebecca Tooher.

Confidentiality and privacy
Once you complete the questionnaire, it will be collected by one of the researchers. All contact details provided will be removed from the questionnaire as soon as possible, and only the research team will have access to this. Following the prize draw all contact details supplied for this purpose will be destroyed. The contact details of participants wanting a summary of the research findings will be destroyed once these findings have been provided.

All electronic data will be stored on The University of Adelaide's server in password protected folders. Only the research team will have access to this data. Paper questionnaires will be stored securely within a locked filing cabinet, in a locked office within The University of Adelaide. These will also be scanned, and all data will be entered onto the computer to allow for analysis, and will be stored on The University of Adelaide's server in password protected folders. All data will be retained for five years following publication.

It is anticipated that results will be presented at conferences, in published papers, and within a PhD thesis. All data will be aggregated so that the identity of participants cannot be determined; thus protecting your privacy and confidentiality.

Consent and complaints

Participation in this project is completely voluntary. By completing and returning the questionnaire you are providing consent to be involved in the study. As this is an anonymous survey, you will not be able to withdraw from the study once your questionnaire has been submitted. Non-participation in the study will not impact upon your study or employment.

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number: H-2015-279). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. Contact the Human Research Ethics Committee's Secretariat on phone +61 8 8313 6028 or by email to hrec@adelaide.edu.au. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

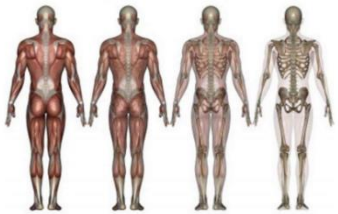
If you have any questions regarding the project, please contact one of the researchers.

Jessica Stanhope, PhD candidate, Ph: 08 8313 1985, jessica.stanhope@adelaide.edu.au
Prof. Dino Pisaniello, Professor of Public Health, Ph: 08 8313 3571, dino.pisaniello@adelaide.edu.au
Prof. Philip Weinstein, Head of the School of Biological Sciences, Ph: 08 8313 6222, philip.weinstein@adelaide.edu.au
Dr. Rebecca Tooher, Senior Lecturer, Ph: 08 8313 1316, rebecca.tooher@adelaide.edu.au

A1.2.3 Recruitment posters[rrr]

A1.2.3.1 Poster for musicians

Can you help us better understand musicians' musculoskeletal disorders?



Musculoskeletal symptoms are commonly experienced by musicians, and we are trying to work out why these symptoms occur, how they impact on people and who is at most risk. We are asking musicians in South Australia to complete a survey which takes about 15-20 minutes, to better understand why these problems are so common.

We value your input, and we are offering participants who submit a completed questionnaire by **June 10, 2016**, the chance to go into a **PRIZE DRAW** for a **$250 gift card**, or one of five $50 gift card runner-up prizes.

Any musician aged 18 years or older can participate. Your participation is voluntary, and your data will be kept **confidential**.

If you wish to participate, please read the information sheet, then click here to access the survey. If the survey does not open automatically, please copy and paste the following link to your internet browser's address bar: https://www.surveymonkey.com/r/Musculoskeletal_ElderCon3

If you would prefer to complete a paper version, or if you have any questions about the survey, please feel free to email me (Jessica.Stanhope@adelaide.edu.au) or give me a call (08 8313 1985).

[rrr]Posters were customised to the target group. Posters were not used to recruit military band musicians, nor musicians through the organisations that were only recruited via email

A1.2.3.2 Poster for non-musicians

Can you help us better understand musculoskeletal disorders?

Musculoskeletal symptoms are a common problem in the general population, and we are trying to understand more about why these occur, how they impact on people and who has the greatest risk. This project focuses on musicians, however we are looking for **staff and students from the School of Biological Sciences** to help us by completing a 5-10 minute survey, as we need a comparison group.

We value your input, and we are offering participants who submit a completed questionnaire by **June 10, 2016** the chance to go into a **PRIZE DRAW** for a **$250 gift card**, or one of five $50 gift card follow up prizes.

You need to be aged 18 years or older to participate. Your participation is voluntary, and your data will be kept confidential.

If you wish to participate, please read the information sheet, then click here to access the survey. If the survey does not open automatically, please copy and paste the following link to your internet browser's address bar: https://www.surveymonkey.com/r/Musculoskeletal_BiologicalSciences1

If you would prefer to complete a paper version, or if you have any questions about the survey, please feel free contact Jessica Stanhope (Jessica.Stanhope@adelaide.edu.au, Ph: 08 8313 1985).

A1.2.4 Questionnaires

A1.2.4.1 Musicians' Musculoskeletal Health Questionnaire[sss]

Musicians' Musculoskeletal Health Questionnaire

THANK YOU FOR PARTICIPATING IN THIS STUDY

This questionnaire is being distributed to musicians in a number of groups in South Australia; please make sure you **only complete it once**.

If you have completed this questionnaire online, please DO NOT complete this version.

By completing this questionnaire you are confirming that you have read the Information Sheet, and consent to participation in this study.

We estimate this questionnaire will take 15-20 minutes to complete

There are 4 parts:

- Part 1 includes general questions about yourself, your musical activity, work and study
- Part 2 includes questions about any musculoskeletal symptoms you have experienced
- Part 3 includes questions about factors which may be associated with your symptoms
- Part 4 is optional, but must be completed, or if you want to go into the prize draw, so that we can contact you if you win!

Unless otherwise indicated, use a tick (✓) to indicate the most appropriate response

Carefully follow the instructions about skipping questions (in red)

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[sss]The questionnanire was targeted to the population (e.g. West Australian organisations were included instead of South Australian in the questionnaire distributed to West Australian musicians. All references to the prize draw were removed from the questionnaires distributed to members of the Australian Defence Force.

PART 1: General Information

1.1 Have you completed the online version of this questionnaire?

☐ Yes *If 'yes', please do not complete this version of the questionnaire*

☐ No

1.2 What date did you complete the questionnaire?

1.3 What is your current age? years *If you are 17 years or younger, you are NOT eligible to participate in this survey. Please DO NOT continue.*

1.4 What is your gender?

1.5 How tall are you? cms

1.6 How much do you weigh? kgs

1.7 What is your residential postcode?

1.8 Which is your dominant hand?

☐ Right hand ☐ Left hand ☐ Equally right and left handed (i.e. ambidextrous)

1.9 How much time do you estimate you spend sitting on a TYPICAL day?

Please DO NOT include time spent sleeping

☐ <4 hours ☐ 4-8 hours ☐ 8-12 hours ☐ >12 hours

The following items are about your musical activity

1.10 How old were you when you first started musical tuition? years

1.11 In the last 12 months, have you played an instrument, sung, conducted or been a drum major?

☐ Yes ☐ No *If 'no', please GO TO Item 1.19 (page 3)*

1.12 List all of the musical activities you have done in the last 12 months

Musical activities may include singing, conducting, being a drum major or playing an instrument.
Please be specific when listing instruments, e.g. tenor saxophone, baritone saxophone

1.13 In the last 7 days, have you played an instrument, sung, conducted or been a drum major?

☐ Yes ☐ No *If 'no', please GO TO Item 1.16 (page 2)*

1.14 What is the TOTAL number of hours you have spent playing an instrument, singing, conducting or being a drum major in the last 7 days?

☐ 0-5 hours ☐ 5-10 hours ☐ 10-15 hours ☐ 15-20 hours

☐ 20-25 hours ☐ 25-30 hours ☐ 30-35 hours ☐ 35 hours or more

1.15 **List all of the musical activities you have done for each estimated time period in the last 7 days**

For example, if you have conducted for 3 hours in the last 7 days, write 'conducting' next to 2-4 hours in the table below.

Musical activities may include singing, conducting, being a drum major or playing an instrument.

Please be specific when listing instruments, e.g. tenor saxophone, baritone saxophone.

	Musical activities performed for each estimated time period
30 or more hours	
25-30 hours	
20-25 hours	
15-20 hours	
10-15 hours	
8-10 hours	
6-8 hours	
4-6 hours	
2-4 hours	
0-2 hours	

1.16 **In the last 12 months, have you done any performances, performance exams and/ or auditions?**

☐ Yes ☐ No ***If 'no', please GO TO Item 1.19 (page 3)***

1.17 **Please circle the number which best describes the intensity of your stage fright**

In the last 12 months, what has been the AVERAGE intensity of your stage fright?	0 1 2 3 4 5 6 7 8 9 10 *No stage fright* *Worst imaginable stage fright*

1.18 **In the last 7 days, have you done any performances, performance exams and/or auditions?**

☐ Yes ☐ No

The following items are about your qualifications and studies

1.19 **Have you completed any music qualifications?**

These qualifications may include university, TAFE and AMEB (or similar) certificates, diplomas and degrees

☐ Yes → Which music qualifications have you completed?
Please include your major (e.g. instrument), where applicable

☐ No

1.20 **Are you currently studying at university?**

This refers to any study, not just music

☐ Yes →
- Which university?
- Which program?
- What is your major? *(e.g. instrument)*
- Which year are you in?
- Are you full time or part time?

☐ No

The following items are about your work (musical and non-musical work)

1.21 **Please tick which of the following organisations you are a current member of**

☐ Music Teachers' Association of South Australia
☐ Musicians' Union of Australia
☐ Neither of these

1.22 **Do you consider yourself to be a professional musician currently?**

☐ Yes → Please tick ALL of your current professional musical activities:
☐ Performing ☐ Teaching ☐ Conducting ☐ Being a drum major
☐ Composing ☐ Singing ☐ Playing an instrument
☐ Other (please specify):

☐ No

1.23 **Have you had ANY paid work in the last 12 months?**

Please note this includes work which is NOT related to music, as well as self-employed work (i.e. where you invoice others)

☐ Yes → How many employers have you had in the last 12 months?
Self-employed work counts as ONE employer

☐ No ***If 'no', please GO TO Part 2 (page 5)***

1.24 **Have you been employed as a MUSICIAN in the last 12 months?**

This includes self-employed work, and may include work performing and/or teaching

☐ Yes ☐ No ***If 'no', please GO TO Part 2 (page 5)***

1.25 **Which of the following organisations have you been EMPLOYED by as a musician (including teaching) in the last 12 months?** *This includes self-employed work. Please tick all that apply*

- ☐ Adelaide Symphony Orchestra
- ☐ Adelaide Art Orchestra
- ☐ State Opera SA
- ☐ Co-Opera
- ☐ Elder Conservatorium of Music
- ☐ James Morrison Academy of Music
- ☐ Other (please specify):
- ☐ South Australian Navy Band
- ☐ Australian Army Band Adelaide
- ☐ Band of the 10/27 Battalion
- ☐ Band of the South Australian Police
- ☐ Instrumental Music Service
- ☐ Self-employed

1.26 **Have you had ANY paid work in the last 7 days?**
Please note this includes self-employed work and work which is NOT related to music
☐ Yes ☐ No ***If 'no', please GO TO Part 2 (page 5)***

1.27 **Please complete the table below regarding your work (music and non-music) in the last 7 days**
Please include any self-employed work (i.e. where you invoice others) as ONE employer, stating 'self-employed' ι the name of the employer.
If you have had more than 3 employers in the last 7 days, please describe the 3 you have worked for the most in the last 7 days

Name of EMPLOYER 1:
- What is your role here? *Include instruments, if applicable*
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Reservist ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? hours

Name of EMPLOYER 2:
- What is your role here? *Include instruments, if applicable*
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Reservist ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? hours

Name of EMPLOYER 3:
- What is your role here? *Include instruments, if applicable*
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Reservist ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? Hours

The following items ask specifically about symptoms which may interfere with playing an instrument, singing, conducting or being a drum major

This first question is to ensure that we only ask you to complete items which are relevant to you

2.1 In the <u>last 12 months</u>, have you played an instrument, sung, conducted or been a drum major?

☐ Yes ☐ No *If 'no', please GO TO Item 2.8 (page 7)*

***MUSIC-RELATED MUSCULOSKELETAL DISORDERS* are defined as pain, weakness, lack of control, numbness, tingling or other symptoms that have interfered with your ability to do your musical activity at the level to which you are accustomed.**

***MUSICAL ACTIVITY* refers to playing an instrument, singing, conducting or being a drum major**

2.2 In the <u>last 12 months</u>, have you had a music-related musculoskeletal disorder?

☐ Yes ☐ No *If 'no', please GO TO Item 2.8 (page 7)*

2.3 Have you at any time during the <u>last 12 months</u> had a music-related musculoskeletal disorder in the following body regions?

Please answer for each body region, referring to the body chart on page 6

Head	☐ No	☐ Yes
Mouth/ jaw	☐ No	☐ Yes
Neck	☐ No	☐ Yes
Shoulder	☐ No	☐ Yes
Elbow	☐ No	☐ Yes
Wrist/ hand	☐ No	☐ Yes
Upper back	☐ No	☐ Yes
Chest/ abdomen	☐ No	☐ Yes
Lower back	☐ No	☐ Yes
Hip/ thigh	☐ No	☐ Yes
Knee	☐ No	☐ Yes
Foot/ ankle	☐ No	☐ Yes

2.4 In the <u>last 7 days</u>, have you had a music-related musculoskeletal disorder?

☐ Yes ☐ No *If 'no', please GO TO Item 2.8 (page 7)*

2.5 Have you experienced a music-related musculoskeletal disorder on most days for MORE THAN 3 MONTHS?

☐ Yes ☐ No

2.6 **Have you had a music-related musculoskeletal disorder at any time during the <u>last 7 days</u> in the following body regions?**

Please answer for each body region, referring to the body chart on page 6

Head	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Mouth/ jaw	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Neck	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Shoulder	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Elbow	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Wrist/ hand	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Upper back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Chest/ abdomen	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Lower back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Hip/ thigh	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Knee	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Foot/ ankle	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side

2.7 **In the following rating scales, circle the number which best describes the amount that your symptoms have interfered with your musical activity in the <u>last 7 days</u>**

	0	1	2	3	4	5	6	7	8	9	10
How much has your music-related musculoskeletal disorder interfered with your musical activity at their WORST in the <u>last 7 days</u>?	*Does not interfere*										*Completely interferes*

	0	1	2	3	4	5	6	7	8	9	10
How much has your music-related musculoskeletal disorder interfered with your musical activity at their LEAST in the <u>last 7 days</u>?	*Does not interfere*										*Completely interferes*

	0	1	2	3	4	5	6	7	8	9	10
How much has your music-related musculoskeletal disorder with your musical activity on AVERAGE in the <u>last 7 days</u>?	*Does not interfere*										*Completely interferes*

The following items are about any ACHE/ PAIN/ DISCOMFORT you have experienced in the <u>last 7 days</u>
These symptoms may or may not interfere with your musical activity

2.8 **Have you experienced ache/ pain/ discomfort at any time during the <u>last 7 days?</u>**

☐ Yes ☐ No ***If 'no', please GO TO Item 2.17 (page 9)***

2.9 **Have you experienced ache/ pain/ discomfort on most days for MORE THAN 3 MONTHS?**

☐ Yes ☐ No

2.10 **Have you experienced ache/ pain/ discomfort at any time during the <u>last 7 days</u> in the following body regions?**

Please answer for each body region, referring to the body chart on page 6

Head	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Mouth/ jaw	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Neck	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Shoulder	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Elbow	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Wrist/ hand	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Upper back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Chest/ abdomen	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Lower back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Hip/ thigh	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Knee	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Foot/ ankle	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side

2.11 **For the following questions, please circle the number that best corresponds to your views regarding the ache/ pain/ discomfort you have experienced in the <u>last 7 days</u>**

How much does your ache/ pain/ discomfort affect your life?	0 1 2 3 4 5 6 7 8 9 10 *No affect at all* … *Severely affects my life*
How long do you think your ache/ pain/ discomfort will continue?	0 1 2 3 4 5 6 7 8 9 10 *A very short time* … *Forever*
How much control do you feel you have over your ache/ pain/ discomfort?	0 1 2 3 4 5 6 7 8 9 10 *No symptoms at all* … *Many severe symptoms*
How concerned are you about your ache/ pain/ discomfort?	0 1 2 3 4 5 6 7 8 9 10 *Not at all concerned* … *Extremely concerned*
How well do you feel you understand your ache/ pain/ discomfort?	0 1 2 3 4 5 6 7 8 9 10 *Don't understand at all* … *Understand very clearly*
How much does your ache/ pain/ discomfort affect you emotionally? (e.g. does it make you angry, scared, upset or depressed?)	0 1 2 3 4 5 6 7 8 9 10 *Not at all affected emotionally* … *Extremely affected emotionally*

2.12 **Are you <u>currently</u> having treatment for your ache/ pain/ discomfort?**

☐ Yes ☐ No ***If 'no', please GO TO Item 2.14 (page 9)***

2.13 **Please circle the number that best corresponds to your views regarding the ache/ pain/ discomfort you have experienced in the <u>last 7 days</u>**

How much do you think your treatment can help your ache/ pain/ discomfort?	0 1 2 3 4 5 6 7 8 9 10 *Not at all* … *Extremely helpful*

2.14 **Please list the three most important factors that you believe caused your current ache/ pain/ discomfort in the order of importance.**
The most important causes for me:

1.
2.
3.

2.15 **For each statement, please circle from 0 to 6 to say how much your MUSICAL ACTIVITY has affected your ache/ pain/ discomfort in the last 7 days**

My ache/ pain/ discomfort was CAUSED by musical activity	0 1 2 3 4 5 6 *Completely disagree* *Unsure* *Completely agree*
My musical activity has AGGRAVATED my ache/ pain/ discomfort	0 1 2 3 4 5 6 *Completely disagree* *Unsure* *Completely agree*

Now think about any PAIN you have experienced in the last 7 days

2.16 **The following scales relate to your PAIN in the last 7 days**

Please rate your pain by circling the one number that best describes your pain at its WORST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* *Pain as bad as you can imagine*
Please rate your pain by circling the one number that best describes your pain at its LEAST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* *Pain as bad as you can imagine*
Please rate your pain by circling the one number that best describes your pain on AVERAGE in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* *Pain as bad as you can imagine*

Now think about any ACHE/ PAIN/ DISCOMFORT you have experienced in the last 12 months

2.17 **Have you at any time during the last 12 months experienced ache/ pain/ discomfort?**

☐ Yes ☐ No ***If 'no', please GO TO Part 3 (page 11)***

2.18 **Have you at any time during the last 12 months experienced ache/ pain/ discomfort in the following body regions?**

Please answer for each body region, referring to the body chart on page 6

Head	☐ No	☐ Yes
Mouth/ jaw	☐ No	☐ Yes
Neck	☐ No	☐ Yes
Shoulder	☐ No	☐ Yes
Elbow	☐ No	☐ Yes
Wrist/ hand	☐ No	☐ Yes
Upper back	☐ No	☐ Yes
Chest/ abdomen	☐ No	☐ Yes
Lower back	☐ No	☐ Yes
Hip/ thigh	☐ No	☐ Yes
Knee	☐ No	☐ Yes
Foot/ ankle	☐ No	☐ Yes

The following items ask about the impact your ACHE/ PAIN/ DISCOMFORT has had on your work and/or studies in the last 12 months

2.19 During the last 12 months have you had to change jobs, duties or studies (even temporarily) because of ache/ pain/ discomfort

Tick all that apply

- ☐ Yes, for musical work/ study
- ☐ Yes, for non-musical work/ study
- ☐ No

2.20 During the last 12 months have you claimed workers' compensation because of ache/ pain/ discomfort?

Tick all that apply

- ☐ Yes, for musical work
- ☐ Yes, for non-musical work
- ☐ No

2.21 During the last 12 months have you at any time taken leave from work/ studies because of ache/ pain/ discomfort?

Tick all that apply

- ☐ Yes, for musical work/ study
- ☐ Yes, for non-musical work/ study
- ☐ No

The following items ask about the things you have done to manage your ACHE/ PAIN/ DISCOMFORT in the last 12 months

2.22 Have you sought advice or treatment from any of the following people to help manage your ache/ pain/ discomfort in the last 12 months?

- ☐ Musician (e.g. teacher, colleague)
- ☐ Medical professional (e.g. general practitioner, medical specialist, surgeon)
- ☐ Psychologist and/or counsellor
- ☐ Physiotherapist and/or occupational therapist
- ☐ Personal trainer, Pilates instructor and/or yoga instructor
- ☐ Chiropractor, osteopath, massage therapist and/or Bowen therapist
- ☐ Naturopath and/or homeopath
- ☐ Alexander technique practitioner, Feldenkrais practitioner and/or body mapping teacher
- ☐ I have NOT sought treatment or advice from anyone
- ☐ Other (please specify):

2.23 Have you tried any self-treatments to manage your ache/ pain/ discomfort in the last 12 months?

- ☐ Medication (including prescription and over-the-counter)
- ☐ Heat and/or ice
- ☐ Exercises and/or stretches
- ☐ Braces, strapping and/or taping
- ☐ I have NOT tried any self-treatments
- ☐ Other (please specify):

PART 3: Other factors

Part 3 includes questions about factors which might be associated with musculoskeletal symptoms

3.1 Over the <u>last 2 weeks</u>, how often have you been bothered by the following problems?
Tick the box which best applies for each row

	Not at all	Several days	More than half the days	Nearly every day
Feeling nervous, anxious or on edge	☐	☐	☐	☐
Not being able to stop or control worrying	☐	☐	☐	☐
Little interest or pleasure in doing things	☐	☐	☐	☐
Feeling down, depressed, or hopeless	☐	☐	☐	☐

3.2 The following items ask about stress. Please circle the number which best reflects your response.
On a scale of 1 to 6…

	1	2	3	4	5	6
How would you rate your ability to handle stress?	*I can shake off stress*					*Stress eats away at me*

	1	2	3	4	5	6
In the <u>last 12 months</u>, how would you rate the amount of stress in your life (at home and at work?)	*No stress*					*Extreme stress*

The remaining items refer to your MUSICAL work and/or studies overall

3.3 Circle the alternative that best describes your opinion

	Very seldom or never	Rather seldom	Sometimes	Rather often	Very often or always
If needed, can you get support and help with your studies/ work from other musicians?	1	2	3	4	5
If needed, are other musicians willing to listen to your study/ work related problems?	1	2	3	4	5

3.4 How much do you agree or disagree with each of the following statement?

Circle the number which best describes your level of agreement/ disagreement

This relates to your musical work/ studies

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
All in all I am satisfied with my job/ studies	1	2	3	4	5
In general, I don't like my job/ studies	1	2	3	4	5
In general, I like working/ studying	1	2	3	4	5

3.5 Tick the ONE option which applies most to you <u>currently</u>

- ☐ I consider myself to mainly be EMPLOYED as a musician ***Please GO TO Part 3.7***
- ☐ I consider myself to mainly be SELF-EMPLOYED as a musician
- ☐ I consider myself to mainly be a music STUDENT

This item is to ensure that the remaining questions are relevant to you

3.6 Are you <u>currently</u> employed as a musician?

This EXCLUDES self-employed work

- ☐ Yes
- ☐ No ***If 'no', please GO TO Part 4 (page 14)***

3.7 Which ONE organisation/ ensemble do you consider to be your <u>current</u> main musical employer?

This EXCLUDES self-employed work

The following items relate to your work with your MAIN MUSICAL EMPLOYER (as stated in Item 3.8)

3.8 Please indicate your level of agreement or disagreement by placing a tick in the appropriate box
This relates to your work with your MAIN musical employer

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Health and safety information is always brought to my attention by my line manager/ supervisor	☐	☐	☐	☐	☐
There is good communication here about health and safety issues which affect me	☐	☐	☐	☐	☐
Management considers health and safety to be equally as important as performance/ achievement	☐	☐	☐	☐	☐
I believe health and safety issues are assigned a high priority	☐	☐	☐	☐	☐
I am involved in informing management of important health and safety issues	☐	☐	☐	☐	☐
I am involved in the ongoing review of health and safety	☐	☐	☐	☐	☐

3.9 For each of the following statements, please indicate whether you strongly agree, agree, disagree or strongly disagree
This relates to your work with your MAIN musical employer

	Strongly agree	Agree	Disagree	Strongly disagree
I have constant time pressure due to a heavy workload	☐	☐	☐	☐
I have many interruptions and disturbances while performing my job	☐	☐	☐	☐
Over the past few years, my job has become more and more demanding	☐	☐	☐	☐
I receive the respect I deserve from my superior or a respective relevant person	☐	☐	☐	☐
My job promotion prospects are poor	☐	☐	☐	☐
I have experienced or I expect to experience an undesirable change in my work situation	☐	☐	☐	☐
My job security is poor	☐	☐	☐	☐
Considering all my efforts and achievements, I receive the respect and prestige I deserve at work	☐	☐	☐	☐
Considering all my efforts and achievements, my job promotion prospects are adequate	☐	☐	☐	☐
Considering all my efforts and achievements, my salary/ income is adequate	☐	☐	☐	☐

PART 4: Contact details

Part 4 is optional; however you will need to complete it if you would like to go into the **PRIZE DRAW**, if you are interested in participating in follow-up interviews, or if you would like to receive a summary of our findings

4.1 Would you like to enter the PRIZE DRAW?

☐ Yes – please provide your contact details

☐ No

Your contact details will be immediately removed from the questionnaire data

4.2 Would you like to receive a summary of our findings?

☐ Yes – please provide your **email address**

☐ No

Your email address will be immediately removed from the questionnaire data.

4.3 Are you interested in being involved in future research?

☐ Yes – please provide your contact details

☐ No

Phone number:

____

OR

Email address:

____

To receive a summary of our findings you must provide an email address

It is anticipated that we will be conducting interviews as part of this project.

Interview participants will be compensated with a ***$20 GIFT CARD***

By providing these details you are not committing to your involvement, but may be invited to participate in future research.

Your contact details will be removed from this questionnaire data and stored with a unique identification number. Your contact details will be stored securely, and will be kept separate from the questionnaire data

THANK YOU FOR COMPLETING THE SURVEY

To be eligible for the PRIZE DRAW you must return the questionnaire WITHIN 2 WEEKS*, and provide your contact details above

Questionnaires can be **returned** to Jessica Stanhope directly, via the supplied reply-paid envelope, or by placing your completed questionnaire in the box marked 'Musicians Musculoskeletal Health Questionnaire' at <the office location was inserted for each site>

*If posting the questionnaire to us the post-mark will be used to confirm the date

A1.2.4.1 Musician’s Musculoskeletal Health Questionnaire

Musculoskeletal Health Questionnaire

THANK YOU FOR PARTICIPATING IN THIS STUDY

If you are currently studying music or working as a professional musician, please complete the *Musicians’ Musculoskeletal Health Questionnaire*, NOT this one.

If you have completed this questionnaire online, please DO NOT complete this version.

By completing this questionnaire you are confirming that you have read the Information Sheet, and consent to participation in this study.

We estimate this questionnaire will take 5-10 minutes to complete.

There are 3 parts:

- Part 1 includes general questions about yourself, your musical activity, work and study
- Part 2 includes questions about any musculoskeletal symptoms you have experienced
- Part 3 is optional, but must be completed if you want to go into the prize draw, so that we can contact you if you win!

Unless otherwise indicated, use a tick (✓) to indicate the most appropriate response

Carefully follow the instructions about skipping questions (in red)

THE UNIVERSITY of ADELAIDE

PART 1: General questions

1.1 Have you completed the online version of this questionnaire?

☐ Yes *If 'yes', please do not complete this version of the questionnaire*

☐ No

1.2 What date did you complete the questionnaire?

1.3 What is your current age? years *If you are 17 years or younger, you are NOT eligible to participate in this survey. Please do NOT continue.*

1.4 What is your gender?

1.5 How tall are you? cms

1.6 How much do you weigh? kgs

1.7 What is your residential postcode?

1.8 Which is your dominant hand?

☐ Right hand ☐ Left hand ☐ Equally right and left (i.e. ambidextrous)

1.9 How much time do you estimate you spend sitting on a TYPICAL day?

Please DO NOT include time spent sleeping

☐ <4 hours ☐ 4-8 hours ☐ 8-12 hours ☐ >12 hours

The following items are about your studies and work

1.10 Are you currently studying at university?

☐ Yes →
- Which university?
- Which program?
- What is your major? *(if applicable)*
- Which year are you in?
- Are you full time or part time?

☐ No

1.11 Have you had ANY paid work in the last 12 months?

Please note this includes self-employed work (i.e. where you invoice others)

☐ Yes → How many employers have you had in the last 12 months? *Self-employed work counts as ONE employer*

☐ No *If 'no' please GO TO Item 1.15 (page 3)*

1.12 Have you had ANY paid work with The University of Adelaide in the last 7 days?

☐ Yes →
- In which school(s)?
- What is your role within The University? *Tick all that apply*
  ☐ Teaching ☐ Research ☐ Professional
  ☐ Other, please specify:
- How many FULL years have you worked here for? *If less than 1 year, please write 0*
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual
  ☐ Other (please specify):

☐ No *If 'no', please GO TO Item 1.15 (page 3)*

1.13 Have you had ANY paid work OUTSIDE of The University of Adelaide in the last 7 days?

This includes self-employed work (i.e. where you invoice others)

☐ Yes ☐ No ***If 'no', please GO TO Item 1.15 (page 3)***

1.14 Please complete the table below regarding your work in the last 7 days

Please include any self-employed work (i.e. where you invoice others), if applicable, as ONE employer

You DO NOT need to name your employers

If you have had more than 3 employers in the last 7 days, please describe the 3 you have worked for the most in the last 7 days.

EMPLOYER 1:

- What is your role here?
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? hours

EMPLOYER 2:

- What is your role here?
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? hours

EMPLOYER 3:

- What is your role here?
- What is your type of employment?
  ☐ Permanent ☐ Contract ☐ Casual ☐ Self-employed
  ☐ Other (please specify):
- How many FULL years have you worked here for? *If less than 1 year, please write 0* years
- How many hours have you worked here in the last 7 days? Hours
- How many other employers have you had in the last 7 days?

The following items are about your musical activity

1.15 **In the last 12 months, have you played an instrument, sung, conducted or been a drum major?**

☐ Yes ☐ No *If 'no', please GO TO Part 2 (page 5)*

1.16 **List all of the musical activities you have done in the last 12 months**

Musical activities may include singing, conducting, being a drum major or playing an instrument.
Please be specific when listing instruments, e.g. tenor saxophone, baritone saxophone.

1.17 **In the last 7 days, have you played an instrument, sung, conducted or been a drum major?**

☐ Yes ☐ No *If 'no', please GO TO Part 2 (page 5)*

1.18 **What is the TOTAL number of hours you have spent playing an instrument, singing, conducting or being a drum major in the last 7 days?**

☐ 0-5 hours ☐ 5-10 hours ☐ 10-15 hours ☐ 15-20 hours
☐ 20-25 hours ☐ 25-30 hours ☐ 30-35 hours ☐ 35 hours or more

1.19 **List all of the musical activities you have done for each estimated time period in the last 7 days**

For example, if you have conducted for 3 hours in the last 7 days, write 'conducting' next to 2-4 hours in the table below.
Musical activities may include singing, conducting, being a drum major or playing an instrument.
Please be specific when listing instruments, e.g. tenor saxophone, baritone saxophone.

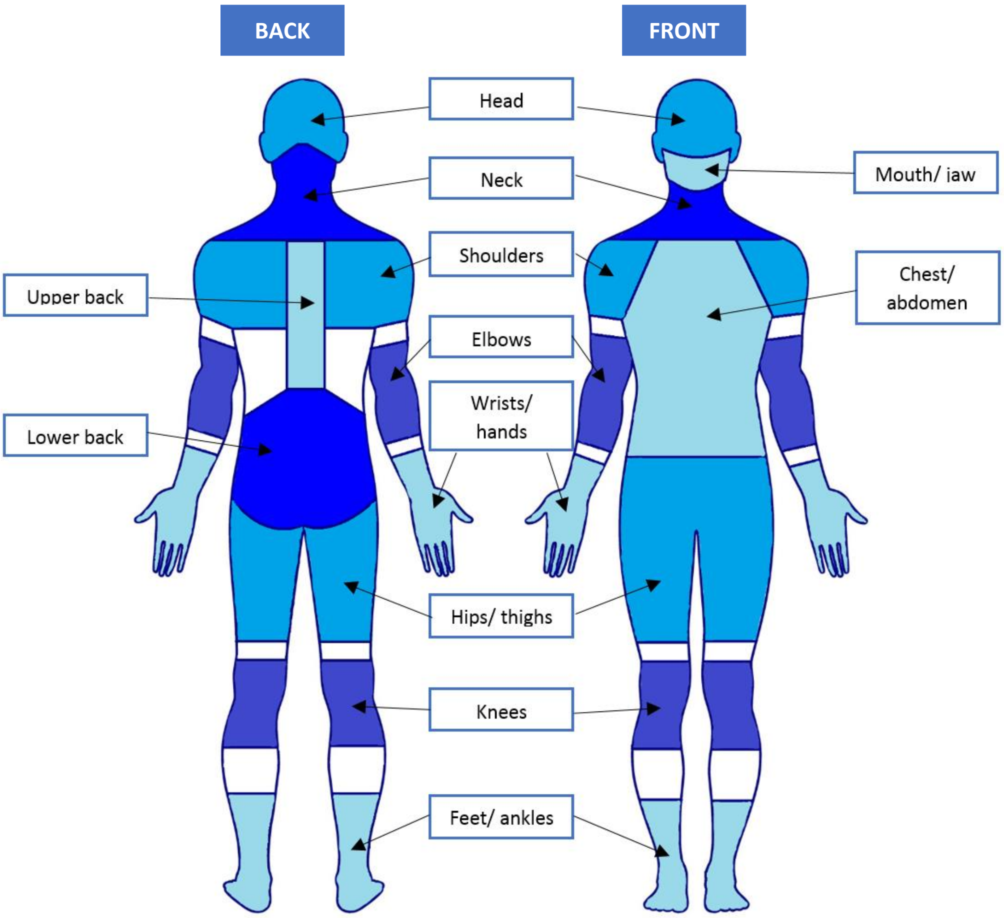
	Musical activities performed for each estimated time period
30 or more hours	
25-30 hours	
20-25 hours	
15-20 hours	
10-15 hours	
8-10 hours	
6-8 hours	
4-6 hours	
2-4 hours	
0-2 hours	

PART 2: Symptoms

In Part 2 we are interested in symptoms which may relate to muscles, joints, bones, tendons, ligaments and nerves.

We are NOT interested in other types of symptoms, such as toothache, sore throat, burns, stomach ache, or indigestion, which do NOT relate to the musculoskeletal system

The body chart below is used to guide your answers to the following items.
You do NOT have to mark the body chart.
The body chart shows how the body has been divided.
Limits are not sharply defined and certain parts overlap. You should decide for yourself which part (if any) is or has been affected.



The following items are about any ACHE/ PAIN/ DISCOMFORT you have experienced in the last 7 days

2.1 Have you experienced ache/ pain/ discomfort at any time during the last 7 days?

☐ Yes ☐ No *If 'no, please GO TO Item 2.6 (page 7)*

2.2 Have you experienced ache/ pain/ discomfort on most days for MORE THAN 3 MONTHS?

☐ Yes ☐ No

2.3 Have you experienced ache/ pain/ discomfort at any time during the last 7 days in the following body regions?

Please answer for each body region, referring to the body chart on page 6

Head	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Mouth/ jaw	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Neck	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Shoulder	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Elbow	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Wrist/ hand	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Upper back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Chest/ abdomen	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Lower back	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Hip/ thigh	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Knee	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side
Foot/ ankle	☐ No	☐ Yes, *both* sides	☐ Yes, *right* side	☐ Yes, *left* side

2.4 For the following questions, please circle the number that best corresponds to your views regarding the ache/ pain/ discomfort you have experienced in the last 7 days

How much does your ache/ pain/ discomfort affect your life?	0 1 2 3 4 5 6 7 8 9 10 *No affect at all* … *Severely affects my life*

How much does your ache/ pain/ discomfort affect you emotionally? (e.g. does it make you angry, scared, upset or depressed?)	0 1 2 3 4 5 6 7 8 9 10 *Not at all affected emotionally* … *Extremely affected emotionally*

2.5 The following scales relate to your PAIN in the last 7 days

Please rate your pain by circling the one number that best describes your pain at its WORST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* … *Pain as bad as you can imagine*

Please rate your pain by circling the one number that best describes your pain at its LEAST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* … *Pain as bad as you can imagine*

Please rate your pain by circling the one number that best describes your pain on AVERAGE in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *No pain* … *Pain as bad as you can imagine*

Now think about any ACHE/ PAIN/ DISCOMFORT you have experienced in the last 12 months

2.6 **Have you at any time during the last 12 months experienced ache/ pain/ discomfort?**

☐ Yes ☐ No *If 'no', please GO TO Part 3 (page 8)*

2.7 **Have you at any time during the last 12 months experienced ache/ pain/ discomfort in the following body regions?** *Please answer for each body region, referring to the body chart on page 6*

Head	☐ No	☐ Yes
Mouth/ jaw	☐ No	☐ Yes
Neck	☐ No	☐ Yes
Shoulder	☐ No	☐ Yes
Elbow	☐ No	☐ Yes
Wrist/ hand	☐ No	☐ Yes
Upper back	☐ No	☐ Yes
Chest/ abdomen	☐ No	☐ Yes
Lower back	☐ No	☐ Yes
Hip/ thigh	☐ No	☐ Yes
Knee	☐ No	☐ Yes
Foot/ ankle	☐ No	☐ Yes

The following items ask about the impact your ACHE/ PAIN/ DISCOMFORT has had on your work and/ or studies in the last 12 months

2.8 **During the last 12 months have you had to change jobs, duties or studies (even temporarily) because of ache/ pain/ discomfort?**

☐ Yes ☐ No

2.9 **During the last 12 months have you claimed workers' compensation because of ache/ pain/ discomfort?**

☐ Yes ☐ No

2.10 **During the last 12 months have you at any time taken leave from work/ studies because of ache/ pain/ discomfort?**

☐ Yes ☐ No

The following items ask about the things you have done to manage your ACHE/ PAIN/ DISCOMFORT in the last 12 months

2.11 **Have you sought advice or treatment from any of the following people to help manage your ache/ pain/ discomfort in the last 12 months?** *Tick all that apply*

☐ Medical professional (e.g. general practitioner, medical specialist, surgeon)
☐ Psychologist and/or counsellor
☐ Physiotherapist and/or occupational therapist
☐ Personal trainer, Pilates instructor and/or yoga instructor
☐ Chiropractor, osteopath, massage therapist and/or Bowen therapist
☐ Naturopath and/or homeopath
☐ I have NOT sought treatment or advice from anyone
☐ Other (please specify):

2.12 **Have you tried any self-treatments to manage your ache/ pain/ discomfort in the last 12 months?**
Tick all that apply

☐ Medication (including prescription and over-the-counter)
☐ Heat and/or ice
☐ Exercises and/or stretches
☐ Braces, strapping and/or taping
☐ I have NOT tried any self-treatments
☐ Other (please specify):

PART 3: Contact details

Part 3 is optional; however you will <u>need</u> to complete it if you would like to go into the **PRIZE DRAW**, or if you would like to receive a summary of our

3.1 Would you like to enter the <u>PRIZE DRAW</u>?

☐ Yes – please provide your contact details

☐ No

Your contact details will be immediately removed from the questionnaire data

3.2 Would you like to receive a summary of our findings?

☐ Yes – please provide your **<u>email address</u>**

☐ No

Your email address will be immediately removed from the questionnaire data.

Phone number:

____

OR

Email address:

____

To receive a summary of our findings you must provide an email address

THANK YOU FOR COMPLETING THE SURVEY

To be eligible for the PRIZE DRAW you must return the questionnaire <u>WITHIN 2 WEEKS</u>*, and provide your contact details above

Questionnaires can be **returned** to Jessica Stanhope directly, via the supplied reply-paid envelope, or by playing your completed questionnaire in the box marked 'Musculoskeletal Health Questionnaire' at <office location will be inserted for each school. This statement will be removed if no box is placed in the office area>.

*If posting the questionnaire to us the post-mark will be used to confirm the date

A1.3 Supplementary material for Chapter 3

Table A1.3.1: List of all reported diagnoses for musicians' musculoskeletal disorder workers' compensation claims

	Injury	Disease
Mouth	Fractured skull and facial bones (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	
Nose	Fractured skull and facial bones (n=1) Other fractures, nec (n=1)	
Face - nec	Fractured skull and facial bones (n=1) Trauma to muscles (n=1) Trauma to muscles and tendons, nec (n=1)	Joint and other articular cartilage diseases, nec (n=1)
Neck	Other fractures, nec (n=1) Trauma to joints and ligaments, nec (n=3) Trauma to muscles (n=2) Trauma to muscles and tendons, nec (n=1) Trauma to muscles and tendons, unspecified (n=5) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=16)	Disc displacement, prolapse or herniation (n=4) Neck pain, cervicalgia (n=10) Spinal vertebrae and intervertebral disc diseases, nec (n=1) Spinal vertebrae and intervertebral disc diseases, unspecified (n=2) Muscle/ tendon strain (non-traumatic) (n=3) Occupational overuse syndrome (n=2) Soft tissue diseases due to non-traumatic causes with insufficient information to code as 'other soft tissue disease' or 'diseases involving the synovium and related tissue' (n=1)
Back – upper or lower	Fracture of vertebral column without mention of spinal cord lesion (n=1) Trauma to joints and ligaments, nec (n=2) Trauma to joints and ligaments, unspecified (n=3) Trauma to muscles (n=5) Trauma to tendon (n=1) Trauma to muscles and tendons, nec (n=2) Trauma to muscles and tendons, unspecified (n=9) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=19)	Disc displacement, prolapse or herniation (n=3) Back pain, lumbago, and sciatica (n=24) Spinal vertebrae and intervertebral disc diseases, unspecified(n=1) Muscle/ tendon strain (non-traumatic) (n=1)
Chest (thorax)	Other fractures, nec (n=1) Trauma to muscles and tendons, nec (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	
Abdomen and pelvic region	Trauma to muscles (n=1)	
Shoulder	Other fractures, nec (n=1) Dislocation (n=3) Trauma to joints and ligaments, nec (n=4) Trauma to joints and ligaments, unspecified (n=2) Traumatic tearing away part of the muscle/ tendon structure, avulsion (n=3) Trauma to muscles (n=3) Trauma to tendon (n=1) Trauma to muscles and tendons, nec (n=6) Trauma to muscles and tendons, unspecified (n=5) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=14)	Joint and other articular cartilage diseases, nec (n=2) Synovitis and tenosynovitis (n=1) Tendinitis (n=15) Frozen shoulder (adhesive capsulitis) (n=2) Muscle/ tendon strain (non-traumatic) (n=7) Bursitis (n=11) Occupational overuse syndrome (n=4) Other specified soft tissue diseases, nec (n=1) Soft tissue diseases due to non-traumatic causes with insufficient information to code as 'other soft tissue disease' or 'diseases involving the synovium and related tissue' (n=6) Musculoskeletal and connective tissue (n=1)
Upper arm		Tendinitis (n=1) Epicondylitis (n=1) Muscle/ tendon strain (non-traumatic) (n=2)

(continued)

	Injury	Disease
Elbow	Other fractures, nec (n=2) Trauma to joints and ligaments, nec (n=1) Trauma to joints and ligaments, unspecified (n=3) Trauma to muscles and tendons, nec (n=1) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=3)	Tendinitis (n=4) Epicondylitis (n=16) Muscle/ tendon strain (non-traumatic) (n=1) Bursitis (n=1) Occupational overuse syndrome (n=2) Soft tissue diseases due to non-traumatic causes with insufficient information to code as 'other soft tissue disease' or 'diseases involving the synovium and related tissue' (n=4)
Forearm	Other fractures, nec (n=5) Trauma to muscles (n=2) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=5)	Tendinitis (n=1) Muscle/ tendon strain (non-traumatic) (n=2) Occupational overuse syndrome (n=2) Soft tissue diseases due to non-traumatic causes with insufficient information to code as 'other soft tissue disease' or 'diseases involving the synovium and related tissue' (n=2)
Wrist	Other fractures, nec (n=3) Trauma to joints and ligaments, nec (n=2) Trauma to joints and ligaments, unspecified (n=1) Traumatic tearing away part of the muscle/ tendon structure, avulsion (n=1) Trauma to muscles (n=1) Trauma to muscles and tendons, nec (n=1) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=6)	Osteoarthritis/ osteoarthrosis (n=1) Synovitis and tenosynovitis (n=6) Ganglion, trigger finger, Dupuytren's contracture (n=1) Tendinitis (n=2) Epicondylitis (n=1) Muscle/ tendon strain (non-traumatic) (n=2) Occupational overuse syndrome (n=3) Musculoskeletal and connective tissue diseases, unspecified (n=1)
Hand, fingers and thumb	Other fractures, nec (n=6) Dislocation (n=1) Trauma to joints and ligaments, nec (n=4) Trauma to joints and ligaments, unspecified (n=2) Traumatic tearing away part of the muscle/ tendon structure, avulsion (n=1) Trauma to muscles (n=3) Trauma to tendon (n=1) Trauma to muscles and tendons, nec (n=5) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=11)	Osteoarthritis/ osteoarthrosis (n=2) Acquired musculoskeletal deformities (n=1) Synovitis and tenosynovitis (n=6) Ganglion, trigger finger, Dupuytren's contracture (n=4) Tendinitis (n=3) Epicondylitis (n=1) Muscle/ tendon strain (non-traumatic) (n=2) Diseases of muscle, tendon and related tissue, nec (n=1) Occupational overuse syndrome (n=5) Complex regional pain syndrome (n=1) Other specified soft tissue diseases, nec (n=1) Soft tissue diseases due to non-traumatic causes with insufficient information to code as 'other soft tissue disease' or 'diseases involving the synovium and related tissue' (n=2)
Upper limb – multiple locations	Trauma to joints and ligaments, unspecified (n=1) Traumatic tearing away part of the muscle/ tendon structure, avulsion (n=1) Trauma to muscles (n=1) Trauma to tendon (n=1) Trauma to muscles and tendons, nec (n=2) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=8)	Tendinitis (n=5) Epicondylitis (n=1) Occupational overuse syndrome (n=1)
Upper limb – unspecified locations	Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	
Hip	Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	
		(continued)

	Injury	Disease
Upper leg	Trauma to muscles (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=2)	
Knee	Other fractures, nec (n=2) Dislocation (n=1) Trauma to joints and ligaments, nec (n=3) Trauma to joints and ligaments, unspecified (n=1) Trauma to muscles (n=1) Trauma to muscles and tendons, nec (n=3) Trauma to muscles and tendons, unspecified (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=8)	Meniscus degenerate/ detached/ retained/ chronic tear (n=3) Muscle/ tendon strain (non-traumatic) (n=1)
Lower leg	Trauma to joints and ligaments, unspecified (n=2) Trauma to muscles (n=1) Trauma to muscles and tendons, unspecified (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	Joint and other articular cartilage diseases, nec (n=1) Muscle/ tendon strain (non-traumatic) (n=1)
Ankle	Other fractures, nec (n=2) Trauma to joints and ligaments, nec (n=4) Trauma to joints and ligaments, unspecified (n=2) Trauma to muscles (n=2) Trauma to muscles and tendons, nec (n=3) Trauma to muscles and tendons, unspecified (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=9)	Muscle/ tendon strain (non-traumatic) (n=1) Occupational overuse syndrome (n=3)
Foot	Other fractures, nec (n=3) Trauma to joints and ligaments, nec (n=1) Trauma to joints and ligaments, unspecified (n=2) Trauma to muscles and tendons, nec (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=3)	Muscle/ tendon strain (non-traumatic) (n=1)
Lower limb – multiple locations		Muscle/ tendon strain (non-traumatic) (n=1)
Lower limb – unspecified locations	Other fractures, nec (n=1)	
Neck and trunk	Trauma to joints and ligaments, nec (n=3) Trauma to muscles (n=2) Trauma to muscles and tendons, unspecified (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=2)	Neck pain, cervicalgia (n=2)
Trunk and limbs	Other fractures, nec (n=1) Trauma to muscles and tendons, unspecified (n=3) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=3)	Tendinitis (n=1) Soft tissue diseases due to non-traumatic causes, nec (n=1)
Upper and lower limbs	Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=2)	Muscle/ tendon strain (non-traumatic) (n=1)
Neck and shoulder	Trauma to joints and ligaments, unspecified (n=1) Trauma to muscles (n=2) Trauma to muscles and tendons, nec (n=3) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=6)	Occupational overuse syndrome (n=1)
Other specified multiple locations	Other fractures, nec (n=1) Trauma to joints and ligaments, nec (n=1) Trauma to joints and ligaments, unspecified (n=2) Trauma to muscles (n=2) Trauma to muscles and tendons, nec (n=1) Trauma to muscles and tendons, unspecified (n=2) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=3)	Muscle/ tendon strain (non-traumatic) (n=2) Other specified soft tissue diseases, nec (n=1)

(continued)

	Injury	Disease
Unspecified multiple locations	Trauma to muscles (n=1) Trauma to muscles and tendons, unspecified (n=1) Soft tissue injuries due to trauma or unknown mechanisms with insufficient information to code elsewhere (n=1)	

Notes: nec indicates not elsewhere classified

A1.4 Supplementary material for Chapter 4

A1.4.1 Prevalence and profile by group classification

The findings presented here informed Questions 1-2; the prevalence and profile of musculoskeletal outcomes, and the priority body regions across all sub-groups of musicians. The groupings for the description sections of Chapter 4 (answers to Questions 1-2) did not include a both category; instead, all participants in those groups were included irrespective of membership in another group. For instance, all students were classified as students, irrespective of their professional status.

A1.4.1.1 All musicians: their demographics, and prevalence and profile of musculoskeletal symptom outcomes

Table A1.4.1: Demographic information for all musicians

	All musicians (n=317)
Age in years (median, IQR)	25.0 (20.0-46.0)
Gender (% female)[a]	55.4
Body mass index (median, IQR)	24.3 (21.3-27.3)
Typical daily sitting time (%)	
<4 hours	20.6
4-8 hours	53.2
8+ hours	26.3
Socioeconomic status[b] (%)	
1	24.1
2	24.4
3	24.4
4	27.0
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)
Hours worked in the last 7 days (median, IQR)	9.0 (0.0-20.0)
Age in years they started their musical activities (median, IQR)	8.0 (6.0-10.0)
Years of musical activity (median, IQR)	18.0 (12.0-38.0)
Amount of musical activity in the last 7 days (%)	
0-10 hours	36.1
10-20 hours	30.1
20 or more hours	33.9
University music student (%)	52.4
Professional musician (%)	71.3
Performed in the last 12 months (%)	90.3
Performed in the last 7 days (%)	56.0
Musical biomechanical exposure in the last 12 months (%)	
Singing/ woodwind/ brass	67.8
Singing	46.2
Brass	16.9
Woodwind	26.2
Flute	12.3
Reed	17.9
Saxophone	13.6
Upper string	14.5
Hands elevated at shoulder level to play	52.5
Repetitive elbow movement to play	74.9
Repetitive finger flexion/ extension to play	92.0
Repetitive finger adduction/ abduction to play	70.4
Repetitive foot movement to play	59.1
Musical biomechanical exposure in the last 7 days (%)	
Singing/ woodwind/ brass	58.5
Singing	35.5
Brass	13.2
Woodwind	21.2
Flute	8.7
Reed	15.6
Saxophone	11.5
Upper string	13.2
Hands elevated at shoulder level to play	42.0
Repetitive elbow movement to play	64.9
Repetitive finger flexion/ extension to play	88.4
Repetitive finger adduction/ abduction to play	64.4
Repetitive foot movement to play	48.2
Job satisfaction score[c] (median, IQR)	40.0 (30.0-40.0)
Social support score[c] (median, IQR)	48.0 (35.0-59.0)
Psychological distress score[c] (median, IQR)	40.0 (19.0-55.0)
Psychosocial stress score[c] (median, IQR)	25.0 (12.0-30.0)

Notes: IQR: interquartile range. [a]44.3% male, 0.3% 'other'. [b]Quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [c]w-scores derived from the Rasch analysis were used (Appendices 2.11-2.14).

Table A1.4.2: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms and musculoskeletal disorders for all musicians

	Musculoskeletal symptoms	Music-related musculoskeletal disorders
Overall	90.1 (86.1-93.0)	57.1 (51.5-62.6)
Combined regions		
Head/ orofacial	37.2 (31.9-42.8)	16.6 (12.8-21.2)
Upper limb	76.7 (71.6-81.2)	49.0 (43.5-54.6)
Neck/ trunk	77.1 (72.0-81.5)	47.1 (41.5-52.7)
Lower limb	40.2 (34.8-45.9)	14.3 (10.8-18.7)
All regions		
Head	24.3 (19.7-29.4)	8.4 (5.8-12.1)
Orofacial	27.2 (22.5-32.6)	14.0 (10.5-18.3)
Neck	63.1 (57.5-68.4)	36.0 (30.8-41.6)
Shoulder	61.8 (56.1-67.1)	36.7 (31.5-42.2)
Elbow	20.3 (16.1-25.2)	14.3 (10.8-18.7)
Wrist/ hand	50.8 (45.2-56.5)	31.8 (26.8-37.3)
Upper back	44.2 (38.6-49.9)	27.6 (22.9-32.9)
Chest/ abdomen	15.3 (11.6-19.8)	5.5 (3.5-8.7)
Lower back	54.2 (48.5-59.7)	28.2 (23.5-33.6)
Hip/ thigh	20.6 (16.4-25.6)	7.5 (5.0-11.0)
Knee	22.9 (18.5-28.0)	6.2 (4.0-9.5)
Ankle/ foot	19.6 (15.5-24.5)	5.8 (3.7-9.1)

Table A1.4.3: The 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms and music-related musculoskeletal disorders for all musicians

		Musculoskeletal symptoms	Music-related musculoskeletal disorders
Overall		72.1 (66.9-76.8)	40.5 (35.1-46.0)
Chronic[a]		35.3 (30.1-40.8)	24.7 (20.2-29.8)
Chronic[a] of those with MSSs/MRMDs		49.3 (42.7-55.9)	60.5 (51.6-68.7)
Moderate-severe pain[b]		23.6 (18.3-30.0)	NA
Combined regions			
Head/ orofacial		20.5 (16.3-25.3)	10.1 (7.2-14.0)
Upper limb		54.2 (48.6-59.7)	31.8 (26.8-37.3)
Neck/ trunk		52.9 (47.3-58.5)	30.2 (25.3-35.6)
Lower limb		22.1 (17.8-27.1)	9.1 (6.4-12.9)
All regions			
Head		13.6 (10.2-18.0)	5.5 (3.5-8.7)
	Right	12.3 (9.1-16.5)	4.9 (3.0-7.9)
	Left	11.0 (8.0-15.1)	4.5 (2.7-7.5)
Orofacial		14.0 (10.5-18.3)	7.8 (5.3-11.4)
	Right	12.3 (9.1-16.5)	7.1 (4.7-10.6)
	Left	11.7 (8.5-15.8)	5.2 (3.2-8.3)
Neck		37.7 (32.4-43.2)	20.5 (16.3-25.4)
	Right	32.1 (27.1-37.6)	16.9 (13.1-21.5)
	Left	34.4 (29.3-39.9)	17.5 (13.7-22.2)
Shoulder		38.6 (33.3-44.2)	23.4 (19.0-28.5)
	Right	28.9 (24.1-34.2)	17.2 (13.4-21.9)
	Left	29.9 (25.0-35.3)	17.5 (13.7-22.2)
Elbow		10.1 (7.2-14.0)	7.1 (4.7-10.6)
	Right	8.1 (5.5-11.8)	5.8 (3.7-9.1)
	Left	5.5 (3.5-8.7)	2.9 (1.5-5.5)
Wrist/ hand		29.9 (25.0-35.2)	18.8 (14.8-23.6)
	Right	23.1 (18.7-28.1)	14.0 (10.5-18.3)
	Left	19.2 (15.1-24.0)	12.0 (8.8-16.2)
Upper back		26.9 (22.3-32.2)	17.9 (14.0-22.6)
	Right	23.7 (19.3-28.8)	16.2 (12.5-20.8)
	Left	22.7 (18.4-27.8)	15.6 (11.9-20.1)
Chest/ abdomen		7.1 (4.7-10.6)	2.3 (1.1-4.7)
	Right	5.2 (3.2-8.3)	2.3 (1.1-4.7)
	Left	6.2 (4.0-9.5)	2.3 (1.1-4.7)
Lower back		36.0 (30.8-41.6)	17.2 (13.4-21.9)
	Right	33.8 (28.7-39.3)	16.6 (12.8-21.2)
	Left	33.4 (28.4-38.9)	16.6 (12.8-21.2)
Hip/ thigh		10.7 (7.7-14.7)	4.9 (3.0-7.9)
	Right	9.1 (6.3-12.9)	3.2 (1.8-5.9)
	Left	6.2 (4.0-9.5)	2.9 (1.5-5.5)
Knee		10.1 (7.2-14.0)	3.6 (2.0-6.3)
	Right	6.2 (4.0-9.5)	2.6 (1.3-5.1)
	Left	6.5 (4.2-9.9)	2.3 (1.1-4.7)
Ankle/ foot		10.1 (7.2-14.0)	3.9 (2.2-6.8)
	Right	7.1 (4.7-10.6)	3.2 (1.8-5.9)
	Left	7.5 (5.0-11.0)	2.0 (0.9-4.3)

Notes: MSS: musculoskeletal symptom. MRMD: music-related musculoskeletal disorder. NA: not applicable. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]of those reporting musculoskeletal symptoms in the last 7 days. Moderate-severe refers to pain ratings on average of 5-10 on an 11-point numeric rating scale.

Table A1.4.4: Musculoskeletal symptom outcome ratings for all musicians

	Rating
Pain intensity on average[a] (median (IQR))	3 (2-4)
MRMD on average[b] (median (IQR))	3 (2-5)
MRMD w-scores[b,c] (mean ± SD)	54.2±25.2
Impact of MSSs on daily life[a] (median (IQR))	3 (2-6)
Emotional impact of MSSs[a] (median (IQR))	3 (1-6)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]of those reporting musculoskeletal symptoms in the last 7 days. [b]of those reporting music-related musculoskeletal disorders in the last 7 days. [c]w-scores from Rasch analysis (Appendix 2.10)

Table A1.4.5: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences for all symptomatic musicians

	All symptomatic musicians
Work/ study in the last 12 months	
Changes to work/ study	15.8 (11.9-20.8)
Musical changes to work/ study	11.1 (7.8-15.6)
Leave from work/ study	21.5 (17.0-26.9)
Musical leave from work/ study	15.7 (11.8-20.7)
Consulting a health professional in the last 12 months	65.1 (59.2-70.5)
Medical professional	38.9 (33.2-44.9)
Psychologist/ counsellor	6.0 (3.7-9.6)
Physiotherapist/ occupational therapist	34.7 (29.2-40.7)
Personal trainer/ Pilates instructor/ yoga instructor	14.0 (10.3-18.7)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	26.8 (21.8-32.5)
Naturopath/ homeopath	3.4 (1.8-6.4)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	3.4 (1.8-6.4)
Other	3.4 (1.8-6.4)
Self-management in the last 12 months	85.7 (81.0-89.4)
Medication	38.1 (32.4-44.1)
Heat/ ice	42.3 (36.4-48.3)
Exercises/ stretches	78.9 (73.5-83.4)
Braces/ strapping/ taping	22.3 (17.6-27.7)
Other	6.4 (4.0-10.1)
Consulting other musicians in the last 12 months	26.7 (21.7-32.4)
Current treatment	33.2 (27.3-39.7)

Notes: The denominator used was musicians with musculoskeletal symptoms in the last 12 months, except for 'current treatment' where the denominator was musicians with musculoskeletal symptoms in the last 7 days.

A1.4.1.2 University music students: their demographics, and prevalence and profile of musculoskeletal symptom outcomes

Table 1.4.6: Demographic information for all university music students, and the sub-groups of students

	All students (n=166)	Performance students (n=122)	Non-performance students (n=40)	Classical performance students (n=46)	Non-classical performance students (n=56)
Age in years (median, IQR)	20.0 (19.0-23.0)	20.0 (19.0-22.0)	21.0 (20.0-24.0)	20.0 (18.0-21.0)	20.0 (18.0-22.0)
Female (%)	57.2	60.7	47.6	71.7	51.8
Body mass index (median, IQR)	22.9 (20.5-25.4)	22.6 (20.1-25.3)	23.4 (21.9-26.0)	22.1 (19.3-25.2)	22.8 (20.1-25.1)
Typical daily sitting time (%)					
<4 hours	16.3	17.2	11.9	19.6	17.9
4-8 hours	54.2	51.6	64.3	45.7	57.1
8+ hours	29.4	31.2	23.8	34.8	25.0
Socioeconomic status[a] (%)					
1	22.2	20.2	29.3	15.6	18.5
2	30.3	30.3	29.3	40.0	20.4
3	27.2	26.1	29.3	26.7	31.5
4	20.4	23.5	12.5	17.8	29.6
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	1.5 (1.0-3.0)	2.0 (1.0-3.0)	1.5 (1.0-3.0)
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)	1.0 (0.0-2.0)	1.0 (0.0-2.0)	1.0 (0.0-2.0)	0.5 (0.0-1.0)
Hours worked in the last 7 days (median, IQR)	2.8 (0.0-12.0)	4.0 (0.0-11.5)	2.0 (0.0-14.0)	1.3 (0.0-12.0)	2.5 (0.0-10.0)
Full time study (%)	90.2	91.0	87.8	89.1	94.6
Professional musician (%)	45.2	45.2	45.9	52.2	37.5
Age (in years) they started their musical activities (median, IQR)	8.0 (6.0-10.0)	7.5 (6.0-10.0)	8.0 (6.0-10.0)	6.5 (5.0-10.0)	8.0 (6.5-11.0)
Years of musical activity (mean, IQR)	13.0 (10.0-16.0)	13.0 (10.0-15.0)	14.5 (11.0-17.5)	13.0 (10.0-15.0)	12.0 (8.0-14.0)
Amount of musical activity in the last 7 days (%)					
0-10 hours	28.5	16.5	59.5	13.3	17.9
10-20 hours	31.5	34.7	23.8	22.2	42.9
20 or more hours	40.0	48.8	16.7	64.4	39.3
Performed in the last 12 months (%)	92.6	96.7	80.0	95.6	98.1
Performed in the last 7 days (%)	61.3	66.4	46.2	75.0	63.6

(continued)

	All students (n=166)	Performance students (n=122)	Non-performance students (n=40)	Classical performance students (n=46)	Non-classical performance students (n=56)
Musical biomechanical exposure in the last 12 months (%)					
Singing/ woodwind/ brass	72.5	75.4	65.9	70.5	85.2
Singing	54.0	53.4	57.1	47.7	63.0
Brass	15.6	17.8	9.8	18.2	22.2
Woodwind	29.4	31.4	24.4	31.8	33.3
Flute	13.8	15.3	9.8	18.2	13.0
Reed	20.6	19.5	24.4	20.5	20.4
Saxophone	15.6	12.7	24.4	9.1	18.5
Upper string	15.5	11.9	24.4	15.9	5.6
Hands elevated at shoulder level to play	53.4	51.7	56.1	65.9	42.6
Repetitive elbow movement to play	75.8	74.6	78.1	79.6	68.5
Repetitive finger flexion/ extension to play	93.1	95.8	85.4	95.5	94.4
Repetitive finger adduction/ abduction to play	75.6	75.4	75.6	72.7	72.2
Repetitive foot movement to play	62.5	62.7	61.0	61.4	61.1
Musical biomechanical exposure in the last 7 days (%)					
Singing/ woodwind/ brass	63.4	69.4	48.8	62.2	76.8
Singing	44.2	46.3	40.5	37.8	51.8
Brass	12.2	13.2	9.8	11.1	17.9
Woodwind	23.8	27.3	14.6	24.4	30.4
Flute	9.8	11.6	4.9	13.3	10.7
Reed	17.3	17.7	17.1	11.4	21.8
Saxophone	12.8	11.8	17.1	4.6	20.0
Upper string	14.1	10.9	22.9	15.9	5.5
Hands elevated at shoulder level to play	40.0	37.3	48.6	45.5	31.5
Repetitive elbow movement to play	65.4	65.6	63.4	68.9	58.2
Repetitive finger flexion/ extension to play	89.1	91.6	85.4	90.9	92.7
Repetitive finger adduction/ abduction to play	71.2	71.4	68.6	68.2	70.9
Repetitive foot movement to play	51.8	53.7	46.3	51.1	51.8
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)	40.0 (30.0-40.0)	40.0 (30.0-40.0)	40.0 (30.0-40.0)	40.0 (30.0-40.0)
Social support score[b] (median, IQR)	48.0 (35.0-71.0)	59.0 (36.0-71.0)	48.0 (35.0-59.0)	53.5 (35.0-59.0)	59.0 (36.0-78.0)
Psychological distress score[b] (median, IQR)	48.5 (33.0-60.0)	51.0 (33.0-60.0)	46.0 (33.0-55.0)	51.0 (33.0-60.0)	46.0 (33.0-55.0)
Psychosocial stress score[b] (median, IQR)	25.0 (12.0-37.0)	25.0 (12.0-37.0)	25.0 (12.0-37.0)	25.0 (12.0-37.0)	25.0 (12.0-30.0)

Notes: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]using w-scores from the Rasch analysis (Appendices 2.11-2.14).

Table A1.4.7: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for university music students, and the sub-groups of students

	All students	Performance	Non-performance	Classical performance	Non-classical performance
Overall	92.5 (87.1-95.7)	94.0 (87.8-97.1)	87.8 (73.7-94.9)	90.9 (77.9-96.6)	96.2 (85.9-99.1)
Combined regions					
Head/ orofacial	44.0 (36.5-51.9)	46.6 (37.6-55.7)	39.0 (25.4-54.6)	43.2 (29.3-58.2)	50.9 (37.6-64.2)
Upper limb	78.6 (71.5-84.3)	81.0 (72.8-87.2)	73.2 (57.6-84.5)	77.3 (62.5-87.4)	81.1 (68.2-89.6)
Neck/ trunk	78.0 (70.8-83.8)	77.6 (69.0-84.3)	80.5 (65.4-90.0)	72.7 (57.7-83.9)	84.9 (72.4-92.3)
Lower limb	34.0 (27.0-41.7)	30.2 (22.5-39.2)	43.9 (29.6-59.3)	31.8 (19.7-47.0)	28.3 (17.7-42.0)
All regions					
Head	27.0 (20.7-34.5)	25.9 (18.7-34.7)	31.7 (19.3-47.4)	25.0 (14.3-40.0)	26.4 (16.2-40.0)
Orofacial	33.3 (26.4-41.1)	38.8 (30.3-48.0)	19.5 (10.0-34.6)	36.4 (23.5-51.6)	45.3 (32.4-58.9)
Neck	64.8 (57.0-71.9)	65.5 (56.4-73.6)	65.9 (50.2-78.7)	61.4 (46.2-74.6)	73.6 (60.0-83.8)
Shoulder	62.3 (54.4-69.5)	63.8 (54.6-72.1)	58.5 (43.0-72.5)	68.2 (53.0-80.3)	60.4 (46.6-82.7)
Elbow	21.4 (15.7-28.5)	25.0 (17.9-33.7)	12.2 (5.1-26.3)	25.0 (14.3-40.0)	22.6 (13.2-36.0)
Wrist/ hand	57.2 (49.4-64.7)	57.8 (48.5-66.5)	58.5 (43.0-72.5)	56.8 (41.8-70.7)	52.8 (39.3-65.9)
Upper back	47.2 (39.5-55.0)	45.7 (36.8-54.9)	51.2 (36.2-66.1)	34.1 (21.6-49.3)	56.6 (42.9-69.3)
Chest/ abdomen	18.2 (12.9-25.1)	16.4 (10.7-24.3)	24.4 (13.6-39.8)	15.9 (7.7-30.0)	15.1 (7.7-27.6)
Lower back	56.0 (48.1-63.5)	55.2 (46.0-64.0)	58.5 (43.0-72.5)	45.5 (31.4-60.3)	66.0 (52.2-77.6)
Hip/ thigh	17.0 (11.9-23.7)	13.8 (8.6-21.4)	26.8 (15.5-42.4)	15.9 (7.7-30.0)	11.3 (5.1-23.2)
Knee	21.4 (15.7-28.5)	20.7 (14.2-29.1)	24.4 (13.6-39.8)	22.7 (12.6-37.5)	20.8 (11.8-33.9)
Ankle/ foot	18.2 (12.9-25.1)	17.2 (11.4-25.3)	19.5 (10.0-34.6)	13.6 (6.2-27.4)	17.0 (9.0-29.7)

Table A1.4.8: The 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders for university music students, and sub-groups of students

	All students	Performance	Non-performance	Classical performance	Non-classical performance
Overall	54.4 (46.6-62.0)	58.7 (49.6-67.2)	43.2 (28.3-59.5)	65.2 (50.4-77.6)	49.1 (36.1-62.2)
Combined regions					
Head/ orofacial	19.1 (13.8-26.0)	20.7 (14.3-28.9)	15.4 (7.0-30.4)	26.1 (15.3-40.7)	16.4 (8.7-28.7)
Upper limb	48.1 (40.5-55.9)	52.9(43.9-61.7)	35.9 (22.5-52.0)	60.9 (46.1-73.9)	43.6 (31.1-57.0)
Neck/ trunk	42.6 (35.2-50.4)	43.0 (34.4-52.0)	43.6 (29.0-59.4)	43.5 (29.9-58.1)	41.8 (29.5-55.3)
Lower limb	11.1 (7.1-17.0)	9.9 (5.7-16.7)	15.4 (7.0-30.4)	13.0 (5.9-26.3)	5.5 (1.7-15.8)
All regions					
Head	10.5 (6.6-16.3)	10.7 (6.3-17.7)	10.3 (3.9-24.5)	15.2 (7.4-28.8)	9.1 (3.8-20.2)
Orofacial	16.0 (11.1-22.6)	19.0 (12.9-27.1)	7.7 (2.5-21.4)	23.9 (13.7-38.4)	16.4 (8.7-28.7)
Neck	33.3 (26.5-41.0)	34.7 (26.7-43.7)	30.8 (18.3-46.9)	41.3 (28.0-56.0)	32.7 (21.6-46.2)
Shoulder	35.8 (28.7-43.5)	38.8 (30.5-47.9)	28.2 (16.3-44.2)	47.8 (33.8-62.2)	32.7 (21.6-46.2)
Elbow	13.0 (8.6-19.1)	14.0 (8.9-21.5)	10.3 (3.9-24.5)	17.4 (8.87-31.3)	10.9 (4.9-22.4)
Wrist/ hand	35.2 (28.2-42.9)	38.8 (30.5-47.9)	25.6 (14.3-41.6)	47.8 (33.8-62.2)	30.9 (20.0-44.4)
Upper back	28.4 (21.9-35.9)	27.3 (20.0-35.9)	33.3 (20.4-49.4)	19.6 (10.4-33.7)	29.1 (18.5-42.5)
Chest/ abdomen	5.6 (2.9-10.4)	5.0 (2.2-10.7)	7.7 (2.5-21.4)	6.5 (2.1-18.6)	5.5 (1.7-15.8)
Lower back	25.3 (19.2-32.6)	28.1 (20.8-36.8)	17.9 (8.8-33.3)	28.3 (17.1-43.0)	25.5 (15.6-38.7)
Hip/ thigh	5.6 (2.9-10.4)	4.1 (1.7-9.6)	10.3 (3.9-24.5)	6.5 (2.1-18.6)	3.6 (0.9-13.6)
Knee	4.3 (2.1-8.8)	4.1 (1.7-9.6)	5.1 (1.3-18.5)	6.5 (2.1-18.6)	1.8 (0.2-12.1)
Ankle/ foot	4.9 (2.5-9.6)	5.0 (2.2-10.7)	5.1 (1.3-18.5)	6.5 (2.1-18.6)	0.0

Table A1.4.9: The 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms for university music students, and sub-groups of students

	All students	Performance	Non-performance	Classical performance	Non-classical performance
Overall	72.6 (65.2-78.9)	74.4 (65.8-81.4)	65.9 (50.2-78.7)	73.9 (59.3-84.7)	75.0 (61.9-84.7)
Chronic[a]	30.4 (23.8-38.0)	29.7 (22.1-38.6)	31.7 (19.3-47.4)	28.9 (17.5-43.8)	33.3 (22.0-47.0)
Chronic[a] of those with MSSs	42.2 (33.5-51.5)	40.2 (30.4-50.9)	48.1 (30.3-66.5)	39.4 (24.3-56.9)	45.0 (30.3-60.6)
Moderate-severe pain[b]	24.8 (17.4-34.0)	24.4 (16.0-35.2)	24.0 (11.0-44.4)	27.6 (14.2-46.6)	21.6 (11.1-38.0)
Combined regions					
Head/ orofacial	22.7 (16.9-29.8)	23.3 (16.6-31.8)	22.0 (11.8-37.2)	28.3 (17.1-43.0)	23.6 (14.2-36.7)
Upper limb	55.2 (47.5-62.7)	57.5 (48.4-66.1)	48.8 (33.9-63.8)	56.5 (41.9-70.1)	56.4 (43.0-68.9)
Neck/ trunk	51.5 (43.8-59.2)	48.3 (39.5-57.3)	61.0 (45.4-74.6)	45.7 (31.8-60.2)	56.4 (43.0-68.9)
Lower limb	17.8 (12.6-24.5)	15.0 (9.6-22.6)	24.4 (13.6-39.8)	13.0 (5.9-26.3)	14.5 (7.4-26.7)
All regions					
Head	14.1 (9.5-20.4)	13.3 (8.3-20.7)	17.1 (8.3-31.8)	13.0 (5.9-26.3)	14.5 (7.4-26.7)
Right	12.9 (8.5-19.0)	11.7 (7.0-18.8)	17.1 (8.3-31.8)	8.7 (3.3-21.2)	14.5 (7.4-26.7)
Left	11.0 (7.0-16.9)	11.7 (7.0-18.8)	9.8 (3.7-23.4)	10.9 (4.5-23.8)	12.7 (6.1-24.6)
Orofacial	16.6 (11.6-23.1)	18.3 (12.3-26.3)	12.2 (5.1-26.3)	26.1 (15.3-40.7)	16.4 (8.7-28.7)
Right	16.0 (11.1-22.5)	18.3 (12.3-26.3)	9.8 (3.7-23.4)	26.1 (15.3-40.7)	16.4 (8.7-28.7)
Left	14.1 (9.5-20.4)	15.8 (10.3-23.6)	9.8 (3.7-23.4)	19.6 (10.4-33.7)	16.4 (8.7-28.7)
Neck	35.6 (28.6-43.3)	35.0 (27.0-44.0)	39.0 (25.4-54.6)	32.6 (20.6-47.5)	41.8 (29.5-55.3)
Right	31.9 (25.2-39.5)	30.8 (23.2-39.7)	36.6 (23.3-52.3)	26.1 (15.3-40.7)	40.0 (27.9-53.5)
Left	32.5 (25.7-40.1)	32.5 (24.7-41.4)	34.1 (21.3-49.8)	30.4 (18.8-45.2)	38.2 (26.2-51.7)
Shoulder	36.8 (29.7-44.5)	37.5 (29.3-46.5)	34.1 (21.3-49.8)	39.1 (26.1-53.9)	38.2 (26.3-51.7)
Right	28.2 (21.8-35.7)	27.5 (20.2-36.2)	29.3 (17.4-44.9)	26.1 (15.3-40.7)	29.1 (18.5-42.5)
Left	30.1 (23.5-37.6)	31.7 (23.9-40.6)	26.8 (15.5-42.4)	34.8 (22.4-49.6)	30.9 (20.0-44.4)
Elbow	9.8 (6.1-15.5)	10.8 (6.4-17.8)	7.3 (2.4-20.5)	10.9 (4.5-23.8)	10.9 (4.9-22.4)
Right	8.0 (4.7-13.3)	8.3 (4.5-14.9)	7.3 (2.4-20.5)	8.7 (3.3-21.2)	9.1 (3.8-20.2)
Left	6.7 (3.8-11.8)	7.5 (3.9-13.9)	4.9 (1.2-17.7)	6.5 (2.1-18.6)	9.1 (3.8-20.2)
Wrist/ hand	34.4 (27.4-42.0)	35.8 (27.7-44.9)	31.7 (19.3-47.4)	41.3 (28.0-56.0)	29.1 (18.5-42.5)
Right	27.0 (20.7-34.4)	28.3 (20.9-37.1)	24.4 (13.6-39.8)	34.8 (22.4-49.6)	21.9 (12.7-34.8)
Left	22.7 (16.9-29.8)	26.7 (19.5-35.3)	12.2 (5.1-26.3)	26.1 (15.3-40.7)	25.5 (15.6-38.7)
Upper back	29.4 (22.9-36.9)	30.0 (22.4-38.8)	26.8 (15.5-42.4)	30.4 (18.8-45.2)	30.9 (20.0-44.4)
Right	25.8 (19.6-33.1)	25.8 (18.7-34.5)	26.8 (15.5-42.4)	21.7 (12.0-36.1)	29.1 (18.5-42.5)
Left	25.2 (19.0-32.4)	25.8 (18.7-34.5)	22.0 (11.8-37.2)	28.3 (17.1-43.0)	25.5 (15.6-38.7)
Chest/ abdomen	10.4 (6.6-16.2)	7.5 (3.9-13.9)	19.5 (10.0-34.6)	6.5 (2.1-18.6)	7.3 (2.7-18.0)
Right	8.0 (4.7-13.3)	5.8 (2.8-11.8)	14.6 (6.7-29.1)	4.3 (1.1-16.0)	5.5 (1.7-15.8)
Left	8.6 (5.1-14.0)	5.8 (2.8-11.8)	17.1 (8.3-31.8)	6.5 (2.1-18.6)	5.5 (1.7-15.8)
Lower back	36.2 (29.1-43.9)	35.8 (27.7-44.9)	36.6 (23.3-52.3)	28.3 (17.1-43.0)	43.6 (31.1-57.0)
Right	34.4 (27.4-42.0)	35.0 (26.9-44.0)	31.7 (19.3-47.4)	28.3 (17.1-43.0)	41.8 (29.5-55.3)
Left	32.5 (25.7-40.1)	34.2 (26.2-43.2)	26.8 (15.5-42.4)	26.1 (15.3-40.7)	43.6 (31.1-57.0)
Hip/ thigh	8.0 (4.7-13.3)	4.2 (1.7-9.7)	19.5 (10.0-34.6)	4.3 (1.1-16.0)	1.8 (0.2-12.1)
Right	6.7 (3.8-11.8)	3.3 (1.2-8.6)	17.1 (8.3-31.8)	4.3 (1.1-16.0)	1.8 (0.2-12.1)
Left	3.1 (1.3-7.2)	1.7 (0.4-6.5)	7.3 (2.4-20.5)	0.0	1.8 (0.2-12.1)
Knee	7.4 (4.2-12.6)	6.7 (3.4-12.8)	9.8 (3.7-23.4)	4.3 (1.1-16.0)	9.1 (3.8-20.2)
Right	4.3 (2.0-8.8)	3.3 (1.2-8.6)	7.3 (2.4-20.5)	2.2 (0.3-14.2)	5.5 (1.7-15.8)
Left	4.3 (2.0-8.8)	5.0 (2.2-10.7)	2.4 (0.3-15.6)	2.2 (0.3-14.2)	7.3 (2.7-18.0)
Ankle/ foot	9.8 (6.1-15.5)	10.8 (6.4-17.8)	4.9 (1.2-17.7)	8.7 (3.3-21.2)	9.1 (3.8-20.2)
Right	8.0 (4.7-13.3)	9.2 (5.1-15.9)	2.4 (0.3-15.6)	4.3 (1.1-16.0)	9.1 (3.8-20.2)
Left	7.4 (4.2-12.6)	8.3 (4.5-14.9)	2.4 (0.3-15.6)	4.3 (1.1-16.0)	9.1 (3.8-20.2)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]pain ratings were only made by those who reporting musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to ratings of pain on average of 5-10 on an 11-point rating scale.

Table A1.4.10: The 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for university music students, and sub-groups of students

	All students	Performance	Non-performance	Classical performance	Non-classical performance
Overall	38.7 (31.4-46.4)	40.2 (31.8-49.2)	35.9 (22.5-52.0)	45.7 (31.8-60.2)	41.1 (28.9-54.4)
Chronic[a]	20.9 (15.3-27.8)	21.3 (14.9-29.5)	21.3 (10.5-36.1)	23.9 (13.7-38.4)	21.4 (12.5-34.2)
Chronic[a] of those with MRMDs	54.0 (41.6-65.9)	53.1 (39.1-66.6)	57.1 (31.5-79.5)	52.4 (31.6-72.4)	52.2 (32.3-71.4)
Combined regions					
Head/ orofacial	10.5 (6.6-16.3)	12.4 (7.6-19.6)	5.1 (1.3-18.5)	17.4 (8.9-31.3)	10.7 (4.8-22.0)
Upper limb	31.5 (24.8-39.1)	33.9 (26.0-42.8)	25.6 (14.3-41.6)	39.1 (26.1-53.9)	35.7 (24.2-49.1)
Neck/ trunk	27.8 (21.4-35.2)	28.1 (20.8-36.8)	28.2 (16.3-44.2)	30.4(18.8-45.2)	30.4 (19.7-43.7)
Lower limb	6.8 (3.8-12.0)	5.8 (2.8-11.8)	10.3 (3.9-24.5)	6.5 (2.1-18.6)	3.6 (0.9-13.6)
All regions					
Head	6.2 (3.3-11.1)	6.6 (3.3-12.7)	5.1 (1.3-18.5)	8.7 (3.3-21.2)	5.4 (1.7-15.5)
Right	5.6 (2.9-10.4)	5.8 (2.8-11.7)	5.1 (1.3-18.5)	6.5 (2.1-18.6)	5.4 (1.7-15.5)
Left	4.9 (2.5-9.6)	5.8 (2.8-11.7)	2.6 (0.4-16.3)	8.7 (3.3-21.2)	5.4 (1.7-15.5)
Orofacial	8.6 (5.2-14.1)	10.7 (6.3-17.7)	2.6 (0.4-16.3)	15.2 (7.4-28.8)	10.7 (4.8-22.0)
Right	8.6 (5.2-14.1)	10.7 (6.3-17.7)	2.6 (0.4-16.3)	15.2 (7.4-28.8)	10.7 (4.8-22.0)
Left	5.6 (2.9-10.4)	7.4 (3.9-13.7)	0.0	8.7 (3.3-21.2)	8.9 (3.7-19.9)
Neck	18.5 (13.2-25.3)	19.0 (12.9-27.1)	17.9 (8.8-33.3)	21.7 (12.0-36.1)	19.6 (11.1-32.3)
Right	16.0 (11.1-22.6)	16.5 (10.9-24.3)	15.4 (7.0-30.4)	17.4 (8.9-31.3)	17.9 (9.8-30.3)
Left	16.7 (11.7-23.3)	16.5 (10.9-24.3)	17.9 (8.8-33.3)	19.6 (10.4-33.7)	16.1 (8.5-28.3)
Shoulder	22.8 (17.0-30.0)	24.0 (17.1-32.4)	20.5 (10.5-36.1)	28.3 (17.1-43.0)	23.2 (13.9-36.2)
Right	17.9 (12.7-24.6)	18.2 (12.2-26.1)	17.9 (8.8-33.3)	17.4 (8.87-31.3)	21.4 (12.5-34.2)
Left	19.1 (13.8-26.0)	19.8 (13.6-28.0)	17.9 (8.8-33.3)	23.9 (13.7-38.4)	17.9 (9.8-30.3)
Elbow	6.8 (3.8-11.9)	7.4 (3.9-13.7)	5.1 (1.3-18.5)	13.0 (5.9-26.3)	5.4 (1.7-15.5)
Right	5.6 (2.9-10.4)	5.8 (2.8-11.7)	5.1 (1.3-18.5)	10.9 (4.5-23.8)	3.6 (0.9-13.4)
Left	3.1 (1.3-7.2)	3.3 (1.2-8.5)	2.6 (0.4-16.3)	4.3 (1.1-16.0)	3.6 (0.9-13.4)
Wrist/ hand	20.4 (14.8-27.3)	23.1 (16.4-31.5)	12.8 (5.4-27.5)	28.3 (17.1-43.0)	23.2 (13.9-36.2)
Right	15.4 (10.6-21.9)	17.4 (11.6-25.2)	10.3 (3.9-24.5)	23.9 (13.7-38.4)	16.1 (8.5-28.3)
Left	13.0 (8.6-19.1)	16.5 (10.9-24.3)	2.6 (0.4-16.3)	15.2 (7.4-28.8)	21.4 (12.5-34.2)
Upper back	17.9 (12.7-24.6)	17.4 (11.6-25.2)	20.5 (10.5-36.1)	15.2 (7.4-28.8)	19.6 (11.1-32.3)
Right	15.4 (10.6-21.9)	14.0 (8.9-21.5)	20.5 (10.5-36.1)	8.7 (3.3-21.2)	17.9 (9.8-30.3)
Left	16.0 (11.1-22.6)	15.7 (10.2-23.4)	17.9 (8.8-33.3)	13.0 (5.9-26.3)	19.6 (11.1-32.3)
Chest/ abdomen	3.1 (1.3-7.2)	1.7 (0.4-6.4)	7.7 (2.5-21.4)	0.0	3.6 (0.9-13.4)
Right	3.1 (1.3-7.2)	1.7 (0.4-6.4)	7.7 (2.5-21.4)	0.0	3.6 (0.9-13.4)
Left	3.1 (1.3-7.2)	1.7 (0.4-6.4)	7.7 (2.5-21.4)	0.0	3.6 (0.9-13.4)
Lower back	17.9 (12.7-24.6)	19.0 (12.9-27.1)	15.4 (7.0-30.4)	23.9 (13.7-38.4)	17.9 (9.8-30.3)
Right	17.3 (12.2-24.0)	19.0 (12.9-27.1)	12.8 (5.4-27.5)	23.9 (13.7-38.4)	17.9 (9.8-30.3)
Left	16.7 (11.7-23.3)	17.4 (11.6-25.2)	15.4 (7.0-30.4)	21.7 (12.0-36.1)	17.9 (9.8-30.3)
Hip/ thigh	3.7 (1.7-8.0)	2.5 (0.8-7.5)	7.7 (2.5-21.4)	4.3 (1.1-16.0)	1.8 (0.2-11.9)
Right	3.1 (1.3-7.2)	2.5 (0.8-7.5)	5.1 (1.3-18.5)	4.3 (1.1-16.0)	1.8 (0.2-11.9)
Left	1.2 (0.3-4.8)	0.8 (0.1-5.7)	2.6 (0.4-16.3)	0.0	1.8 (0.2-11.9)
Knee	1.9 (0.6-5.6)	1.7 (0.4-6.4)	2.6 (0.4-16.3)	2.2 (0.3-14.2)	1.8 (0.2-11.9)
Right	1.2 (0.3-4.8)	1.7 (0.4-6.4)	0.0	2.2 (0.3-14.2)	1.8 (0.2-11.9)
Left	1.2 (0.3-4.8)	0.8 (0.1-5.8)	2.6 (0.4-16.3)	0.0	1.8 (0.2-11.9)
Ankle/ foot	3.1 (1.3-7.3)	3.3 (1.2-8.6)	2.6 (0.4-16.3)	4.3 (1.1-16.0)	0.0
Right	2.5 (0.9-6.4)	3.3 (1.2-8.5)	0.0	4.3 (1.1-16.0)	0.0
Left	1.2 (0.3-4.9)	0.8 (0.1-5.8)	2.6 (0.4-16.3)	0.0	0.0

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to music-related musculoskeletal disorders that were present on most days for at least the last 3 months.

Table A1.4.11: Musculoskeletal symptom outcome ratings for university music students, and the sub-groups of students

	All students	Performance students	Non-performance students	Classical performance students	Non-classical performance students
Pain on average[a] (median (IQR))	3.0 (2.0-4.0)	2.5 (2.0-4.0)	3.0 (1.0-4.0)	3.0 (2.0-5.0)	3.0 (2.0-4.0)
MRMD on average[b] (median (IQR))	3.5 (2.0-5.0)	3.5 (2.0-5.0)	3.5 (2.0-6.0)	5.0 (3.0-5.5)	3.0 (1.5-5.0)
MRMD w-scores[b,c] (mean±SD)	56.8±23.2	56.4±21.9	58.4±28.3	65.0±16.2	48.7±24.3
Impact of MSSs on daily life[a] (median (IQR))	3.0 (2.0-6.0)	3.0 (2.0-5.0)	5.0 (3.0-6.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)
Emotional impact of MSSs[a] (median (IQR))	2.0 (0.0-5.0)	3.0 (1.0-7.0)	5.0 (2.0-7.0)	4.0 (1.0-7.0)	3.0 (1.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder, MSS: musculoskeletal symptom. [a]ratings were only made by those reporting musculoskeletal symptoms in the last 7 days. [b]rating were only made by those reporting music-related musculoskeletal disorders in the last 7 days. [c]w-scores were derived from Rasch analysis (Appendix 2.10).

Table A1.4.12: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences for all symptomatic university music students, and sub-groups of students

	All students	Performance students	Non-performance students	Classical performance students	Non-classical performance students
Work/ study in the last 12 months					
Changes to work/ study	20.4 (14.5-27.9)	18.3 (11.9-27.0)	27.8 (15.6-44.5)	24.3 (13.1-40.8)	14.0 (6.8-26.8)
Musical changes to work/ study	14.2 (9.2-21.2)	13.0 (7.7-21.2)	18.8 (8.6-36.1)	17.1 (7.8-33.5)	12.0 (5.4-24.5)
Leave from work/ study	23.9 (17.6-31.7)	19.2 (12.7-28.0)	38.9 (24.5-55.6)	8.1 (2.6-22.6)	24.0 (14.1-37.9)
Musical leave from work/ study	17.1 (11.7-24.4)	16.5 (10.5-25.0)	20.0 (9.8-36.6)	5.6 (1.4-20.0)	22.0 (12.5-35.7)
Consulting a health professional in the last 12 months	60.5 (52.4-68.2)	56.9 (47.4-65.9)	75.0 (58.4-86.5)	60.0 (44.1-74.0)	58.8 (44.8-71.5)
Medical professional	36.6 (29.1-44.9)	32.7 (24.3-42.3)	50.0 (34.1-65.9)	32.4 (19.3-49.1)	36.0 (23.9-50.2)
Psychologist/ counsellor	5.6 (2.8-10.9)	3.8 (1.4-9.9)	11.1 (4.2-26.3)	2.7 (0.4-17.2)	6.0 (0.2-17.2)
Physiotherapist/ occupational therapist	31.0 (23.9-39.1)	30.8 (22.6-40.3)	33.3 (19.9-50.1)	32.4 (19.3-49.1)	30.0 (18.8-44.2)
Personal trainer/ Pilates instructor/ yoga instructor	11.3 (7.0-17.7)	9.6 (5.2-17.0)	16.7 (7.6-32.6)	8.1 (2.6-22.6)	14.0 (6.8-26.8)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	22.5 (16.4-30.2)	22.1 (15.1-31.2)	25.0 (13.5-41.6)	27.0 (15.1-43.6)	24.0 (14.1-37.9)
Naturopath/ homeopath	3.5 (1.5-8.2)	1.9 (0.5-7.4)	8.3 (2.7-23.0)	4.0 (1.0-14.9)	0.0
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	4.2 (1.9-9.1)	3.8 (1.4-9.9)	5.6 (1.4-19.9)	8.1 (2.6-22.6)	2.0 (0.3-13.2)
Other	2.1 (0.7-6.4)	2.9 (0.9-8.6)	0.0	2.7 (0.4-17.2)	2.0 (0.3-13.2)
Self-management in the last 12 months	83.7 (76.7-88.8)	80.7 (72.2-87.1)	94.4 (80.2-98.6)	80.0 (64.6-89.8)	82.4 (69.2-90.6)
Medication	28.9 (22.0-36.9)	26.0 (18.4-35.3)	36.1 (22.2-52.9)	13.5 (5.7-28.9)	28.0 (17.2-42.1)
Heat/ ice	40.1 (32.3-48.5)	40.4 (31.3-50.1)	41.7 (26.8-58.2)	37.8 (23.7-54.4)	40.0 (27.3-54.2)
Exercises/ stretches	76.8 (69.0-83.0)	76.0 (66.8-83.3)	80.6 (64.3-90.5)	81.1 (65.1-90.8)	76.0 (62.1-85.9)
Braces/ strapping/ taping	24.6 (18.2-32.5)	26.0 (18.4-35.3)	22.2 (11.5-38.7)	37.8 (23.7-54.4)	16.0 (8.1-29.1)
Other	3.5 (1.5-8.2)	4.8 (2.0-11.1)	0.0	2.7 (0.4-17.2)	2.0 (0.3-13.2)
Consulting other musicians in the last 12 months	39.0 (31.3-47.4)	44.2 (34.9-54.0)	25.7 (13.9-42.6)	48.6 (33.0-64.5)	40.0 (27.3-54.2)
Current treatment	29.1 (21.5-38.0)	54.5 (37.5-70.6)	37.0 (21.1-56.4)	33.3 (19.3-51.1)	26.8 (15.4-42.5)

Notes: the denominator was the musicians with musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the denominator was musicians with musculoskeletal symptoms in the last 7 days

A1.4.1.3 Professional musicians: their demographics, and prevalence and profile of musculoskeletal symptom outcomes

Table 1.4.13: Demographic information for professional musicians, and sub-groups of professionals

	All professional musicians (n=225)	**Self-employed (n=141)**	**Employed (n=183)**	**Employed: Education (n=93)**	**Employed: Performance (n=136)**	**Opera (n=33)**	**Orchestra (n=42)**	**Military band (n=48)**	**Other (n=52)**
Age in years (median, IQR)	37.0 (22.0-54.0)	35.0 (21.0-54.5)	35.0 (21.0-48.0)	29.0 (20.0-49.0)	39.0 (25.0-48.0)	46.0 (34.0-55.0)	44.0 (38.0-52.0)	37.0 (31.0-45.0)	24.5 (20.0-44.0)
Female (%)	57.0	59.7	54.7	61.1	50.0	36.4	52.4	44.7	49.0
Body mass index (median, IQR)	25.0 (22.2-27.7)	24.7 (21.7-27.6)	24.8 (22.2-27.5)	24.7 (22.0-26.6)	25.0 (22.5-27.7)	25.1 (22.1-27.7)	24.8 (22.4-27.9)	25.6 (23.3-27.8)	24.2 (21.3-27.6)
Typical daily sitting time (%)									
<4 hours	23.2	20.0	22.5	21.1	23.0	33.3	19.1	25.5	17.3
4-8 hours	54.9	59.2	57.1	62.1	54.8	51.5	47.6	55.3	61.5
8+ hours	21.9	20.8	20.3	16.8	22.2	15.2	33.3	19.2	21.2
Socioeconomic status[a] (%)									
1	23.0	22.7	22.7	21.1	23.1	24.2	16.7	29.8	19.6
2	21.2	21.9	22.7	20.0	23.1	24.2	28.6	21.3	27.5
3	23.4	23.5	21.6	27.4	20.9	21.2	19.1	17.0	27.5
4	32.4	31.9	33.2	31.6	32.8	30.3	35.7	31.9	25.5
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	3.0 (2.0-4.0)	2.0 (1.0-4.0)	3.0 (2.0-4.0)	2.0 (1.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	2.0 (1.0-3.0)	3.0 (2.0-4.0)
Number of employers in the last 7 days (median, IQR)	1.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-3.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)
Hours worked in the last 7 days (median, IQR)	12.0 (4.0-28.0)	15.0 (6.0-26.0)	14.0 (6.0-30.0)	14.0 (8.0-26.0)	15.0 (5.0-36.0)	16.5 (6.0-30.0)	18.0 (8.0-29.0)	33.5 (7.0-48.0)	10.0 (2.8-24.5)
Currently studying music (%)	32.9	44.2	42.6	47.4	25.7	12.1	14.3	10.42	53.9
Age (in years) they started their musical activities (median, IQR)	8.0 (6.0-10.0)	7.5 (5.8-10.0)	8.0 (6.0-10.0)	8.0 (6.0-10.0)	8.0 (6.0-10.0)	7.0 (6.0-10.0)	7.0 (6.0-9.0)	8.0 (7.0-11.0)	7.0 (5.0-10.0)
Years of musical activity (median, IQR)	30.5 (15.0-44.5)	28.0 (15.0-45.5)	27.0 (15.0-40.0)	21.5 (13.0-38.0)	31.5 (18.0-41.0)	39.0 (26.0-48.0)	37.0 (31.0-42.0)	30.0 (23.0-37.0)	18.5 (13.0-37.5)
Performed in the last 12 months (%)	90.8	95.8	94.44	93.5	95.6	100.0	97.6	93.8	96.2
Performed in the last 7 days (%)	54.7	59.0	61.4	59.3	66.4	57.6	82.9	68.89	62.8
Amount of musical activity in the last 7 days (%)									
0-10 hours	37.1	21.7	31.3	18.1	33.8	24.2	11.9	56.3	28.9
10-20 hours	27.7	34.2	29.1	30.9	27.9	30.3	31.0	22.9	28.9
20 or more hours	35.3	44.2	39.6	51.1	38.2	45.5	57.1	20.8	42.3

(continued)

	All professional musicians (n=225)	Self-employed (n=141)	Employed (n=183)	Employed: Education (n=93)	Employed: Performance (n=136)	Opera (n=33)	Orchestra (n=42)	Military band (n=48)	Other (n=52)
Musical biomechanical exposure in the last 12 months (%)									
Singing/ woodwind/ brass	67.1	64.4	72.4	68.5	75.4	75.0	59.0	89.1	75.5
Singing	42.6	43.6	46.0	45.6	45.5	60.6	20.0	44.7	54.0
Brass	18.8	15.7	21.8	21.4	25.4	6.3	25.6	37.0	22.5
Woodwind	25.2	21.6	25.9	19.1	26.9	9.4	20.5	47.8	20.4
Flute	13.1	12.1	13.2	9.0	13.9	3.1	10.3	26.1	10.2
Reed	16.4	13.8	17.8	12.4	19.2	6.3	12.8	37.0	12.2
Saxophone	12.2	8.6	13.8	7.9	16.2	0.0	5.1	34.8	12.2
Upper string	16.4	19.1	17.1	18.0	18.5	21.9	35.9	0.0	26.0
Hands elevated at shoulder level to play	56.5	54.3	63.4	58.9	68.7	50.0	82.1	73.9	67.4
Repetitive elbow movement to play	76.5	80.0	78.7	83.2	73.9	75.0	79.5	69.6	87.8
Repetitive finger flexion/ extension to play	91.7	91.6	91.6	92.4	93.3	81.8	97.6	95.7	94.2
Repetitive finger adduction/ abduction to play	66.7	73.9	62.6	71.9	57.7	75.0	66.7	30.4	71.4
Repetitive foot movement to play	56.8	60.9	55.2	59.6	50.0	56.3	30.8	45.7	59.2
Musical biomechanical exposure in the last 7 days (%)									
Singing/ woodwind/ brass	59.1	57.6	65.4	63.4	66.2	71.9	51.2	76.1	62.8
Singing	32.6	36.1	35.0	36.2	33.6	57.6	14.3	23.9	40.4
Brass	15.0	10.2	17.3	17.2	20.3	3.1	17.1	32.6	17.7
Woodwind	21.4	19.5	22.9	17.2	24.1	9.4	19.5	43.5	17.7
Flute	10.0	8.5	11.2	7.5	12.0	3.1	9.8	21.7	9.8
Reed	14.9	13.3	15.6	11.0	17.1	6.3	12.5	34.9	9.8
Saxophone	9.6	8.9	11.0	7.7	11.6	0.0	5.1	24.4	10.2
Upper string	14.8	17.5	15.6	15.4	17.1	15.6	32.5	0.0	21.6
Hands elevated at shoulder level to play	51.7	48.7	57.2	55.6	62.8	42.4	78.1	69.8	65.4
Repetitive elbow movement to play	72.3	75.4	70.5	79.1	66.7	63.6	73.2	50.0	73.1
Repetitive finger flexion/ extension to play	88.0	89.5	91.6	90.1	87.5	75.0	95.0	85.7	86.3
Repetitive finger adduction/ abduction to play	59.8	65.8	55.5	64.8	48.8	65.6	57.5	16.3	58.8
Repetitive foot movement to play	45.9	50.9	43.0	47.3	37.6	50.0	24.4	21.7	49.0
Job satisfaction score[b] (median, IQR)	40.0 (40.0-40.0)	40.0 (40.0-40.0)	40.0 (40.0-40.0)	40.0 (30.0-40.0)	40.0 (40.0-40.0)	40.0 (25.0-40.0)	40.0 (40.0-40.0)	40.0 (35.0-40.0)	40.0 (40.0-40.0)
Social support score[b] (median, IQR)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	59.0 (35.0-59.0)	48.0 (35.0-59.0)
Psychological distress score[b] (median, IQR)	33.0 (19.0-51.0)	40.0 (19.0-51.0)	36.5 (19.0-51.0)	40.0 (19.0-51.0)	33.0 (19.0-46.0)	40.0 (19.0-46.0)	33.0 (19.0-46.0)	33.0 (19.0-40.0)	33.0 (19.0-51.0)
Psychosocial stress score[b] (median, IQR)	17.0 (5.0-25.0)	17.0 (5.0-30.0)	25.0 (5.0-30.0)	25.0 (17.0-30.0)	17.0 (5.0-25.0)	17.0 (5.0-25.0)	17.0 (5.0-25.0)	21.0 (11.0-25.0)	17.0 (5.0-30.0)

Notes: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]refer to w-scores derived from Rasch analysis (Appendices 2.11-2.14).

Table A1.4.14: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for professional musicians, and sub-groups of professionals

	All professionals	All self-employed	All employed	Education	Performance	Opera	Orchestra	Military	Other
Overall	87.9 (82.8-91.7)	92.9 (86.3-96.4)	87.1 (81.3-91.3)	88.0 (79.6-93.3)	87.0 (80.1-91.8)	87.1 (70.0-95.1)	94.7 (81.0-98.7)	83.3 (69.9-91.5)	84.3 (71.5-92.0)
Combined regions									
Head/ orofacial	36.0 (29.8-42.7)	40.2 (31.5-49.5)	37.3 (30.4-44.7)	38.0 (28.7-48.4)	34.6 (26.9-43.2)	35.5 (20.7-53.6)	36.8 (23.1-53.2)	25.5 (15.0-39.9)	37.3 (25.1-51.3)
Upper limb	77.6 (71.5-82.7)	81.3 (72.9-87.5)	77.4 (70.6-83.0)	81.5 (72.2-88.2)	76.2 (68.0-82.7)	71.0 (52.8-84.2)	92.1 (78.0-97.5)	66.0 (51.3-78.1)	78.4 (65.0-87.7)
Neck/ trunk	76.2 (70.0-81.4)	79.5 (70.9-86.0)	78.0 (71.2-83.5)	80.4 (71.0-87.4)	77.7 (69.7-84.1)	83.9 (66.4-93.2)	84.2 (68.9-92.8)	72.3 (57.8-83.3)	76.5 (62.8-86.2)
Lower limb	42.1 (35.6-48.8)	41.1 (32.3-50.4)	40.7 (33.6-48.1)	39.1 (29.7-49.5)	42.3 (34.1-51.0)	48.4 (31.5-65.6)	28.9 (16.7-45.3)	42.6 (29.2-57.0)	39.2 (26.8-53.2)
All regions									
Head	26.2 (20.7-32.5)	30.4 (22.5-39.5)	26.0 (20.0-33.0)	28.3 (20.0-38.4)	22.3 (15.9-30.3)	22.6 (11.1-40.6)	18.4 (9.0-34.1)	14.9 (7.2-28.2)	25.5 (15.3-39.2)
Orofacial	26.2 (20.7-32.5)	29.5 (21.7-38.6)	28.2 (22.1-35.4)	30.4 (21.9-40.6)	24.6 (17.9-32.8)	25.8 (13.4-43.9)	28.9 (16.7-45.3)	17.0 (8.7-60.7)	27.5 (16.9-41.3)
Neck	62.6 (55.9-68.9)	68.8 (59.5-76.7)	66.7 (59.4-73.3)	70.7 (60.5-79.1)	66.2 (57.6-73.8)	71.0 (52.8-84.2)	76.3 (60.2-87.3)	55.3 (40.9-68.9)	68.6 (54.6-79.9)
Shoulder	63.6 (56.9-69.8)	67.0 (57.7-75.1)	64.4 (57.0-71.1)	71.7 (61.6-80.0)	62.3 (53.6-70.3)	61.3 (43.3-76.7)	78.9 (63.1-89.2)	51.1 (36.9-65.0)	66.7 (52.6-78.3)
Elbow	20.1 (15.2-26.0)	20.5 (14.0-29.1)	22.0 (16.5-28.8)	27.2 (19.0-37.2)	20.0 (14.0-27.8)	16.1 (6.8-33.6)	44.7 (29.8-60.7)	10.6 (4.5-23.3)	15.7 (8.0-28.5)
Wrist/ hand	48.1 (41.5-54.9)	51.8 (42.5-60.9)	47.5 (40.2-54.9)	52.2 (41.9-62.2)	44.6 (36.3-53.3)	35.5 (20.7-53.6)	55.3 (39.3-70.2)	29.8 (18.4-44.4)	52.9 (39.2-66.2)
Upper back	43.5 (36.9-50.2)	46.4 (37.4-55.7)	45.2 (38.0-52.6)	48.9 (38.8-59.1)	42.3 (34.1-51.0)	45.2 (28.7-62.7)	44.7 (29.8-60.7)	34.0 (21.9-48.7)	49.0 (35.6-62.6)
Chest/ abdomen	14.5 (10.4-19.9)	14.3 (8.9-22.1)	15.8 (11.1-22.0)	18.5 (11.8-27.8)	13.1 (8.3-20.1)	16.1 (6.8-33.6)	7.9 (2.5-22.0)	8.5 (3.2-20.7)	21.6 (12.3-35.0)
Lower back	52.8 (46.1-59.4)	57.1 (47.8-66.0)	53.7 (46.3-60.9)	55.4 (45.1-65.3)	51.5 (42.9-60.1)	58.1 (40.3-74.0)	47.4 (32.1-63.1)	48.9 (35.0-63.1)	52.9 (39.2-66.2)
Hip/ thigh	22.0 (16.9-28.0)	22.3 (15.5-31.0)	20.3 (15.0-27.0)	20.7 (13.5-30.2)	21.5 (15.3-29.5)	38.7 (23.3-56.7)	13.2 (5.5-28.1)	8.5 (3.2-20.7)	27.5 (16.9-41.3)
Knee	22.9 (17.7-29.0)	23.2 (16.3-32.0)	22.0 (16.5-28.8)	23.9 (16.2-33.7)	21.5 (15.3-29.5)	32.3 (18.2-50.5)	13.2 (5.5-28.1)	19.1 (10.2-33.0)	19.6 (10.8-32.9)
Ankle/ foot	19.2 (14.4-25.0)	19.6 (13.3-28.1)	18.6 (13.5-25.1)	16.3 (10.0-25.4)	17.7 (12.0-25.3)	16.1 (6.8-33.6)	10.5 (4.0-25.1)	21.3 (11.8-35.4)	13.7 (6.6-26.2)

Table A1.4.15: 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders for professional musicians, and sub-groups of professionals

	All professionals	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Overall	60.2 (53.5-66.5)	71.4 (62.6-78.9)	60.2 (52.9-67.1)	63.4 (53.2-72.6)	60.7 (52.2-68.7)	54.5 (37.5-70.6)	69.0 (53.5-81.2)	55.3 (40.9-68.9)	65.4 (51.5-77.1)
Combined regions									
Head/orofacial	17.7 (13.2-23.4)	22.0 (15.4-30.5)	20.0 (14.8-26.5)	19.1 (12.4-28.4)	19.5 (13.6-27.2)	21.9 (10.7-39.5)	25.0 (13.9-40.7)	12.8 (5.8-25.8)	23.1 (13.5-36.5)
Upper limb	51.4 (44.7-57.9)	62.7 (53.6-71.0)	50.6 (43.3-57.8)	56.4 (46.2-66.1)	50.4 (41.9-58.8	43.8 (27.8-61.1)	60.0 (44.2-74.0)	38.3 (25.5-52.9)	57.7 (43.9-70.4)
Neck/ trunk	50.9 (44.3-57.5)	61.0 (51.9-69.4)	52.2 (44.9-59.5)	55.3 (45.1-65.1)	51.1 (42.6-59.6)	46.9 (30.5-64.0)	60.0 (44.2-74.0)	46.8 (33.0-61.1)	55.8 (42.1-68.7)
Lower limb	15.9 (11.6-21.4)	15.3 (9.8-23.0)	16.1 (11.4-22.3)	18.1 (11.5-27.3)	15.8 (10.5-23.1)	12.5 (4.7-29.1)	15.0 (6.8-29.8)	14.9 (7.2-28.2)	19.2 (10.6-32.3)
All regions									
Head	10.0 (6.7-14.8)	13.6 (8.5-21.0)	11.1 (7.3-16.6)	13.8 (8.2-22.4)	9.8 (5.7-16.2)	9.4 (3.0-25.6)	12.5 (5.3-26.9)	6.4 (2.1-18.2)	13.5 (6.5-25.8)
Orofacial	15.0 (10.8-20.4)	19.5 (13.3-27.7)	17.2 (12.4-23.5)	16.0 (9.8-24.9)	17.3 (11.7-24.7)	21.9 (10.7-39.5)	22.5 (12.1-38.0)	8.5 (3.2-20.7)	21.2 (12.1-34.4)
Neck	39.5 (33.3-46.2)	50.0 (41.0-59.0)	40.6 (33.6-47.9)	45.7 (35.9-55.9)	39.1 (31.1-47.7)	34.4 (20.1-52.2)	55.0 (39.5-69.6)	27.7 (16.7-42.2)	46.2 (33.1-49.8)
Shoulder	40.0 (33.7-46.6)	50.0 (41.0-59.0)	41.7 (34.6-49.0)	48.9 (38.9-59.0)	40.6 (32.5-49.2)	40.6 (25.1-58.2)	50.0 (34.9-65.1)	25.5 (15.0-39.9)	50.0 (36.6-63.4)
Elbow	15.9 (11.6-21.4)	16.1 (10.5-23.9)	16.1 (11.4-22.3)	19.1 (12.4-28.4)	16.5 (11.1-23.9)	9.4 (3.0-25.6)	35.0 (21.8-50.9)	10.6 (4.5-23.3)	15.4 (7.8-28.0)
Wrist/ hand	31.8 (26.0-38.3)	39.0 (30.6-48.1)	29.4 (23.2-36.6)	31.9 (23.2-42.0)	27.8 (20.8-36.1)	15.6 (6.6-32.7)	32.5 (19.8-48.4)	21.3 (11.8-35.4)	34.6 (22.9-48.5)
Upper back	29.5 (23.9-35.9)	38.1 (29.8-47.2)	30.6 (24.2-37.7)	37.2 (28.0-47.5)	27.8 (20.8-36.1)	28.1 (15.2-46.0)	40.0 (26.0-55.8)	19.1 (10.2-33.0)	38.5 (26.2-52.3)
Chest/ abdomen	7.3 (4.5-11.6)	9.3 (5.2-16.1)	8.9 (5.5-14.1)	10.6 (5.8-18.7)	7.5 (4.1-13.5)	12.5 (4.7-29.1)	5.0 (1.24-18.1)	4.3 (1.1-15.7)	13.5 (6.5-25.8)
Lower back	31.8 (26.0-38.3)	37.3 (29.0-46.4)	33.9 (27.3-41.1)	37.2 (28.0-47.5)	30.8 (23.5-39.2)	34.4 (20.1-52.2)	22.5 (12.1-38.0)	29.8 (18.4-44.4)	36.5 (24.6-50.4)
Hip/ thigh	8.6 (5.6-13.2)	8.5 (4.6-15.1)	8.9 (5.5-14.1)	9.6 (5.0-17.5)	9.0 (5.2-15.3)	9.4 (3.0-25.6)	5.0 (1.24-18.1)	6.4 (2.1-18.2)	11.5 (5.2-23.5)
Knee	6.4 (3.8-10.5)	6.8 (3.4-13.0)	6.7 (3.8-11.4)	9.6 (5.0-17.5)	6.8 (3.5-12.5)	12.5 (4.7-29.1)	7.5 (2.4-21.0)	6.4 (2.1-18.2)	5.8 (1.9-16.6)
Ankle/ foot	5.9 (3.5-9.9)	5.9 (2.8-12.0)	5.6 (3.0-10.0)	4.3 (1.6-10.9)	5.3 (2.5-10.7)	3.1 (0.4-19.4)	2.5 (0.3-16.0)	6.4 (2.1-18.2)	5.8 (1.9-16.6)

Table A1.4.16: 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms in professional musicians, and sub-groups of professionals

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Overall	71.5 (65.2-77.1)	79.5 (71.2-85.9)	70.3 (63.3-76.5)	71.3 (61.3-79.6)	69.4 (61.0-76.7)	75.0 (57.2-87.1)	72.5 (56.7-84.2)	66.7 (52.2-78.6)	65.4 (51.5-77.1)
Chronic[a]	38.6 (32.3-45.3)	44.2 (35.3-53.6)	37.5 (30.6-44.9)	41.1 (31.4-51.6)	35.1 (27.4-43.7)	35.5 (20.7-53.6)	36.8 (23.1-53.2)	29.2 (18.0-43.6)	37.3 (25.1-51.3)
Chronic[a] of those with MSSs	54.6 (46.6-62.4)	56.2 (45.7-66.1)	54.1 (45.2-62.8)	58.7 (46.2-70.2)	51.1 (40.8-61.3)	47.8 (28.6-67.7)	51.9 (33.5-69.8)	43.8 (27.8-61.2)	57.6 (40.3-73.1)
Moderate-severe pain[b]	24.7 (18.3-32.4)	25.0 (16.8-35.4)	23.3 (16.6-31.8)	27.4 (17.7-39.9)	22.1 (14.5-32.2)	19.0 (7.3-41.5)	24.0 (11.1-44.5)	16.1 (6.8-33.7)	34.4 (20.0-52.3)
Combined regions									
Head/ orofacial	21.2 (16.2-27.2)	27.8 (20.4-36.8)	20.8 (15.4-27.4)	22.6 (15.2-32.2)	20.6 (14.5-28.4)	29.0 (15.8-47.2)	23.1 (12.4-38.9)	14.9 (7.2-28.2)	21.6 (12.3-35.0)
Upper limb	55.3 (48.6-61.8)	60.0 (50.8-68.6)	53.9 (46.5-61.2)	59.1 (48.8-68.7)	51.9 (43.3-60.4)	54.8 (37.3-71.3)	61.5 (45.5-75.4)	42.6 (29.2-57.0)	54.9 (41.1-68.0)
Neck/ trunk	53.0 (46.3-59.6)	60.9 (51.6-69.4)	54.5 (47.1-61.7)	55.9 (45.6-65.7)	51.1 (42.6-59.6)	58.1 (40.3-74.0)	56.4 (40.6-71.0)	46.8 (33.0-61.1)	47.1 (33.8-60.8)
Lower limb	23.5 (18.3-29.6)	24.3 (17.3-33.1)	21.9 (16.4-28.6)	20.4 (13.4-29.9)	22.1 (15.8-30.1)	32.3 (18.2-50.5)	7.7 (2.5-21.5)	19.1 (10.2-33.0)	27.5 (16.9-41.3)
All regions									
Head	15.2 (11.0-20.7)	19.1 (12.9-27.4)	14.0 (9.6-20.0)	16.1 (9.9-25.1)	13.0 (8.2-19.9)	12.9 (4.9-30.0)	5.1 (1.3-18.5)	10.6 (4.5-23.3)	15.7 (8.0-28.5)
Right	13.8 (9.8-19.1)	17.4 (11.5-25.5)	12.9 (8.7-18.7)	15.1 (9.1-23.9)	11.5 (7.0-18.2)	12.9 (4.9-30.0)	5.1 (1.3-18.5)	8.5 (3.2-20.7)	13.7 (6.6-26.2)
Left	12.4 (8.7-17.6)	15.7 (10.1-23.5)	11.8 (7.8-17.5)	11.8 (6.6-20.2)	11.5 (7.0-18.2)	9.7 (3.1-26.3)	2.6 (0.4-16.3)	10.6 (4.5-23.3)	15.7 (8.0-28.5)
Orofacial	13.8 (9.8-19.1)	20.0 (13.6-28.4)	14.0 (9.6-20.0)	18.3 (11.6-27.5)	13.7 (8.8-20.8)	25.8 (13.4-43.9)	20.5 (10.5-36.1)	6.4 (2.1-18.2)	13.7 (6.6-26.2)
Right	11.5 (7.9-16.5)	18.3 (12.2-26.4)	11.8 (7.8-17.5)	16.1 (9.9-25.1)	11.5 (7.0-18.2)	19.4 (8.9-37.1)	17.9 (8.7-33.3)	6.4 (2.1-18.2)	11.8 (5.3-24.0)
Left	11.1 (7.5-16.0)	15.7 (10.1-23.5)	11.2 (7.3-16.8)	18.3 (11.6-27.5)	9.9 (5.8-16.4)	19.4 (8.9-37.1)	10.3 (3.9-24.5)	4.3 (1.1-15.7)	9.8 (4.1-21.6)
Neck	37.8 (31.6-44.5)	47.0 (38.0-56.1)	38.8 (31.9-46.2)	43.0 (33.3-53.3)	35.1 (27.4-43.7)	48.4 (31.5-65.6)	43.6 (29.0-59.4)	27.7 (16.7-42.2)	29.4 (18.5-43.4)
Right	31.3 (25.5-37.8)	40.0 (31.4-47.2)	33.1 (26.6-40.4)	37.6 (28.3-47.9)	28.2 (21.2-36.6)	38.7 (23.3-56.7)	35.9 (22.4-52.0)	19.1 (10.2-33.0)	23.5 (13.8-37.2)
Left	34.6 (28.5-41.2)	41.7 (33.0-51.0)	35.4 (28.7-42.7)	36.6 (27.4-46.8)	32.1 (24.6-40.6)	48.4 (31.5-65.6)	38.5 (24.6-54.5)	25.5 (15.0-39.9)	27.5 (16.9-41.3)
Shoulder	41.9 (35.5-48.6)	46.1 (37.2-55.3)	41.6 (34.5-49.0)	50.5 (40.4-60.6)	38.2 (30.2-46.8)	41.9 (26.0-59.7)	43.6 (29.0-59.4)	29.8 (18.4-44.4)	41.2 (28.5-55.1)
Right	30.9 (25.1-37.4)	34.8 (26.6-44.0)	30.3 (24.0-37.5)	39.8 (30.3-50.1)	26.7 (19.8-35.0)	32.3 (18.2-50.5)	28.2 (16.3-44.3)	17.0 (8.7-30.7)	29.4 (18.5-43.4)
Left	31.3 (25.5-37.8)	35.7 (27.4-44.8)	31.5 (25.0-38.7)	36.6 (27.4-46.8)	29.8 (22.5-38.2)	29.0 (15.8-47.2)	35.9 (22.4-52.0)	23.4 (13.4-37.7)	33.3 (21.7-47.4)
Elbow	9.2 (6.0-13.9)	8.7 (4.7-15.5)	9.6 (6.0-14.9)	11.8 (6.6-20.2)	10.7 (6.4-17.3)	6.5 (1.6-22.7)	25.6 (14.3-41.6)	4.3 (1.1-15.7)	7.8 (2.9-19.3)
Right	7.8 (4.9-12.3)	7.8 (4.1-14.4)	7.9 (4.7-12.9)	9.7 (5.1-17.6)	8.4 (4.7-14.6)	6.5 (1.6-22.7)	20.5 (10.5-36.1)	2.1 (0.3-13.8)	7.8 (2.9-19.3)
Left	4.1 (2.2-7.8)	5.2 (2.4-11.2)	4.5 (2.3-8.8)	6.5 (2.9-13.7)	5.3 (2.6-10.8)	3.2 (0.4-19.9)	12.8 (5.4-27.5)	2.1 (0.3-13.8)	5.9 (1.9-16.9)
Wrist/ hand	28.6 (22.9-35.0)	31.3 (23.5-40.4)	27.5 (21.4-34.6)	26.9 (18.8-36.8)	27.5 (20.5-35.8)	22.6 (11.1-40.6)	30.8 (18.3-46.9)	19.1 (10.2-33.0)	35.3 (23.4-49.3)
Right	21.7 (16.7-27.7)	22.6 (15.8-31.2)	19.7 (14.4-26.2)	20.4 (13.4-29.9)	18.3 (12.6-25.9)	3.2 (0.4-19.9)	17.9 (8.7-33.3)	14.9 (7.2-28.2)	25.5 (15.3-39.2)
Left	18.4 (13.8-24.2)	22.6 (15.8-31.2)	17.4 (12.5-23.7)	16.1 (9.9-25.1)	18.3 (12.6-25.9)	22.6 (11.1-40.6)	20.5 (10.5-36.1)	8.5 (3.2-20.7)	27.5 (16.9-41.3)
Upper back	26.3 (20.8-32.6)	29.6 (21.9-38.6)	26.0 (20.4-33.4)	31.2 (22.6-41.3)	22.1 (15.8-30.1)	19.4 (8.9-37.1)	25.6 (14.3-41.6)	21.3 (11.8-35.4)	25.5 (15.3-39.2)
Right	23.0 (17.9-29.1)	26.1 (18.8-34.9)	23.6 (17.9-30.4)	28.0 (19.7-38.0)	19.1 (13.2-26.8)	9.7 (3.1-26.3)	20.5 (10.5-36.1)	19.1 (10.2-33.0)	23.5 (13.8-37.2)
Left	21.7 (16.7-27.7)	25.2 (18.1-34.0)	21.3 (15.9-28.0)	26.9 (18.8-36.8)	16.8 (11.3-24.3)	19.4 (8.9-37.1)	17.9 (8.7-33.3)	14.9 (7.2-28.2)	19.6 (10.8-32.9)
Chest/ abdomen	6.0 (3.5-10.1)	7.0 (3.5-13.3)	6.7 (3.9-11.5)	9.7 (5.1-17.6)	5.3 (2.6-10.8)	6.5 (1.6-22.7)	2.6 (0.4-16.3)	2.1 (0.3-13.8)	9.8 (4.1-21.6)
Right	3.2 (1.5-6.6)	4.3 (1.8-10.1)	3.4 (1.5-7.3)	5.4 (2.2-12.3)	0.8 (0.1-5.3)	0.0	0.0	0.0	2.0 (0.3-12.9)
Left	6.0 (3.5-10.1)	7.0 (3.5-13.3)	6.7 (3.9-11.5)	9.7 (5.1-17.6)	5.3 (2.6-10.8)	6.5 (1.6-22.7)	2.6 (0.4-16.3)	2.1 (0.3-13.8)	9.8 (4.1-21.6)
Lower back	35.5 (29.4-42.1)	41.7 (33.0-51.0)	35.4 (28.7-42.7)	37.6 (28.3-47.9)	31.3 (23.9-39.8)	35.5 (20.7-53.6)	23.1 (12.4-38.9)	27.7 (16.7-42.2)	31.4 (20.1-45.4)
Right	33.2 (27.2-39.7)	38.3 (29.8-47.5)	33.7 (27.1-41.0)	35.5 (26.4-45.8)	30.5 (23.2-39.0)	32.3 (18.2-50.5)	23.1 (12.4-38.9)	27.7 (16.7-42.2)	29.4 (18.5-43.4)
Left	33.2 (27.2-39.7)	39.1 (30.6-48.4)	33.1 (26.6-40.4)	37.6 (28.3-47.9)	28.2 (21.2-36.6)	32.3 (18.2-50.5)	20.5 (10.5-36.1)	27.7 (16.7-42.2)	25.5 (15.3-39.2)

(continued)

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Hip/ thigh	12.9 (9.0-18.1)	13.9 (8.7-21.6)	13.5 (9.2-19.4)	12.9 (7.4-21.4)	13.7 (8.8-20.8)	29.0 (15.8-47.2)	0.0	6.4 (2.1-18.2)	19.6 (10.8-32.9)
Right	11.1 (7.5-16.0)	13.0 (8.0-20.6)	11.2 (7.3-16.8)	10.8 (5.9-18.9)	11.5 (7.0-18.2)	22.6 (11.1-40.6)	0.0	6.4 (2.1-18.2)	13.7 (6.6-26.2)
Left	7.4 (4.6-11.7)	7.8 (4.1-14.4)	7.3 (4.3-12.2)	6.5 (2.9-13.7)	8.4 (4.7-14.6)	22.6 (11.1-40.6)	0.0	2.1 (0.3-13.8)	9.8 (4.1-21.6)
Knee	10.6 (7.1-15.5)	11.3 (6.7-18.5)	10.1 (6.4-15.5)	10.8 (5.9-18.9)	10.7 (6.4-17.3)	22.6 (11.1-40.6)	7.7 (2.5-21.5)	4.3 (1.1-15.7)	11.8 (5.3-24.0)
Right	6.5 (3.8-10.6)	7.0 (3.5-13.3)	6.2 (3.4-10.8)	4.3 (1.6-11.0)	7.6 (4.1-13.7)	19.4 (8.9-37.1)	0.0	4.3 (1.1-15.7)	5.9 (1.9-16.9)
Left	6.9 (4.2-11.2)	7.8 (4.1-14.4)	6.2 (3.4-10.8)	8.6 (4.3-16.3)	6.1 (3.1-11.8)	12.9 (4.9-30.0)	7.7 (2.5-21.5)	2.1 (0.3-13.8)	5.9 (1.9-16.9)
Ankle/ foot	8.3 (5.3-12.8)	7.8 (4.1-14.4)	7.3 (4.3-12.2)	5.4 (2.2-12.3)	6.1 (3.1-11.8)	6.5 (1.6-22.7)	0.0	10.6 (4.5-23.3)	2.0 (0.3-12.9)
Right	5.5 (3.2-9.5)	5.2 (2.4-11.2)	5.1 (2.6-9.5)	4.3 (1.6-11.0)	3.8 (1.6-8.9)	3.2 (0.4-19.9)	0.0	6.4 (2.1-18.2)	2.0 (0.3-12.9)
Left	6.0 (3.5-10.1)	6.1 (2.9-12.3)	5.1 (2.6-9.5)	3.2 (1.0-9.6)	4.6 (2.1-9.9)	3.2 (0.4-19.9)	0.0	10.6 (4.5-23.3)	0.0

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]ratings were only made by those who reporting musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to ratings of pain on average of 5-10 on an 11-point rating scale.

Table A1.4.17: The 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for professional musicians, and sub-groups of professionals

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Overall	43.2 (36.8-49.8)	55.9 (46.8-64.7)	43.3 (36.2-50.7)	46.8 (36.9-57.0)	41.4 (33.3-50.0)	40.6 (25.1-58.2)	50.0 (34.9-65.1)	29.8 (18.4-44.4)	46.2 (33.1-59.8)
Chronic[a]	29.2 (23.6-35.6)	35.9 (27.7-45.0)	28.3 (22.2-35.4)	31.9 (23.2-42.0)	27.1 (20.2-35.3)	18.8 (8.6-36.1)	32.5 (19.8-48.4)	19.1 (10.2-33.0)	34.6 (22.9-48.5)
Chronic[a] of those with MRMDs	67.0 (56.9-75.8)	64.6 (52.3-75.3)	64.1 (52.8-74.0)	68.2 (53.1-80.2)	63.6 (50.2-75.3)	46.2 (22.2-72.0)	65.0 (42.4-82.4)	57.1 (31.4-79.5)	75.0 (54.1-88.4)
Combined regions									
Head/ orofacial	11.4 (7.8-16.4)	14.5 (9.2-22.2)	12.3 (8.2-18.0)	11.8 (6.6-20.2)	12.0 (7.5-18.8)	15.63 (6.6-32.7)	20.0 (10.3-35.3)	10.6 (4.5-23.3)	11.5 (5.2-23.5)
Upper limb	33.8 (27.8-40.3)	44.4 (35.7-53.6)	33.5 (27.0-40.8)	38.7 (29.3-49.0)	31.6 (24.2-40.0)	31.3 (17.6-49.1)	42.5 (28.2-58.2)	17.0 (8.7-30.7)	36.5 (24.6-50.4)
Neck/ trunk	34.2 (28.2-40.8)	45.3 (36.5-54.4)	35.2 (28.5-42.5)	38.7 (29.3-49.0)	33.1 (25.6-41.6)	31.3 (17.6-49.1)	45.0 (30.4-60.5)	23.4 (13.4-37.7)	38.5 (26.2-52.3)
Lower limb	10.5 (7.1-15.3)	10.3 (5.9-17.2)	10.6 (6.9-16.1)	11.8 (6.6-20.2)	10.5 (6.3-17.0)	9.4 (3.0-25.6)	7.5 (2.4-21.0)	8.5 (3.2-20.7)	15.4 (7.8-28.0)
All regions									
Head	6.4 (3.8-10.5)	8.5 (4.6-15.2)	6.7 (3.8-11.5)	7.5 (3.6-15.0)	6.8 (3.5-12.5)	9.4 (3.0-25.6)	10.0 (3.8-24.0)	4.3 (1.1-15.7)	7.7 (2.9-18.9)
Right	5.5 (3.1-9.4)	6.8 (3.4-13.1)	5.6 (3.0-10.1)	6.5 (2.9-13.7)	5.3 (2.5-10.7)	9.4 (3.0-25.6)	10.0 (3.8-24.0)	2.1 (0.3-13.8)	5.8 (1.9-16.6)
Left	5.0 (2.8-8.9)	6.8 (3.4-13.1)	5.6 (3.0-10.1)	5.4 (2.2-12.3)	6.0 (3.0-11.6)	9.4 (3.0-25.6)	7.5 (2.4-21.0)	4.3 (1.1-15.7)	7.7 (2.9-18.9)
Orofacial	8.7 (5.6-13.2)	12.0 (7.2-19.2)	9.5 (6.0-14.8)	8.6 (4.3-16.3)	9.0 (5.2-15.3)	15.6 (6.6-32.7)	15.0 (6.8-29.8)	6.4 (2.1-18.2)	9.6 (4.0-21.2)
Right	7.8 (4.9-12.2)	10.3 (5.9-17.2)	8.4 (5.1-13.5)	7.5 (3.6-15.0)	8.3 (4.6-14.4)	12.5 (4.7-29.1)	12.5 (5.3-26.9)	6.4 (2.1-18.2)	9.6 (4.0-21.2)
Left	5.5 (3.1-9.4)	6.8 (3.4-13.1)	6.1 (3.4-10.8)	7.5 (3.6-15.0)	5.3 (2.5-10.7)	9.4 (3.0-25.6)	5.0 (1.2-18.1)	4.3 (1.1-15.7)	5.8 (1.9-16.6)
Neck	23.3 (18.1-29.4)	33.3 (25.4-42.4)	23.5 (17.8-30.3)	26.9 (18.8-36.8)	22.6 (16.2-30.5)	25.0 (12.9-42.8)	37.5 (23.9-53.4)	10.6 (4.5-23.3)	25.0 (15.0-38.6)
Right	18.7 (14.1-24.5)	26.5 (19.3-35.3)	19.6 (14.3-26.1)	23.7 (16.1-33.4)	17.3 (11.7-24.7)	18.8 (8.6-36.1)	32.5 (19.8-48.4)	6.4 (2.1-18.2)	19.2 (10.6-32.3)
Left	20.1 (15.3-26.0)	27.4 (20.0-36.2)	20.7 (15.3-27.3)	21.5 (14.3-31.1)	19.5 (13.6-27.2)	25.0 (12.9-42.8)	32.5 (19.8-48.4)	8.5 (3.2-20.7)	23.1 (13.5-36.5)
Shoulder	26.0 (20.6-32.3)	34.2 (26.1-43.3)	26.8 (20.8-33.8)	33.3 (24.5-43.6)	25.6 (18.8-33.7)	28.1 (15.2-46.0)	32.5 (19.8-48.4)	12.8 (5.8-25.8)	30.8 (19.7-44.6)
Right	18.3 (13.7-24.0)	24.8 (17.8-33.4)	20.1 (14.8-26.7)	28.0 (19.7-38.0)	18.8 (13.0-26.4)	18.8 (8.6-36.1)	22.5 (12.1-38.0)	6.4 (2.1-18.2)	25.0 (15.0-38.6)
Left	18.7 (14.1-24.5)	24.8 (17.8-33.4)	19.0 (13.9-25.5)	23.7 (16.1-33.4)	17.3 (11.7-24.7)	18.8 (8.6-36.1)	25.0 (13.9-40.7)	8.5 (3.2-20.7)	21.2 (12.1-34.4)
Elbow	7.3 (4.5-11.6)	8.5 (4.6-15.2)	7.8 (4.7-12.8)	9.7 (5.1-17.6)	8.3 (4.6-14.4)	6.3 (1.5-22.0)	22.5 (12.1-38.0)	0.0	7.7 (2.9-18.9)
Right	5.9 (3.5-10.0)	6.8 (3.4-13.1)	6.1 (3.4-10.8)	7.5 (3.6-15.0)	6.0 (3.0-11.6)	6.3 (1.5-22.0)	17.5 (8.5-32.6)	0.0	5.8 (1.9-16.6)
Left	3.2 (1.5-6.6)	4.3 (1.8-9.9)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	3.8 (1.6-8.8)	3.1 (0.4-19.4)	10.0 (3.8-24.0)	0.0	3.8 (1.0-14.3)
Wrist/ hand	19.2 (14.5-25.0)	23.9 (17.0-32.5)	18.4 (13.4-24.9)	19.4 (12.5-28.7)	15.8 (10.5-23.1)	9.4 (3.0-25.6)	22.5 (12.1-38.0)	10.6 (4.5-23.3)	19.2 (10.6-32.3)
Right	14.2 (10.1-19.5)	16.2 (10.6-24.1)	12.8 (8.7-18.6)	15.1 (9.1-23.9)	10.5 (6.3-17.0)	3.1 (0.4-19.4)	15.0 (6.8-29.8)	6.4 (2.1-18.2)	15.4 (7.8-28.0)
Left	11.9 (8.2-16.9)	17.1 (11.3-25.1)	11.2 (7.3-16.7)	9.7 (5.1-17.6)	10.5 (6.3-17.0)	9.4 (3.0-25.6)	10.0 (3.8-24.0)	6.4 (2.1-18.2)	13.5 (6.5-25.8)
Upper back	19.6 (14.9-25.5)	25.6 (18.5-34.4)	20.1 (14.8-26.7)	23.7 (16.1-33.4)	18.0 (12.4-25.6)	15.6 (6.6-32.7)	27.5 (15.8-43.3)	14.9 (7.2-28.2)	25.0 (15.0-38.6)
Right	18.3 (13.7-24.0)	23.1 (16.3-31.6)	19.0 (13.9-25.5)	22.6 (15.2-32.2)	16.5 (11.1-23.9)	9.4 (3.0-25.6)	22.5 (12.1-38.0)	14.9 (7.2-28.2)	23.1 (13.5-36.5)
Left	16.9 (12.5-22.5)	23.1 (16.3-31.6)	17.3 (12.4-23.6)	22.6 (15.2-32.2)	14.3 (9.3-21.4)	15.6 (6.6-32.7)	20.0 (10.3-35.3)	10.6 (4.5-23.3)	19.2 (10.6-32.3)
Chest/ abdomen	2.7 (1.2-6.0)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	2.3 (0.7-6.8)	0.0	0.0	2.1 (0.3-13.8)	5.8 (1.9-16.6)
Right	2.7 (1.2-6.0)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	2.3 (0.7-6.8)	0.0	0.0	2.1 (0.3-13.8)	5.8 (1.9-16.6)
Left	2.7 (1.2-6.0)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	2.3 (0.7-6.8)	0.0	0.0	2.1 (0.3-13.8)	5.8 (1.9-16.6)
Lower back	18.3 (13.7-24.0)	22.2 (15.6-30.7)	18.4 (13.4-24.9)	21.5 (14.3-31.1)	15.8 (10.5-23.1)	12.5 (4.7-29.1)	7.5 (2.4-21.0)	14.9 (7.2-28.2)	19.2 (10.6-32.3)
Right	17.4 (12.9-23.0)	20.5 (14.1-28.8)	17.3 (12.4-23.6)	19.4 (12.5-28.7)	15.0 (9.9-22.2)	9.4 (3.0-25.6)	7.5 (2.4-21.0)	14.9 (7.2-28.2)	19.2 (10.6-32.3)
Left	17.8 (13.3-23.5)	21.4 (14.8-29.8)	17.9 (12.8-24.2)	21.5 (14.3-31.1)	15.0 (9.9-22.2)	12.5 (4.7-29.1)	7.5 (2.4-21.0)	14.9 (7.2-28.2)	17.3 (9.2-30.2)

(continued)

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Hip/ thigh	5.9 (3.5-10.0)	6.0 (2.9-12.1)	6.1 (3.4-10.8)	6.5 (2.9-13.7)	6.8 (3.5-12.5)	6.3 (1.5-22.0)	2.5 (0.3-16.0)	4.3 (1.1-15.7)	9.6 (4.0-21.2)
Right	3.7 (1.8-7.2)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	3.8 (1.6-8.8)	3.1 (0.4-19.4)	0.0	2.1 (0.3-13.8)	7.7 (2.9-18.9)
Left	3.7 (1.8-7.2)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	3.2 (1.0-9.6)	3.8 (1.6-8.8)	3.1 (0.4-19.4)	2.5 (0.3-16.0)	2.1 (0.3-13.8)	3.8 (1.0-14.3)
Knee	3.7 (1.8-7.2)	3.4 (1.3-8.8)	3.4 (1.5-7.3)	4.3 (1.6-11.0)	3.0 (1.1-7.8)	6.3 (1.5-22.0)	5.0 (1.2-18.1)	2.1 (0.3-13.8)	3.8 (1.0-14.3)
Right	2.7 (1.2-6.0)	2.6 (0.8-7.7)	2.2 (0.8-5.8)	2.2 (0.5-8.3)	2.3 (0.7-6.8)	3.1 (0.4-19.4)	2.5 (0.3-16.0)	2.1 (0.3-13.8)	1.9 (0.3-12.6)
Left	2.3 (0.9-5.4)	2.6 (0.8-7.7)	1.7 (0.5-5.1)	2.2 (0.5-8.3)	1.5 (0.4-5.9)	3.1 (0.4-19.4)	2.5 (0.3-16.0)	2.1 (0.3-13.8)	1.9 (0.3-12.6)
Ankle/ foot	4.1 (2.1-7.7)	3.4 (1.3-8.8)	3.9 (1.9-8.0)	3.2 (1.0-9.6)	3.0 (1.1-7.8)	3.1 (0.4-19.4)	0.0	4.3 (1.1-15.7)	1.9 (0.3-12.6)
Right	3.7 (1.8-7.2)	2.6 (0.8-7.7)	3.9 (1.9-8.0)	3.2 (1.0-9.6)	3.0 (1.1-7.8)	3.1 (0.4-19.4)	0.0	4.3 (1.1-15.7)	1.9 (0.3-12.6)
Left	2.3 (0.9-5.4)	2.6 (0.8-7.7)	1.7 (0.5-5.1)	1.1 (0.1-7.3)	1.5 (0.4-5.9)	0.0	0.0	4.3 (1.1-15.7)	0.0

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to music-related musculoskeletal disorders on most days for at least the last 3 months.

Table A1.4.18: Ratings of musculoskeletal symptom outcomes made by symptomatic professional musicians, and sub-groups of musicians

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other performance
Pain intensity on average[a] (median (IQR))	3.0 (2.0-4.0)	3.0 (1.0-4.5)	3.0 (2.0-4.0)	3.5 (2.0-5.0)	2.5 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	3.5 (2.0-5.0)
MRMD severity on average[b]	3.0 (2-5.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)	2.0 (1.0-5.0)	3.0 (1.5-5.0)	4.0 (2.0-6.0)	1.0 (1.0-2.0)	4.0 (2.0-5.0)
MRMD w-scores[b,c] (mean±SD)	54.6±25.2	56.0±25.5	51.7±24.6	57.4±23.7	50.8±26.0	54.5±25.2	58.7±26.7	35.6±22.7	59.1±22.9
Impact of MSSs on daily life[a]	3.0 (2.0-6.0)	4.0 (2.0-6.0)	3.0 (2.0-6.0)	4.0 (2.0-6.0)	3.0 (2.0-5.0)	3.0 (1.0-5.0)	3.0 (2.0-6.0)	3.0 (1.0-5.0)	3.5 (2.0-6.0)
Emotional impact of MSSs[a]	3.0 (1.0-6.0)	3.0 (1.0-6.0)	3.0 (1.0-6.0)	4.0 (2.0-6.0)	2.0 (1.0-6.0)	2.0 (0.0-7.0)	3.0 (1.5-6.0)	1.0 (0.0-3.5)	3.5 (2.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those reporting musculoskeletal symptoms in the last 7 days. [b]ratings were only made by those reporting music-related musculoskeletal disorders in the last 7 days. [c]w-scores were derived from Rasch analysis (Appendix 2.10).

Table A1.4.19: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences among symptomatic professional musicians, and sub-groups of professionals

	All professional	Self-employed	Employed	Education	Performance	Opera	Orchestra	Military	Other
Work/ study									
Changes to work/ study	13.5 (9.3-19.3)	12.9 (7.6-21.0)	13.9 (9.2-20.4)	17.7 (10.7-27.8)	12.6 (7.6-20.2)	3.7 (0.5-22.4)	17.1 (7.8-33.4)	7.7 (2.5-21.5)	19.5 (10.0-34.6)
Changes from musical work/ study	9.5 (6.0-14.9)	9.1 (4.8-16.6)	10.3 (6.3-16.4)	13.3 (7.3-23.1)	9.1 (4.9-16.1)	3.7 (0.5-22.4)	14.7 (6.2-31.0)	5.1 (1.3-18.5)	12.5 (5.3-26.9)
Leave from work/ study	21.6 (16.2-28.2)	22.8 (15.6-32.0)	22.5 (16.5-29.9)	21.5 (13.8-32.0)	20.7 (14.1-29.3)	18.5 (7.9-37.7)	20.0 (9.8-36.6)	15.4 (7.0-30.4)	26.8 (15.4-42.4)
Leave from musical work/ study	15.9 (11.3-22.0)	18.0 (11.6-26.8)	18.2 (12.8-25.3)	20.5 (12.9-31.0)	14.5 (9.1-22.5)	7.4 (1.8-25.5)	20.0 (9.8-36.6)	12.8 (5.4-27.5)	17.5 (8.5-32.6)
Workers' compensation	4.3 (2.1-8.3)?	3.0 (0.9-8.9)	5.4 (2.7-10.4)	5.2 (1.9-13.1)	4.5 (1.9-10.4)	3.7 (0.5-22.4)	8.6 (2.8-23.6)	2.6 (0.4-16.3)	0.0
Musical workers' compensation	2.7 (1.1-6.4)	1.0 (0.1-6.8)	3.4 (1.4-7.9)	2.6 (0.6-9.9)	3.6 (1.3-9.3)	0.0	8.6 (2.8-23.6)	2.6 (0.4-16.3)	0.0
Consulting a health professional	69.8 (62.9-76.0)	76.0 (66.8-83.2)	67.7 (59.9-74.7)	70.4 (59.5-79.3)	68.4 (59.3-76.3)	74.1 (54.5-87.2)	61.1 (44.4-75.6)	65.0 (49.1-78.2)	69.8 (54.5-81.7)
Medical professional	41.6 (34.7-48.9)	43.6 (34.2-53.4)	39.7 (32.2-47.8)	45.6 (34.9-56.7)	37.8 (29.3-47.2)	37.0 (21.1-56.4)	37.1 (22.8-54.1)	33.3 (20.3-49.5)	43.9 (29.6-59.3)
Psychologist/ counsellor	5.4 (2.9-9.8)	5.0 (2.1-11.4)	6.6 (3.6-11.9)	5.1 (1.9-12.8)	8.1 (4.2-14.9)	11.1 (3.6-29.6)	11.4 (4.3-27.0)	5.1 (1.3-18.5)	9.8 (3.7-23.4)
Physiotherapist/ occupational therapist	40.0 (33.2-473)	50.5 (40.8-60.2)	41.1 (33.5-49.1)	40.5 (30.2-51.7)	40.5 (31.8-50.0)	55.6 (36.7-72.9)	45.7 (30.1-62.2)	28.2 (16.3-44.3)	41.5 (27.4-57.0)
Personal trainer/ Pilates instructor/ yoga instructor	17.3 (12.5-23.5)	18.8 (12.3-27.7)	17.2 (12.0-24.1)	17.7 (10.7-27.8)	18.9 (12.6-27.4)	18.5 (7.9-37.7)	14.3 (6.0-30.2)	17.9 (8.7-33.3)	22.0 (11.8-37.2)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	30.8 (24.5-37.9)	29.7 (21.6-39.4)	31.8 (24.8-39.7)	35.4 (25.7-46.6)	32.4 (24.3-41.7)	25.9 (12.8-45.5)	20.0 (9.8-36.6)	41.0 (26.8-57.0)	36.6 (23.3-52.3)
Naturopath/ homeopath	4.3 (2.2-8.4)	5.9 (2.7-12.7)	4.6 (2.2-9.4)	7.6 (3.4-16.0)	2.7 (0.9-8.1)	3.7 (0.5-22.4)	2.9 (0.4-18.0)	2.6 (0.4-16.3)	4.9 (1.2-17.7)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	4.3 (2.2-8.4)	5.9 (2.7-12.7)	5.3 (2.7-10.3)	7.6 (3.4-16.0)	5.4 (2.4-11.6)	7.4 (1.8-25.5)	8.6 (2.8-23.6)	2.6 (0.4-16.3)	4.9 (1.2-17.7)
Other	3.8 (1.8-7.8)	5.9 (2.7-12.7)	4.0 (1.8-8.6)	7.6 (3.4-16.0)	4.5 (1.9-10.4)	11.1 (3.6-29.6)	5.7 (1.4-20.4)	2.6 (0.4-16.3)	0.0
Self-management	88.4 (82.9-92.2)	90.4 (83.0-94.8)	87.7 (81.5-92.1)	88.9 (79.9-94.1)	87.7 (80.3-92.6)	100.0	91.7 (76.9-97.3)	80.0 (64.7-89.7)	88.4 (74.8-95.1)
Medication	42.2 (35.2-49.4)	45.5 (36.1-55.4)	41.1 (33.5-49.1)	43.0 (32.5-54.2)	40.5 (31.8-50.0)	51.9 (33.4-69.8)	37.1 (22.8-54.1)	43.6 (29.0-59.4)	34.1 (21.3-49.9)
Heat/ ice	43.8 (36.8-51.1)	46.5 (37.0-56.3)	44.4 (36.6-52.4)	50.6 (39.7-61.5)	42.3 (33.4-51.8)	33.3 (18.2-52.9)	42.9 (27.6-59.6)	41.0 (26.8-57.0)	43.9 (29.6-59.3)
Exercises/ stretches	82.2 (75.9-87.1)	86.1 (77.9-91.6)	83.4 (76.6-88.6)	88.6 (79.5-94.0)	82.9 (74.6-88.8)	96.3 (77.6-99.5)	88.6 (73.0-95.7)	74.4 (58.4-85.7)	85.4 (70.9-93.3)
Braces/ strapping/ taping	23.8 (18.2-30.5)	25.7 (18.1-35.2)	23.2 (17.1-30.6)	22.8 (14.8-33.4)	23.4 (16.4-32.3)	18.5 (7.9-37.7)	14.3 (6.0-30.2)	17.9 (8.7-33.3)	31.7 (19.3-47.4)
Other	7.6 (4.5-12.4)	7.9 (4.0-15.1)	7.3 (4.1-12.7)	5.1 (1.9-12.8)	9.0 (4.9-16.0)	7.4 (1.8-25.5)	8.6 (2.8-23.6)	7.7 (2.5-21.5)	12.2 (5.1-26.3)
Consulting other musicians	25.1 (19.4-32.0)	29.7 (21.6-39.4)	26.8 (20.3-34.6)	37.2 (27.2-48.4)	18.9 (12.6-27.4)	14.8 (5.6-33.7)	22.9 (11.8-39.7)	2.6 (0.4-16.3)	34.1 (21.3-49.9)
Current treatment	40.1 (32.7-48.0)	45.6 (35.5-56.0)	39.4 (31.2-48.2)	48.4 (36.4-60.6)	39.6 (30.2-49.8)	47.8 (28.6-67.7)	39.3 (23.1-58.2)	21.6 (11.1-37.9)	55.9 (39.0-71.5)

Notes: the denominator was all musicians who reported musculoskeletal symptoms in the last 12 months, except for 'current treatment' where the denominator was the musicians who reported musculoskeletal symptoms in the last 7 days.

A1.4.2 Sub-group comparisons

The findings presented here informed Question 3; the comparison of musculoskeletal symptom outcomes between sub-groups of musicians. Musicians who were both student and professionals, self-employed and employed, or employed by education and performance organisations were classified as ‘both’, with each of these comparisons investigating three groups (e.g. students only, professionals only, and both students and professionals).

A1.4.2.1: Comparison between university music students and professional musicians

Table A1.4.20: Comparison of demographics of university music students only, professional musicians only and both university music students and professional musicians

	Student only (n=92)	Professional only (n=151)	Both student & professional (n=74)	p-value
Age in years (median, IQR)	20.0 (18.0-22.0)	46.0 (36.0-60.0)	20.0 (19.0-23.0)	<0.001***
Female (%)	52.2	53.3	63.5	0.278
Male (%)	47.8	46.0	36.5	
Other (%)	0.0	0.7	0.0	
Body mass index (median, IQR)	22.2 (19.2-25.0)	25.7 (22.9-28.4)	23.2 (21.3-25.5)	<0.001***
Typical daily sitting time (%)				0.036*
<4 hours	11.3	25.3	18.9	
4-8 hours	48.9	52.0	60.8	
8+ hours	37.0	22.7	20.3	
Socioeconomic status[a] (%)				0.005**
1	27.0	26.2	16.4	
2	32.6	18.1	27.4	
3	27.0	21.5	27.4	
4	13.5	34.2	28.8	
Number of employers in the last 12 months (median, IQR)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	3.0 (2.0-4.0)	<0.001***
Number of employers in the last 7 days (median, IQR)	0.0 (0.0-1.0)	1.0 (1.0-2.0)	1.0 (1.0-2.0)	<0.001***
Hours worked in the last 7 days (median, IQR)	0.0 (0.0-7.0)	16.0 (5.0-35.5)	10.0 (2.0-15.0)	<0.001***
Age (in years) they started their musical activities (median, IQR)	8.0 (6.0-11.0)	8.0 (6.0-11.0)	7.5 (5.0-10.0)	0.190
Years of musical activity (median, IQR)	12.0 (9.0-15.0)	38.0 (29.0-51.0)	13.0 (11.0-17.0)	<0.001***
Amount of musical activity in the last 7 days (%)				0.001**
0-10 hours	33.7	44.4	21.9	
10-20 hours	35.9	28.5	26.0	
20 or more hours	30.4	27.2	52.1	
Performed in the last 12 months (%)	88.9	87.7	97.2	0.037*
Performed in the last 7 days (%)	59.1	50.0	63.9	0.119
Musical biomechanical exposure in the last 12 months (%)				
Singing/ woodwind/ brass	68.2	62.4	77.8	0.069
Singing	55.1	37.5	52.8	0.014*
Brass	12.5	18.4	19.4	0.394
Woodwind	27.3	22.5	31.9	0.325
Flute	10.2	10.6	18.1	0.253
Reed	20.5	14.8	20.8	0.414
Saxophone	17.1	11.3	13.9	0.465
Upper string	10.1	13.4	22.2	0.094
Hands elevated at shoulder level to play	43.8	51.4	65.3	0.023*
Repetitive elbow movement to play	74.2	73.9	77.8	0.811
Repetitive finger flexion/ extension to play	94.3	90.8	91.7	0.609
Repetitive finger adduction/ abduction to play	79.6	64.5	70.8	0.049*
Repetitive foot movement to play	64.8	55.3	59.7	0.363

(continued)

	Student only (n=92)	Professional only (n=151)	Both student & professional (n=74)	p-value
Musical biomechanical exposure in the last 7 days (%)				
Singing/ woodwind/ brass	57.1	53.1	71.2	0.031*
Singing	42.4	25.7	46.6	0.002**
Brass	8.8	14.3	16.4	0.287
Woodwind	20.9	18.4	27.4	0.315
Flute	5.5	7.5	15.1	0.093
Reed	17.2	13.7	17.4	0.689
Saxophone	13.8	10.1	11.6	0.699
Upper string	9.3	12.2	20.0	0.145
Hands elevated at shoulder level to play	27.9	44.2	55.1	0.002**
Repetitive elbow movement to play	64.8	64.4	66.2	0.966
Repetitive finger flexion/ extension to play	89.5	87.7	88.6	0.913
Repetitive finger adduction/ abduction to play	75.6	56.8	65.7	0.015*
Repetitive foot movement to play	53.9	44.2	49.3	0.344
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)	40.0 (40.0-40.0)	40.0 (30.0-40.0)	0.101
Social support score[b] (median, IQR)	48.0 (36.0-59.0)	36.0 (35.0-59.0)	59.0 (35.0-71.0)	<0.001***
Psychological distress score[b] (median, IQR)	51.0 (40.0-60.0)	33.0 (19.0-46.0)	46.0 (33.0-55.0)	<0.001***
Psychosocial stress score[b] (median, IQR)	25.0 (20.0-37.0)	25.0 (12.0-30.0)	25.0 (12.0-30.0)	0.017*

Notes: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]using w-scores from the Rasch analysis (Appendices 2.11-2.14). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.21: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for university music students only, professional musicians only, and both university music students and professional musicians

	Students only	Professionals only	Both students & professionals
Overall	95.4 (88.3-98.3)	87.4 (80.9-91.9)	88.9 (79.3-94.4)
Combined regions			
Head/ orofacial	40.2 (30.4-50.9)	29.6 (22.6-37.6)	48.6 (37.3-60.1)
Upper limb	74.7 (64.5-82.8)	74.6 (66.8-81.1)	83.3 (72.9-90.3)
Neck/ trunk	79.3 (69.5-86.6)	76.1 (68.3-82.4)	76.4 (65.2-84.8)
Lower limb	35.6 (26.3-46.2)	47.2 (39.1-55.4)	31.9 (22.2-43.6)
Priority regions			
Neck	64.4 (53.8-73.7)	61.3 (53.0-68.9)	65.3 (53.6-75.4)
Shoulder	57.5 (46.9-67.4)	61.3 (53.0-68.9)	68.1 (56.4-77.8)
Wrist/ hand	57.5 (46.9-67.4)	43.7 (35.7-52.0)	56.9 (45.3-67.9)
Upper back	46.0 (35.8-56.5)	40.8 (33.0-49.1)	48.6 (37.3-60.1)
Lower back	57.5 (46.9-67.4)	52.1 (43.9-60.2)	54.2 (42.6-65.3)

Table A1.4.22: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between university music students only, professional musicians only, and both university music students and professional musicians for the 12 month prevalence of musculoskeletal symptoms

	Professional compared with students[a]	Both compared with students[a]	Both compared with professionals[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall	0.335 (0.109-1.024), p=0.055	0.230 (0.053-0.996), p=0.049*		
Combined regions				
Head/ orofacial	0.624 (0.356-1.092), p=0.099		2.252 (1.253-4.047), p=0.007**	
Lower limb	1.614 (0.932-2.793), p=0.087		0.525 (0.290-0.953), p=0.034*	
Priority regions				
Shoulder				
Wrist/ hand	0.574 (0.335-0.983), p=0.043*		1.707 (0.963-3.025), p=0.067	2.017 (0.902-4.509), p=0.088

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.23: The 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders for university music students only, professional musicians only, and both university music students and professional musicians

	Students only	Professionals only	Both students & professionals
Overall	49.4 (39.1-59.8)	60.1 (52.0-67.7)	60.3 (48.7-70.8)
Combined regions			
Head/ orofacial	13.6 (7.9-22.5)	13.7 (9.0-20.3)	25.7 (17.0-36.8)
Upper limb	43.2 (33.2-53.7)	50.0 (41.9-58.1)	54.1 (42.6-65.1)
Neck/ trunk	37.5 (28.0-48.1)	52.1 (43.9-60.1)	48.6 (37.5-60.0)
Lower limb	10.2 (5.4-18.5)	17.8 (12.4-24.9)	12.2 (6.4-21.8)
Priority regions			
Neck	27.3 (19.0-37.5)	39.0 (31.4-47.2)	40.5 (30.0-52.1)
Shoulder	28.4 (20.0-38.7)	37.7 (30.2-45.8)	44.6 (33.7-56.0)
Wrist/ hand	31.8 (22.9-42.3)	28.1 (21.4-35.9)	39.2 (28.7-50.7)
Upper back	22.7 (15.1-32.7)	26.7 (20.1-34.5)	35.1 (25.1-46.7)
Lower back	19.3 (12.3-28.9)	31.5 (24.5-39.5)	32.4 (22.7-43.9)

Table A1.4.24: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between university music students only, professional musicians only, and both university music students and professional musicians for the 12 month prevalence of music-related musculoskeletal disorders

	Professional compared with students[a]	Both compared with students[a]	Both compared with professionals[a]	
	Unadjusted	Unadjusted	Unadjusted	Adjusted
Combined regions				
Head/ orofacial		2.188 (0.981-4.877), p=0.056	2.176 (1.077-4.397), p=0.030*	
Neck/ trunk	1.810 (1.054-3.105), p=0.031*			
Priority regions				
Neck	1.708 (0.961-3.035), p=0.068	1.818 (0.940-3.417), p=0.076		
Shoulder		2.028 (1.057-3.892), p=0.033*		2.500 (0.981-6.371), p=0.055
Wrist/ hand			1.650 (0.915-2.977), p=0.096	2.771 (1.123-6.840), p=0.027*
Upper back		1.842 (0.924-3.672), p=0.083		
Lower back	1.921 (1.019-3.622), p=0.044*	2.005 (0.977-4.114), p=0.058		

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.25: The 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms for university music students only, professional musicians only, and both university music students and professional musicians

	Students only	Professionals only	Both
Overall	73.6 (63.6-81.7)	71.6 (63.8-78.3)	71.2 (59.8-80.5)
Chronic[a]	27.5 (19.3-37.6)	40.7 (33.0-48.9)	34.3 (24.1-46.1)
Chronic[a] of those with MSSs	37.3 (26.6-49.5)	57.3 (47.5-66.5)	49.0 (35.4-62.8)
Pain-moderate pain[b]	21.1 (12.3-33.6)	22.4 (15.2-31.8)	29.2 (18.0-43.5)
Combined regions			
Head/ orofacial	18.7 (11.9-28.1)	17.9 (12.5-25.1)	27.8 (18.6-39.2)
Upper limb	51.6 (41.4-61.7)	53.1 (44.9-61.1)	59.7 (48.0-70.4)
Neck/ trunk	52.7 (42.5-62.8)	54.5 (46.3-62.4)	50.0 (38.6-61.4)
Lower limb	18.7 (11.9-28.1)	26.9 (20.3-34.7)	16.7 (9.7-27.1)
Priority regions			
Neck	37.4 (28.0-47.7)	40.0 (32.3-48.2)	33.3 (23.4-45.0)
Shoulder	30.8 (22.1-41.0)	40.7 (33.0-48.9)	44.4 (33.4-56.1)
Wrist/ hand	33.0 (24.1-43.3)	24.8 (18.5-43.5)	36.1 (25.9-47.8)
Upper back	28.6 (20.2-38.7)	24.1 (17.8-31.8)	30.6 (21.0-42.1)
Lower back	37.4 (28.0-47.7)	35.9 (28.5-44.0)	34.7 (24.6-46.4)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain ratings on average of 5-10 on an 11-point numeric rating scale.

Table A1.4.26: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between university music students only, professional musicians only, and both university music students and professional musicians for the 7 day prevalence of musculoskeletal symptoms

	Professional compared with students[a]		Both compared with students[a]		Both compared with professionals[a]	
	Unadjusted	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Overall						
Chronic[b]	1.811 (1.027-3.193), p=0.040*					
Chronic[b] of those with MSSs	2.253 (1.199-4.232), p=0.012*					
Moderate-severe pain[c]		0.158 (0.036-0.694), p=0.015*		5.145 (1.437-18.421), p=0.012*		
Combined regions						
Head/ orofacial					1.760 (0.903-3.433), p=0.097	
Neck/ trunk		2.555 (1.085-6.016), p=0.032*				0.430 (0.188-0.987), p=0.046*
Lower limb					0.544 (0.265-1.117), p=0.097	
Priority regions						
Shoulder			1.800 (0.947-3.426), p=0.073			
Wrist/ hand		0.396 (0.148-1.062), p=0.066			1.711 (0.929-3.152), p=0.085	3.202 (1.255-8.168), p=0.015*

Notes: MSS: musculoskeletal symptom. [a]denotes the reference group. [b]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [c]ratings were made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to ratings of pain on average of 5-10 on an 11-point numeric rating scale. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.27: The 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for university music students only, professional musicians only, and both university music students and professional musicianss

	Students only	Professional only	Both students & professionals
Overall	33.7 (24.6-44.1)	42.5 (34.7-50.6)	44.6 (33.7-56.0)
Chronic[a]	13.5 (7.8-22.3)	29.0 (22.1-36.9)	29.7 (20.4-41.1)
Chronic[a] of those with MRMDs	40.0 (24.3-58.1)	67.2 (54.5-77.8)	66.7 (49.2-80.5)
Combined regions			
Head/ orofacial	6.7 (3.1-14.2)	9.6 (5.7-15.6)	15.1 (8.5-25.2)
Upper limb	27.0 (18.8-37.1)	32.2 (25.1-40.2)	37.0 (26.7-48.6)
Neck/ trunk	20.2 (13.1-29.9)	32.9 (25.7-40.9)	37.0 (26.7-48.6)
Lower limb	5.7 (2.4-13.0)	11.6 (7.3-18.0)	8.2 (3.7-17.2)
Priority regions			
Neck	13.5 (7.8-22.3)	22.6 (16.5-30.1)	24.7 (16.1-35.8)
Shoulder	16.9 (10.4-26.1)	24.0 (17.7-31.6)	30.1 (20.7-41.6)
Wrist/ hand	18.0 (11.3-27.4)	17.1 (11.8-24.1)	23.3 (15.0-34.4)
Upper back	13.5 (7.8-22.3)	17.8 (12.4-24.9)	23.3 (15.0-34.4)
Lower back	14.6 (8.7-23.6)	16.4 (11.3-23.4)	21.9 (13.9-32.9)

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to music-related musculoskeletal disorders on most days for at least the last 3 months

Table A1.4.28: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between university music students only, professional musicians only, and both university music students and professional musicians for the 7 day prevalence of music-related musculoskeletal disorders

	Professional compared with students[a]		Both compared with students[a]		Both compared with professionals[a]
	Unadjusted	**Adjusted**	**Unadjusted**	**Adjusted**	**Adjusted**
Overall					
Chronic[b]	2.617 (1.291-5.302), p=0.008*		2.715 (1.236-5.960), p=0.013*	2.558 (1.092-5.992), p=0.031*	
Chronic[b] if MRMDs	3.075 (1.244-7.602), p=0.015*		3.000 (1.073-8.389), p=0.036*		3.305 (0.873-12.520), p=0.079
Combined regions					
Head/ oral			2.454 (0.861-6.997), p=0.093		
Neck/ trunk	1.932 (1.037-3.598), p=0.019*		2.315 (1.147-4.673), p=0.019*		2.442 (0.916-6.510), p=0.074
Priority regions					
Neck	1.874 (0.911-3.855), p=0.088		2.100 (0.936-4.712), p=0.072		
Shoulder			2.128 (1.008-4.492), p=0.048*		
Wrist/ hand		0.348 (0.110-1.100), p=0.072			3.071 (1.053-8.959), p=0.040*
Lower back					2.834 (0.965-8.323), p=0.058

Notes: MRMD: music-related musculoskeletal disorder. [a]denotes the reference group. [b]chronic refers to music-related musculoskeletal disorders experienced on most days for at least the last 3 months. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.29: Musculoskeletal symptom outcome ratings for university music students only, professional musicians only, and both university music students and professional musicians who reported musculoskeletal symptoms in the last 7 days

	Students only	Professionals only	Both students & professionals
Pain intensity on average[a] (median, IQR)	2.0 (1.0-4.0)	3.0 (2.0-4.0)	3.0 (2.0-5.0)
MRMD severity on average[b] (median, IQR)	3.0 (2.0-5.0)	2.0 (1.0-5.0)	4.5 (2.0-5.0)
MRMD severity w-scores[c] (mean±SD)	53.1±25.9	51.9±26.9	60.1±20.4
Impact of MSSs on daily life[a] (median, IQR)	3.0 (2.0-5.0)	3.5 (2.0-6.0)	3.0 (2.0-6.0)
Emotional impact of MSSs[a] (median, IQR)	4.0 (1.0-7.0)	2.0 (1.0-5.0)	4.0 (1.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [b]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days. [c]w-scores were derived from the Rasch analysis (Appendix 2.10).

Table A1.4.30: Beta coefficients (95% confidence intervals) for the comparisons of ratings between university music students only, professional musicians only, and both university music students and professional musicians with musculoskeletal symptoms in the last 7 days

Ratings	Professional compared with students[a]		Both compared with professionals[a]
	Unadjusted	**Adjusted**	**Adjusted**
MRMD severity W-scores[b]		-23.540 (-43.244- -3.835), p=0.020*	25.081 (7.854-42.308), p=0.005**
Emotional impact of MSSs[c]	-0.510 (-1.054-0.035), p=0.066	-0.889 (-1.809-0.011), p=0.053	

Notes: MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. Comparison of the pain intensity ratings were reported in Table 1.4.16. [a]denotes the reference group. [b]ratings were only made by those who experienced music-related musculoskeletal disorders in the last 7 days, and w-scores were derived from the Rasch analysis (Appendix 2.10). [c]ratings were made by those who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.4.31: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences for symptomatic university music students only, professional musicians only, and both university music students and professional musicians

	Students only	Professionals only	Both students & professionals
Work/ study in the last 12 months			
Changes to work/ study	21.3 (13.6-31.6)	10.6 (6.2-17.4)	19.4 (11.3-31.1)
Musical changes to work/ study	14.9 (8.4-24.9)	7.6 (4.0-14.0)	13.3 (6.8-24.5)
Leave from work/ study	21.3 (13.6-31.6)	18.7 (12.7-26.6)	27.4 (17.7-39.8)
Musical leave from work/ study	15.2 (8.8-24.9)	14.0 (8.9-21.5)	19.7 (11.5-31.6)
Consulting a health professional in the last 12 months	54.2 (43.4-64.6)	70.4 (61.8-77.8)	68.8 (56.4-78.9)
Medical professional	32.5 (23.1-43.5)	41.5 (33.1-50.4)	41.9 (30.3-54.5)
Psychologist/ counsellor	7.5 (3.4-15.8)	6.5 (3.3-12.5)	3.2 (0.8-12.1)
Physiotherapist/ occupational therapist	22.5 (14.6-33.0)	39.0 (30.8-47.9)	41.9 (30.3-54.5)
Personal trainer/ Pilates instructor/ yoga instructor	6.3 (2.6-14.2)	17.1 (11.4-24.8)	17.7 (10.1-29.3)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	17.5 (10.6-27.5)	31.7 (24.1-40.5)	29.0 (19.1-41.5)
Naturopath/ homeopath	1.3 (0.2-8.4)	3.3 (1.2-8.4)	6.5 (2.4-16.0)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	1.3 (0.2-8.4)	2.4 (0.8-7.3)	8.1 (3.4-18.0)
Other	2.5 (0.6-9.5)	4.9 (2.2-10.5)	1.6 (0.2-10.7)
Self-management in the last 12 months	79.5 (69.4-86.9)	88.0 (81.0-92.6)	89.1 (78.7-94.7)
Medication	28.8 (19.9-39.6)	48.8 (40.0-57.6)	29.0 (19.1-41.5)
Heat/ ice	38.8 (28.7-49.8)	44.7 (36.1-53.6)	41.9 (30.3-54.5)
Exercises/ stretches	71.3 (60.4-80.1)	81.3 (73.4-87.3)	83.9 (72.5-91.1)
Braces/ strapping/ taping	18.8 (11.6-28.9)	19.5 (13.4-27.5)	32.3 (21.8-44.8)
Other	3.8 (1.2-11.0)	9.8 (5.6-16.4)	3.2 (0.8-12.1)
Consulting other musicians in the last 12 months	30.4 (21.2-41.4)	12.4 (7.6-19.6)	50.0 (37.8-62.2)
Current treatment	16.7 (9.4-27.7)	37.7 (29.0-47.4)	45.1 (32.1-58.9)

Notes: The denominator for all prevalence estimates was the number of musicians reporting musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the number of musicians reporting musculoskeletal symptoms in the last 7 days was used.

Table A1.4.32: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between university music students only, professional musicians only, and both university music students and professional musicians for the musculoskeletal consequences

	Professional compared with students[a]		Both compared with students[a]		Both compared with professionals[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Changes to work/ study	0.438 (0.200-0.961), p=0.039*					
Changes to musical work/ study		0.235 (0.054-1.031), p=0.055				
Consult any health professional	2.008 (1.127-3.579), p=0.018*		1.858 (0.939-3.676), p=0.075			
Consult a musician	0.324 (0.157-0.668), p=0.002**		2.292 (1.148-4.574), p=0.019*	1.999 (0.958-4.173), p=0.065	7.067 (3.389-14.737), p<0.001***	4.527 (1.578-12.985), p=0.005**
Current treatment	3.030 (1.421-6.461), p=0.004**		4.107 (1.755-9.614), p=0.001**	2.509 (0.924-6.814), p=0.071		4.105 (1.418-11.886), p=0.009**

Notes: [a]denotes the reference group. The sample referred to musicians who reported experiencing musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the sample was musicians who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. The type of treatment (e.g. chiropractor, medication, exercises/ stretches) were not compared. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

A1.4.2.2: Comparison between sub-groups of university music students

Table A1.4.33: Demographic information for the different types of university music students

	Of the students			Of the performance students		
	Performance (n=122)	**Non-performance (n=40)**	**p-value**	**Classical (n=46)**	**Non-classical (n=56)**	**p-value**
Age in years (median, IQR)	20.0 (19.0-22.0)	21.0 (20.0-24.0)	0.007*	20.0 (18.0-21.0)	20.0 (18.0-22.0)	0.584
Female (%)	60.7	47.6	0.143	71.7	51.8	0.111
Body mass index (median, IQR)	22.6 (20.1-25.3)	23.4 (21.9-26.0)	0.534	22.1 (19.3-25.2)	22.8 (20.1-25.1)	0.725
Typical daily sitting time (%)			0.365			0.474
<4 hours	17.2	11.9		19.6	17.9	
4-8 hours	51.6	64.3		45.7	57.1	
8+ hours	31.2	23.8		34.8	25.0	
Socioeconomic status[a] (%)			0.385			0.186
1	20.2	29.3		15.6	18.5	
2	30.3	29.3		40.0	20.4	
3	26.1	29.3		26.7	31.5	
4	23.5	12.5		17.8	29.6	
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	1.5 (1.0-3.0)	0.656	2.0 (1.0-3.0)	1.5 (1.0-3.0)	0.828
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)	1.0 (0.0-2.0)	0.874	1.0 (0.0-2.0)	0.5 (0.0-1.0)	0.242
Hours worked in the last 7 days (median, IQR)	4.0 (0.0-11.5)	2.0 (0.0-14.0)	0.518	1.3 (0.0-12.0)	2.5 (0.0-10.0)	0.696
Full time study (%)	91.0	87.8	0.555	89.1	94.6	0.312
Age (in years) they started their musical activities (median, IQR)	7.5 (6.0-10.0)	8.0 (6.0-10.0)	0.980	6.5 (5.0-10.0)	8.0 (6.5-11.0)	0.021*
Years of musical activity (median, IQR)	13.0 (10.0-15.0)	14.5 (11.0-17.5)	0.012*	13.0 (10.0-15.0)	12.0 (8.0-14.0)	0.050
Performed in the last 12 months (%)	96.7	80.0	0.002**	95.6	98.1	0.458
Performed in the last 7 days (%)	66.4	46.2	0.026*	75.0	63.6	0.228
Amount of musical activity in the last 7 days (%)			<0.001***			0.040*
0-10 hours	16.5	59.5		13.3	17.9	
10-20 hours	34.7	23.8		22.2	42.9	
20 or more hours	48.8	16.7		64.4	39.3	

(continued)

	Of the students			Of the performance students		
	Performance (n=122)	Non-performance (n=40)	p-value	Classical	Non-classical	p-value
Musical biomechanical exposure in the last 12 months (%)						
Singing/ woodwind/ brass	75.4	65.9	0.237	70.5	85.2	0.082
Singing	53.4	57.1	0.675	47.7	63.0	0.132
Brass	17.8	9.8	0.230	18.2	22.2	0.622
Woodwind	31.4	24.4	0.401	31.8	33.3	0.874
Flute	15.3	9.8	0.384	18.2	13.0	0.477
Reed	19.5	24.4	0.506	20.5	20.4	0.992
Saxophone	12.7	24.4	0.082	9.1	18.5	0.193
Upper string	11.9	24.4	0.058	15.9	5.6	0.106
Hands elevated at shoulder level to play	51.7	56.1	0.627	65.9	42.6	0.023*
Repetitive elbow movement to play	74.6	78.1	0.656	79.6	68.5	0.222
Repetitive finger flexion/ extension to play	95.8	85.4	0.033*	95.5	94.4	0.821
Repetitive finger adduction/ abduction to play	75.4	75.6	0.981	72.7	72.2	0.956
Repetitive foot movement to play	62.7	61.0	0.843	61.4	61.1	0.980
Musical biomechanical exposure in the last 7 days (%)						
Singing/ woodwind/ brass	69.4	48.8	0.019*	62.2	76.8	0.114
Singing	46.3	40.5	0.515	37.8	51.8	0.162
Brass	13.2	9.8	0.561	11.1	17.9	0.347
Woodwind	27.3	14.6	0.108	24.4	30.4	0.510
Flute	11.6	4.9	0.229	13.3	10.7	0.687
Reed	17.7	17.1	0.945	11.4	21.8	0.177
Saxophone	11.8	17.1	0.408	4.6	20.0	0.038*
Upper string	10.9	22.9	0.077	15.9	5.5	0.100
Hands elevated at shoulder level to play	37.3	48.6	0.233	45.5	31.5	0.158
Repetitive elbow movement to play	65.6	63.4	0.805	68.9	58.2	0.271
Repetitive finger flexion/ extension to play	91.6	85.4	0.062	90.9	92.7	0.742
Repetitive finger adduction/ abduction to play	71.4	68.6	0.744	68.2	70.9	0.769
Repetitive foot movement to play	53.7	46.3	0.415	51.1	51.8	0.946
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)	40.0 (30.0-40.0)	0.375	40.0 (30.0-40.0)	40.0 (30.0-40.0)	0.498
Social support score[b] (median, IQR)	59.0 (36.0-71.0)	48.0 (35.0-59.0)	0.161	53.5 (35.0-59.0)	59.0 (36.0-78.0)	0.325
Psychological distress score[b] (median, IQR)	51.0 (33.0-60.0)	46.0 (33.0-55.0)	0.413	51.0 (33.0-60.0)	46.0 (33.0-55.0)	0.225
Psychological stress score[b] (median, IQR)	25.0 (12.0-37.0)	25.0 (12.0-37.0)	0.739	25.0 (12.0-37.0)	25.0 (12.0-30.0)	0.435

Notes: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]scores refer to the w-scores from the Rasch analysis (Appendices 2.11-2.14). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.34: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms among university music students

	Performance	Non-performance	Classical performance	Non-classical performance
Overall	94.0 (87.8-97.1)	87.8 (73.7-94.9)	90.9 (77.9-96.6)	96.2 (85.9-99.1)
Combined regions				
Head/ orofacial	46.6 (37.6-55.7)	39.0 (25.4-54.6)	43.2 (29.3-58.2)	50.9 (37.6-64.2)
Upper limb	81.0 (72.8-87.2)	73.2 (57.6-84.5)	77.3 (62.5-87.4)	81.1 (68.2-89.6)
Neck/ trunk	77.6 (69.0-84.3)	80.5 (65.4-90.0)	72.7 (57.7-83.9)	84.9 (72.4-92.3)
Lower limb	30.2 (22.5-39.2)	43.9 (29.6-59.3)	31.8 (19.7-47.0)	28.3 (17.7-42.0)
Priority regions				
Neck	65.5 (56.4-73.6)	65.9 (50.2-78.7)	61.4 (46.2-74.6)	73.6 (60.0-83.8)
Shoulder	63.8 (54.6-72.1)	58.5 (43.0-72.5)	68.2 (53.0-80.3)	60.4 (46.6-82.7)
Wrist/ hand	57.8 (48.5-66.5)	58.5 (43.0-72.5)	56.8 (41.8-70.7)	52.8 (39.3-65.9)
Upper back	45.7 (36.8-54.9)	51.2 (36.2-66.1)	34.1 (21.6-49.3)	56.6 (42.9-69.3)
Lower back	55.2 (46.0-64.0)	58.5 (43.0-72.5)	45.5 (31.4-60.3)	66.0 (52.2-77.6)

Table 1.4.35: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) differences between the types of university music students regarding the 12 month prevalence of musculoskeletal symptoms

	Non-classical performance compared with classical performance[a]	
	Unadjusted	Adjusted
Upper back	2.522 (1.103-5.765), p=0.028*	2.372 (1.022-5.507), p=0.044*
Lower back	2.333 (1.026-5.307), p=0.043*	2.341 (1.006-5.448), p=0.048*

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. There were no significant or near-significant differences between performance and non-performance students, hence they were omitted from the table. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.36: The 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders among the sub-groups of university music students

	Performance	Non-performance	Classical performance	Non-classical performance
Overall	58.7 (49.6-67.2)	43.2 (28.3-59.5)	65.2 (50.4-77.6)	49.1 (36.1-62.2)
Combined region				
Head/ orofacial	20.7 (14.3-28.9)	15.4 (7.0-30.4)	26.1 (15.3-40.7)	16.4 (8.7-28.7)
Upper limb	52.9(43.9-61.7)	35.9 (22.5-52.0)	60.9 (46.1-73.9)	43.6 (31.1-57.0)
Neck/ trunk	43.0 (34.4-52.0)	43.6 (29.0-59.4)	43.5 (29.9-58.1)	41.8 (29.5-55.3)
Lower limb	9.9 (5.7-16.7)	15.4 (7.0-30.4)	13.0 (5.9-26.3)	5.5 (1.7-15.8)
Priority regions				
Neck	34.7 (26.7-43.7)	30.8 (18.3-46.9)	41.3 (28.0-56.0)	32.7 (21.6-46.2)
Shoulder	38.8 (30.5-47.9)	28.2 (16.3-44.2)	47.8 (33.8-62.2)	32.7 (21.6-46.2)
Wrist/ hand	38.8 (30.5-47.9)	25.6 (14.3-41.6)	47.8 (33.8-62.2)	30.9 (20.0-44.4)
Upper back	27.3 (20.0-35.9)	33.3 (20.4-49.4)	19.6 (10.4-33.7)	29.1 (18.5-42.5)
Lower back	28.1 (20.8-36.8)	17.9 (8.8-33.3)	28.3 (17.1-43.0)	25.5 (15.6-38.7)

Table A1.4.37: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) differences between the types of university music students regarding the 12 month prevalence of music-related musculoskeletal disorders

	Performance compared with non-performance students[a]		Non-classical performance compared with classical performance students[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall		2.338 (1.053-5.188), p=0.037*		0.456 (0.191-1.086), p=0.076
Combined regions				
Upper limb	2.005 (0.952-4.225), p=0.067	2.343 (1.003-5.477), p=0.049*	0.498 (0.224-1.104), p=0.086	0.490 (0.213-1.126), p=0.093
Priority regions				
Shoulder		2.262 (0.930-5.506), p=0.072		
Wrist/ hand			0.488 (0.216-1.101), p=0.084	0.469 (0.203-1.082), p=0.076

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.38: The 7 day prevalence (95% confidence interval) of musculoskeletal symptoms for the university music students sub-groups

	Performance	Non-performance	Classical performance	Non-classical performance
Overall	74.4 (65.8-81.4)	65.9 (50.2-78.7)	73.9 (59.3-84.7)	75.0 (61.9-84.7)
Chronic[a]	29.7 (22.1-38.6)	31.7 (19.3-47.4)	28.9 (17.5-43.8)	33.3 (22.0-47.0)
Chronic[a] of those with MSSs	40.2 (30.4-50.9)	48.1 (30.3-66.5)	39.4 (24.3-56.9)	45.0 (30.3-60.6)
Moderate-severe pain[b]	24.4 (16.0-35.2)	24.0 (11.0-44.4)	27.6 (14.2-46.6)	21.6 (11.1-38.0)
Combined regions				
Head/ orofacial	23.3 (16.6-31.8)	22.0 (11.8-37.2)	28.3 (17.1-43.0)	23.6 (14.2-36.7)
Upper limb	57.5 (48.4-66.1)	48.8 (33.9-63.8)	56.5 (41.9-70.1)	56.4 (43.0-68.9)
Neck/ Trunk	48.3 (39.5-57.3)	61.0 (45.4-74.6)	45.7 (31.8-60.2)	56.4 (43.0-68.9)
Lower limb	15.0 (9.6-22.6)	24.4 (13.6-39.8)	13.0 (5.9-26.3)	14.5 (7.4-26.7)
Priority regions				
Neck	35.0 (27.0-44.0)	39.0 (25.4-54.6)	32.6 (20.6-47.5)	41.8 (29.5-55.3)
Shoulder	37.5 (29.3-46.5)	34.1 (21.3-49.8)	39.1 (26.1-53.9)	38.2 (26.3-51.7)
Wrist/ hand	35.8 (27.7-44.9)	31.7 (19.3-47.4)	41.3 (28.0-56.0)	29.1 (18.5-42.5)
Upper back	30.0 (22.4-38.8)	26.8 (15.5-42.4)	30.4 (18.8-45.2)	30.9 (20.0-44.4)
Lower back	35.8 (27.7-44.9)	36.6 (23.3-52.3)	28.3 (17.1-43.0)	43.6 (31.1-57.0)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain ratings on average of 5-10 on an 11-point numeric rating scale.

There were no significant nor near-significant (p<0.10) differences between performance and non-performance students, and classical and non-classical students regarding the 7 day prevalence of music-related musculoskeletal disorders.

Table A1.4.39: 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders among the university music students sub-groups

	Performance	Non-performance	Classical performance	Non-classical performance
Overall	40.2 (31.8-49.2)	35.9 (22.5-52.0)	45.7 (31.8-60.2)	41.1 (28.9-54.4)
Chronic[a]	21.3 (14.9-29.5)	21.3 (10.5-36.1)	23.9 (13.7-38.4)	21.4 (12.5-34.2)
Chronic[a] if MRMDs	53.1 (39.1-66.6)	57.1 (31.5-79.5)	52.4 (31.6-72.4)	52.2 (32.3-71.4)
Combined regions				
Head/ orofacial	12.4 (7.6-19.6)	5.1 (1.3-18.5)	17.4 (8.9-31.3)	10.7 (4.8-22.0)
Upper limb	33.9 (26.0-42.8)	25.6 (14.3-41.6)	39.1 (26.1-53.9)	35.7 (24.2-49.1)
Neck/ trunk	28.1 (20.8-36.8)	28.2 (16.3-44.2)	30.4(18.8-45.2)	30.4 (19.7-43.7)
Lower limb	5.8 (2.8-11.8)	10.3 (3.9-24.5)	6.5 (2.1-18.6)	3.6 (0.9-13.6)
Priority regions				
Neck	19.0 (12.9-27.1)	17.9 (8.8-33.3)	21.7 (12.0-36.1)	19.6 (11.1-32.3)
Shoulder	24.0 (17.1-32.4)	20.5 (10.5-36.1)	28.3 (17.1-43.0)	23.2 (13.9-36.2)
Wrist/ hand	23.1 (16.4-31.5)	12.8 (5.4-27.5)	28.3 (17.1-43.0)	23.2 (13.9-36.2)
Upper back	17.4 (11.6-25.2)	20.5 (10.5-36.1)	15.2 (7.4-28.8)	19.6 (11.1-32.3)
Lower back	19.0 (12.9-27.1)	15.4 (7.0-30.4)	23.9 (13.7-38.4)	17.9 (9.8-30.3)

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to having music-related musculoskeletal disorders on most days for at least the last 3 months.

The only near-significant differences was between performance and non-performance students, where performance students had a higher prevalence of wrist/ hand music-related musculoskeletal disorders after adjusting for confounders (adjusted odds ratio 3.285, 95% confidence interval 0.951-11.348, p=0.060). There were no significant differences.

Table A1.4.40: Ratings of musculoskeletal symptom outcomes for sub-groups of university music students who reported musculoskeletal symptoms in the last 7 days

	Performance students	Non-performance students	Classical performance students	Non-classical performance students
Pain intensity on average[a] (median, IQR)	2.5 (2.0-4.0)	3.0 (1.0-4.0)	3.0 (2.0-5.0)	3.0 (2.0-4.0)
MRMD severity on average[b] (median, IQR)	3.5 (2.0-5.0)	3.5 (2.0-6.0)	5.0 (3.0-5.5)	3.0 (1.5-5.0)
MRMD severity W-scores[b,c] (mean±SD)	56.4±21.9	58.4±28.3	65.0±16.2	48.7±24.3
Impact of MSSs on daily life[a] (median, IQR)	3.0 (2.0-5.0)	5.0 (3.0-6.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)
Emotional impact of MSSs[a] (median, IQR)	3.0 (1.0-7.0)	5.0 (2.0-7.0)	4.0 (1.0-7.0)	3.0 (1.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal disorder. [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [b]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days.

Table A1.4.41: Beta coefficients (95% confidence interval) for the ratings made by sub-groups of symptomatic university music students

	Performance compared with non-performance students[a]	Non-classical performance compared with classical performance students[a]	
	Unadjusted	Unadjusted	Adjusted
MRMD severity w-scores[b]		-16.350 (-29.593- -3.107), p=0.017*	-17.296 (-30.265- -4.327), p=0.010*
Impact of MSSs on daily life[c]	-0.699 (-1.512-0.114), p=0.092		

Notes: MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal disorder. [a]denotes the reference group. [b]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days, with w-scores derived from the Rasch analysis (Appendix 2.10). [c]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.4.42: Prevalence (95% confidence interval) of musculoskeletal symptom consequences of sub-groups of symptomatic university music students

	Performance students	Non-performance students	Classical performance students	Non-classical performance students
Work/ study in the last 12 months				
Changes to work/ study	18.3 (11.9-27.0)	27.8 (15.6-44.5)	24.3 (13.1-40.8)	14.0 (6.8-26.8)
Musical changes to work/ study	13.0 (7.7-21.2)	18.8 (8.6-36.1)	17.1 (7.8-33.5)	12.0 (5.4-24.5)
Leave from work/ study	19.2 (12.7-28.0)	38.9 (24.5-55.6)	8.1 (2.6-22.6)	24.0 (14.1-37.9)
Musical leave from work/ study	16.5 (10.5-25.0)	20.0 (9.8-36.6)	5.6 (1.4-20.0)	22.0 (12.5-35.7)
Consulting a health professional in the last 12 months	56.9 (47.4-65.9)	75.0 (58.4-86.5)	60.0 (44.1-74.0)	58.8 (44.8-71.5)
Medical professional	32.7 (24.3-42.3)	50.0 (34.1-65.9)	32.4 (19.3-49.1)	36.0 (23.9-50.2)
Psychologist/ counsellor	3.8 (1.4-9.9)	11.1 (4.2-26.3)	2.7 (0.4-17.2)	6.0 (0.2-17.2)
Physiotherapist/ occupational therapist	30.8 (22.6-40.3)	33.3 (19.9-50.1)	32.4 (19.3-49.1)	30.0 (18.8-44.2)
Personal trainer/ Pilates instructor/ yoga instructor	9.6 (5.2-17.0)	16.7 (7.6-32.6)	8.1 (2.6-22.6)	14.0 (6.8-26.8)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	22.1 (15.1-31.2)	25.0 (13.5-41.6)	27.0 (15.1-43.6)	24.0 (14.1-37.9)
Naturopath/ homeopath	1.9 (0.5-7.4)	8.3 (2.7-23.0)	4.0 (1.0-14.9)	0.0
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	3.8 (1.4-9.9)	5.6 (1.4-19.9)	8.1 (2.6-22.6)	2.0 (0.3-13.2)
Other	2.9 (0.9-8.6)	0.0	2.7 (0.4-17.2)	2.0 (0.3-13.2)
Self-management in the last 12 months	80.7 (72.2-87.1)	94.4 (80.2-98.6)	80.0 (64.6-89.8)	82.4 (69.2-90.6)
Medication	26.0 (18.4-35.3)	36.1 (22.2-52.9)	13.5 (5.7-28.9)	28.0 (17.2-42.1)
Heat/ ice	40.4 (31.3-50.1)	41.7 (26.8-58.2)	37.8 (23.7-54.4)	40.0 (27.3-54.2)
Exercises/ stretches	76.0 (66.8-83.3)	80.6 (64.3-90.5)	81.1 (65.1-90.8)	76.0 (62.1-85.9)
Braces/ strapping/ taping	26.0 (18.4-35.3)	22.2 (11.5-38.7)	37.8 (23.7-54.4)	16.0 (8.1-29.1)
Other	4.8 (2.0-11.1)	0.0	2.7 (0.4-17.2)	2.0 (0.3-13.2)
Consulting other musicians in the last 12 months	44.2 (34.9-54.0)	25.7 (13.9-42.6)	48.6 (33.0-64.5)	40.0 (27.3-54.2)
Current treatment	54.5 (37.5-70.6)	37.0 (21.1-56.4)	33.3 (19.3-51.1)	26.8 (15.4-42.5)

Notes: The denominator for all prevalence estimates was the number of musicians reporting musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the number of musicians reporting musculoskeletal symptoms in the last 7 days was used.

Table A1.4.43: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) differences between the sub-groups of symptomatic university music students regarding the prevalence of musculoskeletal symptom consequences

	Performance compared with non-performance students[a]		Non-classical performance compared with classical performance students[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Leave	0.374 (0.163-0.857), p=0.020*		3.579 (0.931-13.766), p=0.064	7.073 (1.405-35.603), p=0.018*
Musical leave			4.795 (0.992-23.169), p=0.051	10.513 (1.440-76.756), p=0.020*
Health professional	0.440 (0.189-1.023), p=0.056	0.293 (0.106-0.814), p=0.019*		
Any self-management	0.246 (0.055-1.109), p=0.068	0.125 (0.023-0.663), p=0.015*		
Consult other musicians	2.291 (0.978-5.366), p=0.056			

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Only musicians who reported musculoskeletal symptoms in the last 12 months were included in the analysis. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1.000. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1.000. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

A1.4.2.3 Comparison between self-employed and employed professional musicians

Table A1.4.44: Demographic information for the self-employed, employed and 'both' groups of professional musicians

	Self-employed musicians (n=45)	Employed musicians (n=87)	Both self-employed & employed (n=96)	p-value
Age in years (median, IQR)	60.5 (20.0-69.5)	37.0 (21.0-46.0)	33.0 (21.5-48.0)	<0.001***
Female (%)	54.2	49.4	61.1	0.283
Body mass index (median, IQR)	26.0 (22.0-29.3)	24.9 (22.5-27.3)	23.8 (21.3-27.2)	0.580
Typical daily sitting time (%)				
<4 hours	20.8	25.8	19.8	0.449
4-8 hours	50.0	52.8	61.5	
8+ hours	29.2	21.4	18.8	
Socioeconomic status[a] (%)				0.642
1	24.4	24.4	21.1	
2	14.6	20.9	24.2	
3	31.7	19.8	23.2	
4	29.3	34.9	31.6	
Number of employers in the last 12 months (median, IQR)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	3.0 (2.0-4.0)	0.047*
Number of employers in the last 7 days (median, IQR)	1.0 (1.0-1.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	<0.001***
Hours worked in the last 7 days (median, IQR)	8.0 (3.0-20.0)	12.0 (3.0-32.0)	16.0 (8.0-29.0)	0.066
Currently studying music (%)	25.0	30.0	40.6	0.184
Age (in years) they started their musical activities (median, IQR)	8.0 (5.0-10.0)	8.0 (6.0-10.0)	7.0 (6.0-10.0)	0.810
Years of musical activity (median, IQR)	51.5 (15.0-61.5)	29.5 (14.5-40.0)	25.5 (15.0-40.5)	0.077
Performed in the last 12 months (%)	87.5	90.7	97.9	0.046*
Performed in the last 7 days (%)	33.3	56.0	65.6	0.016*
Amount of musical activity in the last 7 days (%)				<0.001***
0-10 hours	50.0	50.6	14.6	
10-20 hours	25.0	21.4	36.5	
20 or more hours	25.0	28.1	49.0	

(continued)

	Self-employed musicians (n=45)	Employed musicians (n=87)	Both self-employed & employed (n=96)	p-value
Musical biomechanical exposure in the last 12 months (%)				
Singing/ woodwind/ brass	39.1	74.1	70.7	0.007**
Singing	20.8	41.9	49.5	0.033*
Brass	8.7	25.9	17.4	0.114
Woodwind	25.0	31.8	20.7	0.240
Flute	16.7	15.3	10.9	0.607
Reed	12.5	22.4	14.1	0.285
Saxophone	4.2	18.8	9.8	0.068
Upper string	17.4	15.3	19.6	0.756
Hands elevated at shoulder level to play	34.8	67.1	59.1	0.021*
Repetitive elbow movement to play	82.6	71.8	79.4	0.376
Repetitive finger flexion/ extension to play	91.7	91.9	91.6	0.998
Repetitive finger adduction/ abduction to play	82.6	54.1	71.7	0.008**
Repetitive foot movement to play	65.2	48.2	59.8	0.184
Musical biomechanical exposure in the last 7 days (%)				
Singing/ woodwind/ brass	33.3	67.1	63.8	0.010*
Singing	20.8	29.6	40.0	0.119
Brass	8.3	23.9	10.6	0.029*
Woodwind	20.8	27.3	19.2	0.416
Flute	8.3	13.6	8.5	0.499
Reed	14.3	19.1	13.0	0.543
Saxophone	4.8	11.9	9.8	0.577
Upper string	13.6	13.1	18.5	0.595
Hands elevated at shoulder level to play	28.6	62.7	53.3	0.018*
Repetitive elbow movement to play	81.8	66.7	73.9	0.293
Repetitive finger flexion/ extension to play	90.9	85.5	89.1	0.688
Repetitive finger adduction/ abduction to play	77.3	46.4	63.0	0.011*
Repetitive foot movement to play	62.5	36.4	47.9	0.051
Job satisfaction score[b] (median, IQR)	40.0 (40.0-40.0)	40.0 (30.0-40.0)	40.0 (40.0-40.0)	0.691
Social support score[b] (median, IQR)	35.0 (15.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	0.009**
Psychological distress score[b] (median, IQR)	33.0 (19.0-51.0)	33.0 (19.0-46.0)	40.0 (19.0-51.0)	0.259
Psychosocial stress score[b] (median, IQR)	17.0 (5.0-25.0)	25.0 (17.0-25.0)	25.0 (5.0-30.0)	0.333

Notes: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]refer to w-scores from the Rasch analysis (Appendices 2.11-2.14). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.45: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for the self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed &employed
Overall	90.9 (69.9-97.7)	80.9 (71.3-87.8)	93.3 (85.9-97.0)
Combined regions			
Head/ orofacial	31.8 (15.9-53.5)	31.8 (22.9-42.3)	42.2 (32.4-52.7)
Upper limb	77.3 (55.5-90.3)	72.7 (62.5-81.0)	82.2 (72.9-88.8)
Neck/ trunk	63.6 (42.2-80.7)	72.7 (62.5-81.0)	83.3 (74.1-89.7)
Lower limb	40.9 (22.7-61.9)	39.8 (30.1-50.4)	41.1 (31.4-51.6)
All regions			
Neck	45.5 (26.4-66.0)	59.1 (48.5-68.9)	74.4 (64.4-82.4)
Shoulder	54.5 (34.0-73.6)	59.1 (48.5-68.9)	70.0 (59.7-78.6)
Wrist/ hand	40.9 (22.7-61.9)	39.8 (30.1-50.4)	54.4 (44.1-64.5)
Upper back	27.3 (12.7-49.1)	39.8 (30.1-50.4)	51.1 (40.8-61.3)
Lower back	50.0 (30.1-69.9)	48.9 (38.6-59.3)	58.9 (48.4-68.6)

Table A1.4.46: Odds ratio (95% confidence intervals) for the significant or near-significant (p<0.10) differences between the self-employed, employed and 'both' groups of professional musicians regarding the 12 months prevalence of musculoskeletal symptoms

	Both compared with self-employed only[a]		Both compared with employed only[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall			3.306 (1.238-8.830), p=0.017*	
Combined regions				
Neck/ trunk	2.857 (1.020-8.007), p=0.046*	2.924 (0.906-9.434), p=0.073	1.875 (0.907-3.876), p=0.090	
Priority regions				
Neck	3.496 (1.334-9.163), p=0.011*	3.747 (1.235-11.362), p=0.020*	2.017 (1.067-3.811), p=0.031*	2.396 (1.167-4.922), p=0.017*
Wrist/ hand			1.810 (0.998-3.282), p=0.051	
Upper back	2.788 (1.000-7.772), p=0.050	3.271 (1.012-10.570), p=0.048*		

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. There were no significant nor near-significant (p<0.100) differences between employed only and self-employed only musicians; hence these comparisons were omitted from the table. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.47: 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders for the self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed & employed
Overall	70.8 (50.0-85.5)	47.1 (36.9-57.6)	71.6 (61.7-79.8)
Combined regions			
Head/orofacial	8.3 (2.1-28.1)	13.8 (8.0-22.8)	25.5 (17.7-35.3)
Upper limb	62.5 (42.1-79.3)	36.8 (27.3-47.4)	62.8 (52.5-72.0)
Neck/ trunk	58.3 (38.2-76.0)	41.4 (31.5-52.0)	61.7 (51.5-71.0)
Lower limb	16.7 (6.4-37.1)	17.2 (10.6-26.7)	14.9 (9.0-23.7)
All regions			
Neck	41.7 (24.0-61.8)	27.6 (19.2-37.9)	52.1 (42.0-62.1)
Shoulder	37.5 (20.7-57.9)	28.7 (20.2-39.1)	53.2 (43.1-63.1)
Wrist/ hand	45.8 (27.4-65.5)	20.7 (13.4-30.5)	37.2 (28.0-47.5)
Upper back	33.3 (17.6-54.0)	20.7 (13.4-30.5)	39.4 (30.0-49.6)
Lower back	33.3 (17.6-54.0)	28.7 (20.2-39.1)	38.3 (29.0-48.5)

Table A1.4.48: Odds ratio (95% confidence intervals) for the significant or near-significant (p<0.10) differences between the self-employed, employed and 'both' groups of professional musicians regarding the 12 month prevalence of music-related musculoskeletal disorders

	Employed only compared with self-employed only[a]		Both compared with self-employed only[a]	Both compared with employed only[a]	
	Unadjusted	Adjusted	Unadjusted	Unadjusted	Adjusted
Overall	0.367 (0.138-0.974), p=0.04**			2.826 (1.530-5.217), p=0.001**	2.153 (1.108-4.186), p=0.024*
Combined regions					
Head/ orofacial			3.771 (0.825-17.243), p=0.087	2.143 (0.996-4.608), p=0.051	2.049 (0.935-4.489), p=0.073
Upper limb	0.349 (0.137-0.889), p=0.027*	0.252 (0.087-0.732), p=0.011*		2.897 (1.584-5.300), p=0.001**	2.598 (1.306-5.167), p=0.006**
Neck/ trunk				2.282 (1.258-4.141), p=0.007**	2.220 (1.212-4.066), p=0.010*
Priority regions					
Neck				2.858 (1.537-5.315), p=0.001**	2.973 (1.460-6.055), p=0.003*
Shoulder				2.818 (1.522-5.219), p=0.001**	2.984 (1.490-5.976), p=0.002**
Wrist/ hand	0.308 (0.119-0.802), p=0.016*	0.288 (0.104-0.798), p=0.017*		2.274 (1.168-4.428), p=0.016*	
Upper back				2.488 (1.282-4.831), p=0.007**	2.677 (1.298-5.518), p=0.008**

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.49: 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms in the self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed & employed
Overall	87.5 (67.5-95.9)	63.3 (52.9-72.7)	77.4 (67.8-84.8)
Chronic[a]	45.8 (27.4-65.5)	31.8 (22.9-42.3)	43.8 (33.9-54.3)
Chronic[a] of those with MSSs	52.4 (31.7-72.2)	50.9 (37.9-63.8)	57.4 (45.3-68.6)
Moderate-severe pain[b]	22.2 (8.5-46.7)	20.4 (11.6-33.3)	25.8 (16.6-37.7)
Combined regions			
Head/ orofacial	25.0 (11.6-45.8)	12.5 (7.0-21.2)	28.6 (20.2-38.7)
Upper limb	66.7 (46.0-82.4)	50.0 (39.6-60.4)	58.2 (47.8-68.0)
Neck/ trunk	54.2 (34.5-72.6)	46.6 (36.4-57.1)	62.6 (52.2-72.0)
Lower limb	33.3 (17.6-54.0)	21.6 (14.2-31.5)	22.0 (14.6-31.7)
Priority regions			
Neck	37.5 (20.7-57.9)	28.4 (19.9-38.7)	49.5 (39.3-59.7)
Shoulder	50.0 (30.9-69.1)	38.6 (29.0-49.2)	45.1 (35.1-55.4)
Wrist/ hand	29.2 (14.5-50.0)	22.7 (15.1-32.7)	31.9 (23.1-42.2)
Upper back	25.0 (11.6-45.8)	22.7 (15.1-32.7)	30.8 (22.1-41.0)
Lower back	41.7 (24.0-61.8)	29.5 (20.9-39.9)	41.8 (32.0-52.2)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to ratings of pain on average of 5-10 on an 11-point numeric rating scale

Table A1.4.50: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between self-employed, employed and 'both' groups of professional musicians regarding the of 7 day prevalence of musculoskeletal symptoms

	Employed only compared with self-employed only[a]		Both compared with employed only[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall	0.247 (0.068-0.891), p=0.033*	0.198 (0.050-0.782), p=0.021*	1.985 (1.038-3.795), p=0.038*	
Combined regions				
Head/ orofacial		0.280 (0.082-0.952), p=0.042*	2.800 (1.286-6.099), p=0.010*	2.765 (1.232-6.207), p=0.014*
Neck/ trunk			1.922 (1.058-3.490), p=0.032*	1.715 (0.923-3.188), p=0.088
Priority regions				
Neck			2.465 (1.327-4.579), p=0.004**	2.177 (1.126-4.208), p=0.021*
Lower back			1.710 (0.921-3.175), p=0.090	1.765 (0.909-3.430), p=0.094

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. There were no significant or near-significant (p<0.100) differences between self-employed only and both groups; hence these comparisons were omitted from the table. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.51: The 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for the self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed & employed
Overall	58.3 (38.2-76.0)	29.9 (21.2-40.3)	55.3 (45.1-65.1)
Chronic[a]	43.5 (25.1-63.8)	21.8 (14.3-31.8)	34.0 (25.2-44.2)
Chronic[a] of those with MRMDs	76.9 (47.7-92.4)	69.2 (49.3-839)	61.5 (47.7-73.7)
Combined regions			
Head/ orofacial	8.3 (2.1-28.1)	8.0 (3.9-16.0)	16.1 (9.9-25.1)
Upper limb	45.8 (27.4-65.5)	21.8 (14.3-31.8)	44.1 (34.3-54.3)
Neck/ trunk	41.7 (24.0-61.8)	23.0 (15.3-33.0)	46.2 (36.3-56.4)
Lower limb	12.5 (4.1-32.5)	11.5 (6.3-20.1)	9.7 (5.1-17.6)
Priority regions			
Neck	29.2 (14.5-50.0)	11.5 (6.3-20.1)	34.4 (25.4-44.7)
Shoulder	29.2 (14.5-50.0)	17.2 (10.6-26.7)	35.5 (26.4-45.7)
Wrist/ hand	29.2 (14.5-50.0)	13.8 (8.0-22.8)	22.6 (15.2-32.2)
Upper back	20.8 (8.9-41.5)	12.6 (7.1-21.5)	26.9 (18.8-36.8)
Lower back	25.0 (11.6-45.8)	14.9 (8.9-24.1)	21.5 (14.3-31.1)

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to music-related musculoskeletal disorders on most days for at least the last 3 months.

Table A1.4.52: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between the self-employed, employed and 'both' groups of professional musicians regarding the 7 day prevalence of music-related musculoskeletal disorders

	Employed only compared with self-employed only[a]		Both compared with employed only[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall	0.304 (0.120-0.773), p=0.012*	0.297 (0.105-0.837), p=0.022*	2.905 (1.573-5.363), p=0.001**	2.382 (1.198-4.734), p=0.013*
Chronic[b]	0.363 (0.138-0.957), p=0.040*	0.380 (0.131-1.099), p=0.074	1.847 (0.951-3.588), p=0.070	1.849 (0.904-3.780), p=0.092
Combined regions				
Head/ orofacial				2.696 (0.905-8.032), p=0.075
Upper limb	0.330 (0.128-0.854), p=0.022*	0.329 (0.102-1.058), p=0.062	2.822 (1.469-5.421), p=0.002**	2.264 (1.062-4.826), p=0.034*
Neck/ trunk	0.418 (0.161-1.084), p=0.073	0.340 (0.117-0.998), p=0.047*	2.881 (1.512-5.489), p=0.001**	2.447 (1.197-5.004), p=0.014*
Priority regions				
Neck	0.315 (0.105-0.947), p=0.040*		4.039 (1.841-8.861), p<0.001***	2.491 (1.055-5.884), p=0.037*
Shoulder			2.640 (1.311-5.316), p=0.007**	
Wrist/ hand	0.389 (0.133-1.133), p=0.084			
Upper back			2.540 (1.163-5.547), p=0.019*	

Notes: [a]denotes the reference group. [b]chronic refers the experiencing music-related musculoskeletal disorders on most days for at least the last 3 months. Only odds ratios with p<0.100 are shown. There were no significant differences between the self-employed and 'both' groups, hence they were not included in the table. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.5.53: Musculoskeletal symptom outcome ratings made by symptomatic self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed & employed
Pain intensity on average[a] (median, IQR)	3.0 (1.0-4.0)	3.0 (2.0-4.0)	3.0 (1.0-5.0)
MRMD severity on average[b] (median, IQR)	4.0 (1.0-6.0)	2.0 (1.0-5.0)	3.0 (2.0-5.0)
MRMD severity w-scores[b,c] (mean±SD)			
Impact of MSSs on daily life[a] (median, IQR)	3.0 (2.0-6.0)	3.0 (2.0-5.0)	4.0 (2.0-6.0)
Emotional impact of MSSs[a] (median, IQR)	3.0 (1.0-5.0)	2.0 (0.5-5.0)	3.0 (2.0-7.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [b]ratings were only made by those who reported music-related musculoskeletal disorders. [c]w-scores were derived from Rasch analysis (Appendix 2.10)

Table A1.5.54: Beta coefficients (95% confidence intervals) for musculoskeletal symptom outcome ratings for symptomatic self-employed, employed and 'both' groups of professional musicians

	Both compared with employed only	
	Unadjusted	Adjusted
Emotional impact of musculoskeletal symptoms[b]	0.734 (0.089-1.379), p=0.026*	0.787 (0.120-1.454), p=0.021*

Notes: Employed musicians were the reference group. Ratings were only made by those who reported musculoskeletal symptoms the last 7 days. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.4.55: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences among symptomatic musicians in the self-employed, employed and 'both' groups of professional musicians

	Self-employed only	Employed only	Self-employed & employed
Work/ study in the last 12 months			
Changes to work/ study	0.0	12.7 (6.7-22.7)	16.0 (9.5-25.8)
Changes to musical work/ study	0.0	10.3 (5.0-20.1)	11.4 (6.0-20.5)
Leave from work/ study	5.0 (0.7-28.5)	18.3 (10.9-29.1)	27.2 (18.6-37.9)
Leave from musical work/ study	5.0 (0.7-28.5)	14.5 (7.9-25.0)	21.3 (13.6-31.6)
Consulting a health professional in the last 12 months	75.0 (52.0-89.3)	58.3 (46.6-69.2)	76.2 (65.9-84.1)
Medical professional	35.0 (17.6-57.6)	33.8 (23.7-45.6)	45.7 (35.1-56.6)
Psychologist/ counsellor	0.0	7.0 (2.9-15.9)	6.2 (2.6-14.1)
Physiotherapist/ occupational therapist	40.0 (21.3-62.1)	26.8 (17.7-38.3)	53.1 (42.2-63.7)
Personal trainer/ Pilates instructor/ yoga instructor	20.0 (7.7-43.0)	15.5 (8.8-25.9)	18.5 (11.4-28.5)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	20.0 (7.7-43.0)	31.0 (21.3-45.7)	32.1 (22.8-43.0)
Naturopath/ homeopath	0.0	2.8 (0.7-10.7)	7.4 (3.3-15.6)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	0.0	2.8 (0.7-10.7)	7.4 (3.3-15.6)
Other	5.0 (0.7-28.5)	1.4 (0.2-9.4)	6.2 (2.6-14.1)
Self-management in the last 12 months	90.0 (67.4-97.5)	84.7 (74.4-91.4)	90.5 (82.0-95.2)
Medication	50.0 (29.3-70.7)	36.6 (26.2-48.4)	44.4 (34.0-55.4)
Heat/ ice	35.0 (17.6-57.6)	39.4 (28.7-51.2)	49.4 (38.6-60.2)
Exercises/ stretches	70.0 (47.1-85.9)	76.1 (64.7-84.6)	90.1 (81.4-95.0)
Braces/ strapping/ taping	35.0 (17.6-57.6)	22.5 (14.2-33.7)	23.5 (15.4-33.9)
Other	10.0 (2.5-32.6)	7.0 (2.9-15.9)	7.4 (3.3-15.6)
Consulting other musicians in the last 12 months	20.0 (7.7-43.0)	21.7 (13.5-33.1)	32.1 (22.8-43.0)
Current treatment	38.1 (20.2-59.9)	30.5 (20.1-43.4)	47.8 (36.3-59.6)

Notes: The denominator for all prevalence estimates was the number of musicians reporting musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the number of musicians reporting musculoskeletal symptoms in the last 7 days was used.

Table A1.4.56: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between symptomatic musicians in the self-employed, employed, and 'both' groups for professional musicians regarding the consequences of musculoskeletal symptoms

	Both compared with self-employed only[a]	Both compared with employed only[a]	
	Unadjusted	**Unadjusted**	**Adjusted**
Leave from work/ study	7.085 (0.894-56.1), p=0.064		
Health professional		2.286 (1.150-4.542), p=0.018*	2.393 (1.181-4.851), p=0.015*
Current treatment		2.088 (1.008-4.325), p=0.048*	2.206 (1.048-4.643), p=0.037*

Notes: [a]denotes the reference group. The sample referred to musicians who reported experiencing musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the sample was musicians who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. The type of treatment (e.g. chiropractor, medication, exercises/ stretches) were no compared. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

A1.4.2.4 Comparison between musicians working for education and performance organisations

Table A1.4.57: Demographic information for musicians employed in education organisations, performance organisations and 'both'

	Education only (n=47)	Performance only (n=90)	Both (n=46)	p-value
Age in years (median, IQR)	21.0 (20.0-35.0)	40.0 (25.0-47.0)	39.0 (29.0-53.0)	0.005**
Female (%)	68.1	48.9	52.17	0.090
Body mass index (median, IQR)	23.5 (21.1-26.4)	24.8 (22.7-27.7)	25.5 (22.4-27.6)	0.591
Typical daily sitting time (%)				0.740
<4 hours	21.3	23.6	21.7	
4-8 hours	63.8	52.8	58.7	
8+ hours	14.9	23.6	19.6	
Socioeconomic status[a] (%)				0.864
1	21.3	23.9	21.7	
2	21.3	25.0	19.6	
3	23.4	17.1	28.3	
4	34.0	34.1	30.4	
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	4.0 (2.0-4.0)	0.018*
Number of employers in the last 7 days (median, IQR)	1.5 (1.0-2.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	0.005**
Hours worked in the last 7 days (median, IQR)	12.0 (8.0-20.0)	12.0 (4.0-35.0)	16.3 (9.0-36.0)	0.070
Currently studying music (%)	63.8	23.3	30.4	<0.001***
Age (in years) they started their musical activities (median, IQR)	8.0 (6.0-11.0)	8.0 (6.0-11.0)	7.0 (5.0-9.0)	0.247
Years of musical activity (median, IQR)	15.0 (11.0-28.0)	31.0 (18.5-41.0)	31.5 (18.0-44.0)	0.002**
Performed in the last 12 months (%)	91.1	95.5	95.7	0.561
Performed in the last 7 days (%)	46.7	62.8	73.3	0.032*
Amount of musical activity in the last 7 days (%)				<0.001***
0-10 hours	23.9	45.6	10.9	
10-20 hours	32.6	27.8	28.3	
20 or more hours	43.5	26.7	60.9	
Musical biomechanical exposure in the last 12 months (%)				
Singing/ woodwind/ brass	63.6	75.9	74.4	0.329
Singing	47.7	46.6	43.2	0.902
Brass	11.4	21.8	32.6	0.052
Woodwind	22.7	32.2	16.3	0.120
Flute	11.4	17.2	7.0	0.224
Reed	13.6	23.0	11.6	0.192
Saxophone	9.1	20.7	7.0	0.051
Upper string	11.4	16.1	23.3	0.328
Hands elevated at shoulder level to play	45.5	66.7	72.7	0.019*
Repetitive elbow movement to play	81.8	67.8	86.1	0.038*
Repetitive finger flexion/ extension to play	86.4	90.9	97.8	0.100
Repetitive finger adduction/ abduction to play	77.3	54.0	65.1	0.028*
Repetitive foot movement to play	70.5	49.4	51.2	0.056
Musical biomechanical exposure in the last 7 days (%)				
Singing/ woodwind/ brass	63.0	67.1	64.4	0.889
Singing	39.1	34.1	32.6	0.783
Brass	8.7	17.1	26.7	0.072
Woodwind	19.6	28.4	15.6	0.198
Flute	8.7	14.8	6.7	0.298
Reed	11.4	20.2	11.1	0.262
Saxophone	9.1	14.3	6.7	0.365
Upper string	11.4	15.5	20.0	0.530
Hands elevated at shoulder level to play	40.9	59.5	68.9	0.024*
Repetitive elbow movement to play	81.8	60.7	77.8	0.020*
Repetitive finger flexion/ extension to play	88.6	84.3	93.3	0.301
Repetitive finger adduction/ abduction to play	75.0	44.1	57.8	0.003**
Repetitive foot movement to play	58.7	37.5	37.8	0.046*
Job satisfaction score[b] (median, IQR)	40.0 (30.0-40.0)	40.0 (40.0-40.0)	40.0 (40.0-40.0)	0.422
Social support score[b] (median, IQR)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	48.0 (35.0-59.0)	0.628
Psychological distress score[b] (median, IQR)	48.5 (33.0-60.0)	33.0 (19.0-46.0)	40.0 (19.0-48.5)	0.005**
Psychosocial stress score[b] (median, IQR)	25.0 (17.0-32.5)	17.0 (5.0-30.0)	17.0 (17.0-25.0)	0.004**

Note: IQR: interquartile range. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]scores refer to the w-scores from the Rasch analysis (Appendices 2.11-2.14). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.58: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for musicians employed by education organisations, performance organisations and 'both'

	Education only	Performance only	Both
Overall	86.7 (732.-93.9)	86.0 (76.9-91.9)	88.9 (75.8-95.3)
Combined regions			
Head/ orofacial	42.2 (28.7-57.0)	35.3 (25.8-46.1)	33.3 (21.1-48.3)
Upper limb	80.0 (65.7-89.3)	72.9 (62.5-81.4)	82.2 (68.2-90.9)
Neck/ trunk	77.8 (63.3-87.7)	75.3 (65.0-83.4)	82.2 (68.2-90.9)
Lower limb	35.6 (23.0-50.5)	42.4 (32.3-53.1)	42.2 (28.7-57.0)
Priority regions			
Neck	68.9 (54.0-80.7)	63.5 (52.8-73.1)	71.1 (56.3-82.5)
Shoulder	68.9 (54.0-80.7)	56.5 (45.7-66.6)	73.3 (58.6-84.2)
Wrist/ hand	55.6 (40.9-69.3)	42.4 (32.3-53.1)	48.9 (34.7-63.3)
Upper back	51.1 (36.7-65.3)	41.2 (31.2-52.0)	44.4 (30.7-59.1)
Lower back	57.8 (43.0-71.3)	51.8 (41.1-62.2)	51.1 (36.7-65.3)

There were no significant differences between the three groups, and only one near-significant difference ('both' compared with performance only for the shoulder region (unadjusted): odds ratio 2.120, 95% confidence interval 0.964-4.660, p=0.062.

Table A1.4.59: 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms for musicians employed by education organisations, performance organisations and 'both'

	Education only	Performance only	Both
Overall	71.7 (57.1-82.9)	69.3 (58.9-78.1)	69.6 (54.8-81.1)
Chronic[a]	46.5 (32.2-61.4)	34.9 (25.5-45.6)	35.6 (23.0-50.5)
Chronic[a] of those with MSSs	66.7 (48.2-81.1)	50.8 (38.2-63.4)	51.6 (34.4-68.4)
Moderate-severe pain intensity[b]	29.0 (15.7-47.2)	19.3 (11.0-31.7)	27.6 (14.3-46.5)
Combined region			
Head/ orofacial	22.2 (12.3-36.7)	18.8 (11.8-28.6)	23.9 (13.7-38.3)
Upper limb	57.8 (43.0-71.3)	48.2 (37.8-58.9)	58.7 (44.0-72.0)
Neck/ trunk	62.2 (47.3-75.1)	52.9 (42.3-63.3)	47.8 (33.9-62.1)
Lower limb	22.2 (12.3-36.7)	23.5 (15.7-33.8)	19.6 (10.5-33.6)
Priority regions			
Neck	48.9 (34.7-63.3)	35.3 (25.8-46.1)	34.8 (22.5-49.6)
Shoulder	48.9 (34.7-63.3)	31.8 (22.7-42.4)	50.0 (35.8-64.2)
Wrist/ hand	28.9 (17.5-43.7)	28.2 (19.6-38.8)	26.1 (15.4-40.6)
Upper back	35.6 (23.0-50.5)	21.2 (13.7-31.2)	23.9 (13.7-38.3)
Lower back	44.4 (30.7-59.1)	32.9 (23.8-43.6)	28.3 (17.1-42.9)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 12 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to pain intensity on average of 5-10 on an 11-point numeric rating scale.

Table A1.4.60: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed by education organisations, performance organisations and 'both' regarding the 7 day prevalence of musculoskeletal symptoms

	Performance only compared with employed only[a]	Both compared with performance only[a]	
	Unadjusted	Unadjusted	Adjusted
Combined regions			
Neck/ trunk			0.460 (0.198-1.071), p=0.072
Priority regions			
Shoulder	0.487 (0.232-1.022), p=0.057	2.148 (1.028-4.487), p=0.042*	

Notes: [a]denotes the reference group. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.61: 12 month prevalence (95% confidence intervals) of music-related musculoskeletal disorders for musicians employed by education organisations, performance organisations and 'both'

	Education only	Performance only	Both
Overall	58.7 (44.0-72.0)	56.2 (45.7-66.2)	69.6 (54.8-81.1)
Combined regions			
Head/ orofacial	21.3 (11.8-35.3)	20.7 (13.4-30.5)	17.4 (8.9-31.2)
Upper limb	51.1 (37.0-65.0)	43.7 (33.6-54.3)	63.0 (48.3-75.7)
Neck/ trunk	55.3 (41.0-68.8)	48.3 (37.9-58.8)	56.5 (42.0-70.0)
Lower limb	17.0 (8.7-30.6)	13.8 (8.0-22.8)	19.6 (10.5-33.6)
Priority regions			
Neck	44.7 (31.2-59.0)	34.5 (25.2-45.1)	47.8 (33.9-62.1)
Shoulder	44.7 (31.2-59.0)	33.3 (24.2-43.9)	54.3 (39.9-68.1)
Wrist/ hand	34.0 (21.9-48.7)	26.4 (18.2-36.7)	30.4 (18.9-45.2)
Upper back	38.3 (25.6-52.9	23.0 (15.3-33.0)	37.0 (24.3-51.7)
Lower back	42.6 (29.3-57.0)	29.9 (21.2-40.4)	32.6 (20.6-47.4)

Table A1.4.62: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed by education organisations, performance organisations and 'both' regarding the 12 month prevalence of music-related musculoskeletal disorders

	Performance only compared with employed only[a]	Both compared with performance only[a]
	Unadjusted	Unadjusted
Combined regions		
Upper limb		2.200 (1.056-4.580), p=0.035*
Priority regions		
Shoulder		2.381 (1.146-4.949), p=0.020*
Upper back	0.481 (0.222-1.040), p=0.063	1.964 (0.901-4.282), p=0.090

Notes: [a]denotes the reference group. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.63: 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for musicians employed by education organisations, performance organisations and 'both'

	Education only	Performance only	Both
Overall	48.9 (35.0-63.0)	39.1 (29.4-49.7)	45.7 (31.9-60.1)
Chronic[a]	31.9 (20.2-46.5)	24.1 (16.3-34.3)	32.6 (20.6-47.4)
Chronic[a] of those with MRMDs	65.2 (44.1-81.6)	58.8 (41.8-74.0)	71.4 (49.1-86.6)
Combined regions			
Head/ orofacial	13.0 (5.9-26.2)	12.6 (7.1-21.5)	10.9 (4.6-23.7)
Upper limb	39.1 (26.2-53.9)	27.6 (19.2-37.9)	39.1 (26.2-53.9)
Neck/ trunk	41.3 (28.0-56.0)	31.0 (22.2-41.6)	37.0 (24.3-51.7)
Lower limb	10.9 (4.6-23.7)	9.2 (4.6-17.4)	13.0 (5.9-26.2)
Priority regions			
Neck	26.1 (15.4-40.6)	19.5 (12.5-29.3)	28.3 (17.1-42.9)
Shoulder	30.4 (18.9-45.2)	19.5 (12.5-29.3)	37.0 (24.3-51.7)
Wrist/ hand	26.1 (15.4-40.6)	17.2 (10.6-26.7)	13.0 (5.9-26.2)
Upper back	26.1 (15.4-40.6)	16.1 (9.7-25.4)	21.7 (12.1-36.0)
Lower back	26.1 (15.4-40.6)	14.9 (8.8-24.1)	17.4 (8.9-31.2)

Notes: MRMD: music-related musculoskeletal disorder. [a]chronic refers to experiencing music-related musculoskeletal disorders on most days for at least the last 3 months

Table A1.4.64: 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for musicians employed by education organisations, performance organisations and 'both'

	Both compared with employed only[a]	Both compared with performance only[a]	
	Adjusted	Unadjusted	Adjusted
Priority regions			
Shoulder		2.414 (1.085-5.370), p=0.031*	
Wrist/ hand	0.334 (0.097-1.147), p=0.082		0.345 (0.111-1.072), p=0.066

Notes: [a]denotes the reference group. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.65: Ratings of musculoskeletal symptom outcomes for professional musicians employed by education organisations only, performance organisations only, and 'both'

	Education only	Performer only	Performer and teacher
Pain intensity on average[a] (median, IQR)	4.0 (3.0-5.0)	2.0 (1.0-4.0)	3.0 (1.0-5.0)
MRMD severity on average[b] (median, IQR)	3.5 (2.0-5.0)	2.0 (1.0-5.0)	3.0 (2.0-5.0)
MRMD severity W-scores[b,c] (mean±SD)	59.3±21.9	48.3±26.1	55.3±26.0
Impact of MSSs on daily life[a] (median, IQR)	4.0 (3.0-6.5)	3.0 (2.0-5.0)	4.5 (2.0-6.0)
Emotional impact of MSSs[a] (median, IQR)	4.0 (2.0-6.0)	2.0 (0.0-4.0)	3.5 (1.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [b]ratings were only made by those who reported music-related musculoskeletal disorders. [c]w-scores were derived from Rasch analysis (Appendix 2.10)

Table A1.4.66: Beta coefficients (95% confidence intervals) for ratings of musculoskeletal symptom outcomes for professional musicians employed by education organisations only, performance organisations only, and 'both'

	Performance only compared with education only[a]	
	Unadjusted	Adjusted
MRMD severity[b]		-12.652 (-26.898-1.595), p=0.081
Impact of MSSs on daily life[c]	-0.994 (-1.786- -0.203), p=0.014*	-0.771 (-1.602-0.059), p=0.069
Emotional impact of MSSs[c]	-1.142 (-1.947- -0.337), p=0.005**	-0.955 (-1.909- -0.000), p=0.050

Notes: MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]denotes the reference group. [b]ratings were only made by those who reported music-related musculoskeletal symptoms the last 7 days, and were analysed using w-scores derived from Rasch analysis (Appendix 2.10). [c]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.4.67: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences for professional musicians employed by education organisations only, performance organisations only, and ‘both’

	Education only	Performance only	Education & performance
Work/ study in the last 12 months (%)			
Changes to work/ study	18.4 (9.0-34.0)	11.1 (5.6-20.8)	15.4 (7.0-30.4)
Changes to musical work/ study	13.9 (5.9-29.5)	8.3 (3.8-17.4)	10.5 (4.0-25.0)
Leave from work/ study	28.9 (16.7-45.2)	25.0 (16.3-36.3)	12.8 (5.4-27.5)
Leave from musical work/ study	28.9 (16.7-45.2)	15.5 (8.8-25.9)	12.8 (5.4-27.5)
Consulting a health professional in the last 12 months (%)	66.7 (50.6-79.6)	66.2 (54.7-76.1)	72.5 (56.7-84.1)
Medical professional	47.4 (32.2-63.1)	34.7 (24.6-46.4)	43.6 (29.0-59.4)
Psychologist/ counsellor	2.6 (0.4-16.7)	8.3 (3.8-17.4)	7.7 (2.5-21.4)
Physiotherapist/ occupational therapist	42.1 (27.5-58.2)	41.7 (30.8-53.4)	38.5 (24.6-54.5)
Personal trainer/ Pilates instructor/ yoga instructor	10.5 (4.0-25.0)	16.7 (9.7-27.2)	23.1 (12.4-38.8)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	31.6 (18.8-47.9)	27.8 (18.6-39.3)	41.0 (26.8-56.9)
Naturopath/ homeopath	10.5 (4.0-25.0)	2.8 (0.7-10.5)	2.6 (0.4-16.3)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	5.3 (1.3-18.9)	2.8 (0.7-10.5)	10.3 (3.9-24.5)
Other	2.6 (0.4-16.7)	0.0	12.8 (5.4-27.7)
Self-management in the last 12 months (%)	87.2 (72.5-94.6)	86.5 (76.6-92.6)	90.0 (76.1-96.2)
Medication	44.7 (29.8-60.7)	38.9 (28.3-50.6)	43.6 (29.0-59.4)
Heat/ ice	50.0 (34.5-65.5)	38.9 (28.3-50.6)	48.7 (33.5-64.1)
Exercises/ stretches	84.2 (68.9-92.8)	77.8 (66.7-86.0)	92.3 (78.6-97.5)
Braces/ strapping/ taping	21.1 (10.8-36.9)	23.6 (15.2-34.8)	23.1 (12.4-38.8)
Other	2.6 (0.4-16.7)	9.7 (4.7-19.1)	7.7 (2.5-21.4)
Consulting other musicians in the last 12 months (%)	50.0 (34.5-65.5)	16.7 (9.7-27.2)	23.1 (12.4-38.8)
Current treatment (%)	38.7 (23.3-56.7)	31.3 (21.0-43.7)	56.3 (38.8-72.2)

Notes: the denominator was the musicians with musculoskeletal symptoms in the last 12 months, with the exception of ‘current treatment’ where the denominator was musicians with musculoskeletal symptoms in the last 7 days

Table A1.4.68: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between symptomatic professional musicians employed by education organisations only, performance organisations only, and ‘both’ regarding musculoskeletal symptom consequences in the last 12 months

	Performance only compared with education only[a]		Both compared with education only[a]		Both compared with performance only[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Leave from work/ study			0.361 (0.112-1.165), p=0.088			0.340 (0.107-1.084), p=0.068
Leave from musical work/ study			0.361 (0.112-1.165), p=0.088			
Consult musician	0.200 (0.082-0.486), p<0.001***	0.299 (0.111-0.805), p=0.017*	0.300 (0.113-0. 799), p=0.016*	0.315 (0.105-0.941), p=0.039*		
Current treatment					2.829 (1.178-6.791), p=0.020*	2.388 (0.893-6.382), p=0.083

Notes: [a]denotes the reference group.

Type of musicians’ performance employment

Table A1.4.69: Demographic information for musicians employed by opera companies, orchestras, military bands, and ‘other’ performance organisations

	Opera (n=33)		Orchestra (n=42)		Military band (n=48)		Other (n=52)	
	Yes	p-value	Yes	p-value	Yes	p-value	Yes	p-value
Age in years (median, IQR)	46.0 (34.0-55.0)	0.009**	44.0 (38.0-52.0)	0.014*	37.0 (31.0-45.0)	0.924	24.5 (20.0-44.0)	0.001**
Female (%)	36.4	0.074	52.4	0.710	44.7	0.366	49.0	0.859
Body mass index (median, IQR)	25.1 (22.1-27.7)	0.899	24.8 (22.4-27.9)	0.745	25.6 (23.3-27.8)	0.795	24.2 (21.3-27.6)	0.806
Typical daily sitting time (%)		0.220		0.120		0.773		0.387
<4 hours	33.3		19.1		25.5		17.3	
4-8 hours	51.5		47.6		55.3		61.5	
8+ hours	15.2		33.3		19.2		21.2	
Socioeconomic status[a] (%)		0.988		0.550		0.571		0.252
1	24.2		16.7		29.8		19.6	
2	24.2		28.6		21.3		27.5	
3	21.2		19.1		17.0		27.5	
4	30.3		35.7		31.9		25.5	
Number of employers in the last 12 months (median, IQR)	3.0 (2.0-4.0)	0.806	3.0 (2.0-4.0)	0.837	2.0 (1.0-3.0)	0.021*	3.0 (2.0-4.0)	0.026*
Number of employers in the last 7 days (median, IQR)	2.0 (1.0-3.0)	0.725	2.0 (1.0-2.0)	0.942	2.0 (1.0-2.0)	0.674	2.0 (1.0-2.0)	0.782
Hours worked in the last 7 days (median, IQR)	16.5 (6.0-30.0)	0.807	18.0 (8.0-29.0)	0.769	33.5 (7.0-48.0)	0.001**	10.0 (2.8-24.5)	0.029*
Currently studying music at university (%)	12.1	0.048*	14.3	0.046*	10.42	0.004**	53.9	<0.001***
Age (in years) they started their musical activities (median, IQR)	7.0 (6.0-10.0)	0.953	7.0 (6.0-9.0)	0.126	8.0 (7.0-11.0)	0.297	7.0 (5.0-10.0)	0.802
Years of musical activity (median, IQR)	39.0 (26.0-48.0)	0.918	37.0 (31.0-42.0)	0.867	30.0 (23.0-37.0)	0.424	18.5 (13.0-37.5)	0.001**
Performed in the last 12 months	100.0	NA	97.6	0.466	93.8	0.456	96.2	0.790
Performed in the last 7 days	57.6	0.216	82.9	0.009**	68.89	0.664	62.8	0.478
Amount of musical activity in the last 7 days (%)		0.400		0.002**		<0.001***		0.606
0-10 hours	24.2		11.9		56.3		28.9	
10-20 hours	30.3		31.0		22.9		28.9	
20 or more hours	45.5		57.1		20.8		42.3	

(continued)

	Opera (n=33)		Orchestra (n=42)		Military band (n=48)		Other (n=52)	
	Yes	p-value	Yes	p-value	Yes	p-value	Yes	p-value
Musical biomechanical exposures in the last 12 months								
Singing/ woodwind/ brass	75.0	0.954	59.0	0.006**	89.1	0.010*	75.5	0.979
Singing	60.6	0.046*	20.0	<0.001***	44.7	0.894	54.0	0.125
Brass	6.3	0.011*	25.6	0.965	37.0	0.027*	22.5	0.550
Woodwind	9.4	0.016*	20.5	0.283	47.8	<0.001***	20.4	0.196
Flute	3.1	0.075	10.3	0.441	26.1	0.005**	10.2	0.354
Reed	6.3	0.047*	12.8	0.230	37.0	<0.001***	12.2	0.122
Saxophone	0.0	NA	5.1	0.040*	34.8	<0.001***	12.2	0.349
Upper string	21.9	0.644	35.9	0.002**	0.0	NA	26.0	0.117
Hands elevated at shoulder level to play	50.0	0.011*	82.1	0.033*	73.9	0.324	67.4	0.832
Repetitive elbow movement to play	75.0	0.766	79.5	0.650	69.6	0.144	87.8	0.027*
Repetitive finger flexion/ extension to play	81.8	0.007**	97.6	0.219	95.7	0.411	94.2	0.728
Repetitive finger adduction/ abduction to play	75.0	0.026*	66.7	0.177	30.4	<0.001***	71.4	0.015*
Repetitive foot movement to play	56.3	0.416	30.8	0.005**	45.7	0.464	59.2	0.105
Musical biomechanical exposures in the last 7 days								
Singing/ woodwind/ brass	71.9	0.435	51.2	0.016*	76.1	0.081	62.8	0.511
Singing	57.6	0.001**	14.3	0.002**	23.9	0.089	40.4	0.186
Brass	3.1	0.023*	17.1	0.538	32.6	0.012*	17.7	0.549
Woodwind	9.4	0.035*	19.5	0.414	43.5	<0.001***	17.7	0.176
Flute	3.1	0.023*	9.8	0.592	21.7	0.017*	9.8	0.535
Reed	6.3	0.078	12.5	0.360	34.9	<0.001***	9.8	0.084
Saxophone	0.0	NA	5.1	0.147	24.4	0.003**	10.2	0.693
Upper string	15.6	0.804	32.5	0.003**	0.0	NA	21.6	0.273
Hands elevated at shoulder level to play	42.4	0.003**	78.1	0.033*	69.8	0.389	65.4	0.881
Repetitive elbow movement to play	63.6	0.922	73.2	0.156	50.0	0.020*	73.1	0.091
Repetitive finger flexion/ extension to play	75.0	0.018*	95.0	0.102	85.7	0.670	86.3	0.733
Repetitive finger adduction/ abduction to play	65.6	0.031*	57.5	0.189	16.3	<0.001***	58.8	0.068
Repetitive foot movement to play	50.0	0.099	24.4	0.039*	21.7	0.007**	49.0	0.033*
Job satisfaction score[b] (median, IQR)	40.0 (25.0-40.0)	0.327	40.0 (40.0-40.0)	0.016*	40.0 (35.0-40.0)	0.189	40.0 (40.0-40.0)	0.323
Social support score[b] (median, IQR)	48.0 (35.0-59.0)	0.283	48.0 (35.0-59.0)	0.500	59.0 (35.0-59.0)	0.288	48.0 (35.0-59.0)	0.621
Psychological distress score[b] (median, IQR)	40.0 (19.0-46.0)	0.814	33.0 (19.0-46.0)	0.825	33.0 (19.0-40.0)	0.091	33.0 (19.0-51.0)	0.155
Psychosocial stress score[b] (median, IQR)	17.0 (5.0-25.0)	0.180	17.0 (5.0-25.0)	0.682	21.0 (11.0-25.0)	0.790	17.0 (5.0-30.0)	0.354

Note: IQR: interquartile range. NA: not applicable. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] [b]refer to w-scores derived from Rasch analysis (Appendices 2.11-2.14). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.70: 12 month prevalence (95% confidence intervals) of musculoskeletal symptoms for musicians employed by opera companies, orchestras, military bands, and other performance organisations

	Opera	Orchestra	Military band	Other
Overall	87.1 (70.0-95.1)	94.7 (81.0-98.7)	83.3 (69.9-91.5)	84.3 (71.5-92.0)
Combined regions				
Head/ orofacial	35.5 (20.7-53.6)	36.8 (23.1-53.2)	25.5 (15.0-39.9)	37.3 (25.1-51.3)
Upper limb	71.0 (52.8-84.2)	92.1 (78.0-97.5)	66.0 (51.3-78.1)	78.4 (65.0-87.7)
Neck/ trunk	83.9 (66.4-93.2)	84.2 (68.9-92.8)	72.3 (57.8-83.3)	76.5 (62.8-86.2)
Lower limb	48.4 (31.5-65.6)	28.9 (16.7-45.3)	42.6 (29.2-57.0)	39.2 (26.8-53.2)
Priority regions				
Neck	71.0 (52.8-84.2)	76.3 (60.2-87.3)	55.3 (40.9-68.9)	68.6 (54.6-79.9)
Shoulder	61.3 (43.3-76.7)	78.9 (63.1-89.2)	51.1 (36.9-65.0)	66.7 (52.6-78.3)
Wrist/ hand	35.5 (20.7-53.6)	55.3 (39.3-70.2)	29.8 (18.4-44.4)	52.9 (39.2-66.2)
Upper back	45.2 (28.7-62.7)	44.7 (29.8-60.7)	34.0 (21.9-48.7)	49.0 (35.6-62.6)
Lower back	58.1 (40.3-74.0)	47.4 (32.1-63.1)	48.9 (35.0-63.1)	52.9 (39.2-66.2)

Table A1.4.71: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences musicians in different types of performance organisation for the 12 month prevalence of musculoskeletal symptoms

	Orchestra compared with non-orchestral[a]		Military band compared with non-military band[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Combined regions				
Head/ orofacial				
Upper limb	5.104 (1.448-17.993), p=0.011*	5.736 (1.581-20.807), p=0.008**	0.427 (0.188-0.973), p=0.043*	
Trunk				
Lower limb	0.444 (0.197-1.001), p=0.050	0.283 (0.111-0.725), p=0.008**		
Priority regions				
Neck			0.475 (0.224-1.004), p=0.051	
Shoulder	3.015 (1.248-7.280), p=0.014*	3.704 (1.361-10.081), p=0.010*	0.476 (0.228-0.994), p=0.048*	0.411 (0.166-1.016), p=0.054
Wrist/ hand		2.338 (1.019-5.362), p=0.045*	0.375 (0.176-0.804), p=0.012*	0.390 (0.177-0.859), p=0.019*
Upper back				
Lower back				

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.72: The 12 month prevalence (95% confidence interval) of music-related musculoskeletal disorders for musicians employed by opera companies, orchestras, military bands, and other performance organisations

	Opera	Orchestra	Military band	Other
Overall	54.5 (37.5-70.6)	69.0 (53.5-81.2)	55.3 (40.9-68.9)	65.4 (51.5-77.1)
Combined regions				
Head/ orofacial	21.9 (10.7-39.5)	25.0 (13.9-40.7)	12.8 (5.8-25.8)	23.1 (13.5-36.5)
Upper limb	43.8 (27.8-61.1)	60.0 (44.2-74.0)	38.3 (25.5-52.9)	57.7 (43.9-70.4)
Trunk	46.9 (30.5-64.0)	60.0 (44.2-74.0)	46.8 (33.0-61.1)	55.8 (42.1-68.7)
Lower limb	12.5 (4.7-29.1)	15.0 (6.8-29.8)	14.9 (7.2-28.2)	19.2 (10.6-32.3)
Priority regions				
Neck	34.4 (20.1-52.2)	55.0 (39.5-69.6)	27.7 (16.7-42.2)	46.2 (33.1-49.8)
Shoulder	40.6 (25.1-58.2)	50.0 (34.9-65.1)	25.5 (15.0-39.9)	50.0 (36.6-63.4)
Wrist/ hand	15.6 (6.6-32.7)	32.5 (19.8-48.4)	21.3 (11.8-35.4)	34.6 (22.9-48.5)
Upper back	28.1 (15.2-46.0)	40.0 (26.0-55.8)	19.1 (10.2-33.0)	38.5 (26.2-52.3)
Lower back	34.4 (20.1-52.2)	22.5 (12.1-38.0)	29.8 (18.4-44.4)	36.5 (24.6-50.4)

Table A1.4.73: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed by different types of performance groups

	Opera compared with non-opera [a]	Orchestra compared with non-orchestral [a]		Military band compared with non-military band [a]		'Other' compared with non-'opera'[a]	
	Unadjusted	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Combined regions							
Head/ orofacial			3.456 (1.108-10.778), p=0.033*		0.249 (0.065-0.950), p=0.042*		
Upper limb				0.469 (0.227-0.969), p=0.041*			
Trunk			2.089 (0.903-4.833), p=0.085				
Priority regions							
Neck		2.567 (1.201-5.486), p=0.015*	2.384 (1.065-5.338), p=0.035*	0.461 (0.214-0.992), p=0.048*			2.107 (0.929-4.781), p=0.075
Shoulder				0.359 (0.165-0.784), p=0.010*		1.893 (0.930-3.853), p=0.078	2.023 (0.911-4.490), p=0.083
Wrist/ hand	0.399 (0.141-1.132), p=0.084						
Upper back		2.286 (1.029-5.076), p=0.042*	2.213 (0.972-5.040), p=0.058		0.225 (0.007-0.729), p=0.013*	2.353 (1.0860-5.099), p=0.030*	3.328 (1.309-8.464), p=0.012*
Lower back			0.442 (0.182-1.076), p=0.072				2.013 (0.900-4.502), p=0.089

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.74: The 7 day prevalence (95% confidence intervals) of musculoskeletal symptoms for musicians employed by opera companies, orchestras, military bands, and other performance organisations

	Opera	Orchestra	Military band	Other
Overall	75.0 (57.2-87.1)	72.5 (56.7-84.2)	66.7 (52.2-78.6)	65.4 (51.5-77.1)
Chronic[a]	35.5 (20.7-53.6)	36.8 (23.1-53.2)	29.2 (18.0-43.6)	37.3 (25.1-51.3)
Chronic[a] of those with MSSs	47.8 (28.6-67.7)	51.9 (33.5-69.8)	43.8 (27.8-61.2)	57.6 (40.3-73.1)
Moderate-severe pain intensity[b]	19.0 (7.2-41.5)	24.0 (11.1-44.5)	16.1 (6.8-33.7)	34.4 (20.0-52.3)
Combined regions				
Head/ orofacial	29.0 (15.8-47.2)	23.1(12.4-38.9)	14.9 (7.2-28.2)	21.6 (12.3-35.0)
Upper limb	54.8 (37.3-71.3)	61.5 (45.5-75.4)	42.6 (29.2-57.0)	54.9 (41.1-68.0)
Neck/ trunk	58.1 (40.3-74.0)	56.4 (40.6-71.0)	46.8 (33.0-61.1)	47.1 (33.8-60.8)
Lower limb	32.3 (18.2-50.5)	7.7 (2.5-21.5)	19.1 (10.2-33.0)	27.5 (16.9-41.3)
Priority regions				
Neck	48.4 (31.5-65.6)	43.6 (29.0-59.4)	27.7 (16.7-42.2)	29.4 (18.5-43.4)
Shoulder	41.9 (26.0-59.7)	43.6 (29.0-59.4)	29.8 (18.4-44.4)	41.2 (28.5-55.1)
Wrist/ hands	22.6 (11.1-40.6)	30.8 (18.3-46.9)	19.1 (10.2-33.0)	35.3 (23.4-49.3)
Upper back	19.4 (8.9-37.1)	25.6 (14.3-41.6)	21.3 (11.8-35.4)	25.5 (15.3-39.2)
Lower back	35.5 (20.7-53.6)	23.1 (12.4-38.9)	27.7 (16.7-42.2)	31.4 (20.1-45.4)

Notes: MSS: musculoskeletal symptom. [a]chronic refers to musculoskeletal symptoms on most days for at least the last 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain ratings on average of 5-10 on an 11-point numeric rating scale.

Table A1.4.75: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed by different types of performance organisations for the 7 day prevalence of musculoskeletal symptoms

	Opera compared with non-opera[a]		Orchestra compared with non-orchestra[a]		'Other' compared with non-'other'[a]	
	Unadjusted	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Overall						
Moderate-severe pain intensity[b]					3.012 (1.057-8.580), p=0.039*	3.934 (1.204-12.859), p=0.023*
Combined regions						
Head/ orofacial		3.156 (1.070-9.310), p=0.037*				
Lower limb			0.212 (0.060-0.747), p=0.016*	0.124 (0.032-0.487), p=0.003**		
Priority regions						
Neck	2.087 (0.917-4.748), p=0.079	2.620 (1.030-6.664), p=0.043*				

Notes: [a]denotes the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1 Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.76: The 7 day prevalence (95% confidence intervals) of music-related musculoskeletal disorders for musicians employed by opera companies, orchestras, military bands and other performance organisations

	Opera	Orchestra	Military band	Other
Overall	40.6 (25.1-58.2)	50.0 (34.9-65.1)	29.8 (18.4-44.4)	46.2 (33.1-59.8)
Chronic[a]	18.8 (8.6-36.1)	32.5 (19.8-48.4)	19.1 (10.2-33.0)	34.6 (22.9-48.5)
Chronic[a] of those with MRMDs	46.2 (22.2-72.0)	65.0 (42.4-82.4)	57.1 (31.4-79.5)	75.0 (54.1-88.4)
Combined regions				
Head/ orofacial	15.6 (6.6-32.7)	20.0 (10.3-35.3)	10.6 (4.5-23.3)	11.5 (52-23.5)
Upper limb	31.3 (17.6-49.1)	42.5 (28.2-58.2)	17.0 (8.7-30.7)	36.5 (24.6-50.4)
Neck/ trunk	31.3 (17.6-49.1)	45.0 (30.4-60.5)	23.4 (13.4-37.7)	38.5 (26.2-52.3)
Lower limb	9.4 (3.0-25.6)	7.5 (2.4-21.0)	8.5 (3.2-20.7)	15.4 (7.8-28.0)
Priority regions				
Neck	25.0 (12.9-42.8)	37.5 (23.9-53.4)	10.6 (4.5-23.3)	25.0 (15.0-38.6)
Shoulder	28.1 (15.2-46.0)	32.5 (19.8-48.4)	12.8 (5.8-25.8)	30.8 (19.7-44.6)
Wrist/ hands	9.4 (3.0-25.6)	22.5 (12.1-38.0)	10.6 (4.5-23.3)	19.2 (10.6-32.3)
Upper back	15.6 (6.6-32.7)	27.5 (15.8-43.3)	14.9 (7.2-28.2)	25.0 (15.0-38.6)
Lower back	12.5 (4.7-29.1)	7.5 (2.4-21.0)	14.9 (7.2-28.2)	19.2 (10.6-32.3)

Notes: MRMD: music-related musculoskeletal disorders. [a]chronic refers to music-related musculoskeletal disorders on most days for at least the last 3 months

Table A1.4.77: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed in different types of performance organisation for the 7 day prevalence of music-related musculoskeletal disorders

	Opera compared with non-opera[a]	Orchestral compared with non-orchestral[a]		Military band compared with non-military band[a]		'Other' compared with non-'other'[a]	
	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall				0.446 (0.219-0.991), p=0.047*	0.382 (0.152-0.962), p=0.041*		
Chronic[b]							2.148 (0.868-5.316), p=0.098
Chronic[b] of those with MRMDs	0.277 (0.066-1.156), p=0.078						
Combined regions							
Head/ orofacial		2.656 (0.919-7.674), p=0.071					
Upper limb		2.010 (0.925-4.371), p=0.078		0.314 (0.131-0.753), p=0.009**			
Trunk			2.108 (0.976-4.554), p=0.058	0.491 (0.220-1.095), p=0.083			
Lower limb			0.221 (0.045-1.084), p=0.063				
Priority regions							
Neck		3.120 (1.339-7.268), p=0.008**		0.290 (0.103-0.820), p=0.020*			
Shoulder				0.303 (0.115-0.798), p=0.016*			
Upper back		2.334 (0.941-5.790), p=0.067				2.121 (0.868-5.183), p=0.099	4.065 (1.374-12.021), p=0.011*
Lower back		0.338 (0.094-1.220), p=0.098					3.405 (1.011-11.472), p=0.048*

Notes: MRMD: music-related musculoskeletal disorders. [a]denotes the reference group. [b]chronic refers to music-related musculoskeletal disorders experienced on most days for at least the last 3 months. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.4.78: Musculoskeletal symptom outcome ratings for musicians employed by different types of performance organising who reported musculoskeletal symptoms in the last 7 days

	Opera	Orchestral	Military band	'Other'
Pain intensity on average[a] (median, IQR)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	3.5 (2.0-5.0)
MRMD severity on average[b] (median, IQR)	3.0 (1.5-5.0)	4.0 (2.0-6.0)	1.0 (1.0-2.0)	4.0 (2.0-5.0)
MRMD severity w-scores[c] (mean±SD)	54.5±25.2	58.7±26.7	35.6±22.7	59.1±22.9
Impact of MSSs on daily life[a] (median, IQR)	3.0 (1.0-5.0)	3.0 (2.0-6.0)	3.0 (1.0-5.0)	3.5 (2.0-6.0)
Emotional impact of MSSs[c] (median, IQR)	2.0 (0.0-7.0)	3.0 (1.5-6.0)	1.0 (0.0-3.5)	3.5 (2.0-6.0)

Notes: IQR: interquartile range. SD: standard deviation. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [c]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days. [d]w-scores were derived from the Rasch analysis (Appendix 2.10).

Table A1.4.79: Beta coefficients (95% confidence intervals) for the comparisons of ratings of symptomatic musicians employed by different types of performance organisations

	Orchestral compared with non-orchestral[a]		Military band compared with non-military band[a]		'Other' compared with non-'other'[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
MRMD severity w-scores[b]	12.354 (-2.358-27.067), p=0.098	12.866 (-2.446-28.179), p=0.098	-20.711 (-36.088- -5.333), p=0.009**		14.155 (-0.008-28.319), p=0.050	
Emotional impact of MSSs[c]	0.734 (-0.091-1.558), p=0.081		-0.906 (-1.698- -0.115), p=0.025*	-0.935 (-1.818- -0.053), p=0.038*	0.695 (-0.087-1.478), p=0.081	0.849 (-0.076-1.775), p=0.070

Notes: MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]denotes the reference group. [b]ratings were only made by those who experienced music-related musculoskeletal disorders in the last 7 days, and w-scores were derived from the Rasch analysis (Appendix 2.10). [c]ratings were made by those who reported musculoskeletal symptoms in the last 7 days. Only significant and near-significant associations (p<0.100) are shown. The comparison between opera and non-opera musicians was omitted, as there were no significant nor near-significant differences. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.4.80: Prevalence (95% confidence intervals) of musculoskeletal symptom consequences for symptomatic professional musicians employed by different types of performance organisations

	Opera	Orchestral	Military band	'Other'
Work/ study in the last 12 months				
Changes to work/ study	3.7 (0.5-22.4)	17.1 (7.8-33.4)	7.7 (2.5-21.5)	19.5 (10.0-34.6)
Leave from work/ study	18.5 (7.9-37.7)	20.0 (9.8-36.6)	15.4 (7.0-30.4)	26.8 (15.4-42.4)
Workers' compensation claim	3.7 (0.5-22.4)	8.6 (2.8-23.6)	2.6 (0.4-16.3)	0.0
Changes to musical work/study	3.7 (0.5-22.4)	14.7 (6.2-31.0)	5.1 (1.3-18.5)	12.5 (5.3-26.9)
Leave from musical work/study	7.4 (1.8-25.5)	20.0 (9.8-36.6)	12.8 (5.4-27.5)	17.5 (8.5-32.6)
Workers' compensation claim for musical work	0.0	8.6 (2.8-23.6)	2.6 (0.4-16.3)	0.0
Consulting a health professional in the last 12 months	74.1 (54.5-87.2)	61.1 (44.4-75.6)	65.0 (49.1-78.2)	69.8 (54.5-81.7)
Medical professional	37.0 (21.1-56.4)	37.1 (22.8-54.1)	33.3 (20.3-49.5)	43.9 (29.6-59.3)
Psychologist/ counsellor	11.1 (3.6-29.6)	11.4 (4.3-27.0)	5.1 (1.3-18.5)	9.8 (3.7-23.4)
Physiotherapist/ occupational therapist	55.6 (36.7-72.9)	45.7 (30.1-62.2)	28.2 (16.3-44.3)	41.5 (27.4-57.0)
Personal trainer/ Pilates instructor/ yoga instructor	18.5 (7.9-37.7)	14.3 (6.0-30.2)	17.9 (8.7-33.3)	22.0 (11.8-37.2)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	25.9 (12.8-45.5)	20.0 (9.8-36.6)	41.0 (26.8-57.0)	36.6 (23.3-52.3)
Naturopath/ homeopath	3.7 (0.5-22.4)	2.9 (0.4-18.0)	2.6 (0.4-16.3)	4.9 (1.2-17.7)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	7.4 (1.8-25.5)	8.6 (2.8-23.6)	2.6 (0.4-16.3)	4.9 (1.2-17.7)
Other	11.1 (3.6-29.6)	5.7 (1.4-20.4)	2.6 (0.4-16.3)	0.0
Self-management in the last 12 months	100.0	91.7 (76.9-97.3)	80.0 (64.7-89.7)	88.4 (74.8-95.1)
Medication	51.9 (33.4-69.8)	37.1 (22.8-54.1)	43.6 (29.0-59.4)	34.1 (21.3-49.9)
Heat/ ice	33.3 (18.2-52.9)	42.9 (27.6-59.6)	41.0 (26.8-57.0)	43.9 (29.6-59.3)
Exercises/ stretches	96.3 (77.6-99.5)	88.6 (73.0-95.7)	74.4 (58.4-85.7)	85.4 (70.9-93.3)
Braces/ strapping/ taping	18.5 (7.9-37.7)	14.3 (6.0-30.2)	17.9 (8.7-33.3)	31.7 (19.3-47.4)
Other	7.4 (1.8-25.5)	8.6 (2.8-23.6)	7.7 (2.5-21.5)	12.2 (5.1-26.3)
Consulting other musicians in the last 12 months	14.8 (5.6-33.7)	22.9 (11.8-39.7)	2.6 (0.4-16.3)	34.1 (21.3-49.9)
Current treatment	47.8 (28.6-67.7)	39.3 (23.1-58.2)	21.6 (11.1-37.9)	55.9 (39.0-71.5)

Notes: The denominator for all prevalence estimates was the number of musicians reporting musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the number of musicians reporting musculoskeletal symptoms in the last 7 days was used.

Table A1.4.81: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) differences between musicians employed by different types of performance organisations for the musculoskeletal consequences

	Orchestral compared with non-orchestral[a]	Military band compared with military band[a]		'Other' compared with non-'other' [a]	
	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Changes to work/ study					3.018 (0.859-10.609), p=0.085
Self-management		0.353 (0.113-1.102), p=0.073			
Current treatment		0.271 (0.101-0.722), p=0.009**	0.338 (0.117-0.976), p=0.045*	2.463 (1.024-5.924), p=0.044*	2.390 (0854-6.694), p=0.097
Consult musicians	2.901 (0.891-9.444), p=0.077	0.068 (0.009-0.532), p=0.010*	0.074 (0.009-0.590), p=0.014*	4.667 (1.694-12.853), p=0.003**	3.100 (1.024-9.387), p=0.045*

Notes: [a]denotes the reference group. The sample referred to musicians who reported experiencing musculoskeletal symptoms in the last 12 months, with the exception of 'current treatment' where the sample was musicians who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. The type of treatment (e.g. chiropractor, medication, exercises/ stretches) were not compared. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

S1.5: Supplementary material for Chapter 5

Table A1.5.1: Demographic information for university music and science students, professional musicians and university staff

	Student comparison			Professional/ staff comparison		
	Music students (n=166)	**Science students (n=259)**	**p-value**	**Professional musicians (n=225)**	**University staff (n=208)**	**p-value**
Age in years (median, IQR)	20.0 (19.0-23.0)	19.5 (18.0-23.0)	0.292	37.0 (22.0-54.0)	41.0 (31.0-52.0)	0.087
Female (%)	57.2	64.0	0.166	57.0	74.5	<0.001***
Body mass index (median, IQR)	22.9 (20.5-25.5)	22.0 (20.1-23.9)	0.021*	25.0 (22.2-27.7)	24.1 (21.7-27.2)	0.314
Typical daily sitting time (%)			0.004**			<0.001***
<4 hours	16.3	6.2		23.2	8.7	
4-8 hours	54.2	56.2		54.9	41.4	
8+ hours	29.5	37.6		21.9	50.0	
Socioeconomic status[a] (%)			0.432			0.050
1	20.5	26.0		20.1	24.9	
2	26.1	27.5		20.6	21.5	
3	28.0	22.1		22.8	29.3	
4	25.5	24.4		36.5	24.4	
Current university student (%)	100.0	100.0	NA	40.0	18.3	<0.001***
Full time study (%)	90.2	96.5	0.010*	NA	NA	NA
Number of employers in the last 12 months (median, IQR)	2 (1-3)	1 (0-2)	<0.001***	2 (1-3)	1 (1-2)	<0.001***
Number of employers in the last 7 days (median, IQR)	1 (0-2)	0 (0-0)	<0.001***	1 (1-2)	1 (1-1)	<0.001***
Hours worked in the last 7 days (median, IQR)	2.75 (0-12)	0 (0-0)	<0.001***	12 (4-28)	37.5 (28.5-45)	<0.001***

Notes: IQR: interquartile range. NA: not applicable. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] *p<0.050, **p<0.010, ***p<0.001***

Table A1.5.2: Demographic information for male university music and science students, professional musicians and university staff

	Student comparison			Professional/ staff comparison		
	Music students (n=71)	**Science students (n=93)**	**p-value**	**Professional musicians (n=96)**	**University staff (n=53)**	**p-value**
Age in years (median, IQR)	20.0 (19.0-23.0)	20.0 (18.0-24.0)	0.583	43.5 (26.5-56.0)	46.0 (32.0-55.0)	0.635
Body mass index (median, IQR)	23.2 (21.1-26.2)	22.3 (20.3-23.8)	0.028*	25.8 (23.1-28.4)	24.4 (22.5-26.3)	0.097
Typical daily sitting time (%)			0.041*			0.002**
<4 hours	14.1	5.4		24.0	7.6	
4-8 hours	56.3	48.4		54.2	50.9	
8+ hours	29.6	46.2		21.9	41.5	
Socioeconomic status[a] (%)			0.610			0.717
1	29.4	21.5		24.0	17.7	
2	23.5	28.0		16.7	19.6	
3	20.6	18.3		25.0	31.4	
4	26.5	32.3		34.4	31.4	
Current university student (%)	100.0	100.0	NA	31.3	18.9	0.106
Full time study (%)	89.9	95.7	0.155	NA	NA	NA
Number of employers in the last 12 months (%)	1.0 (1.0-3.0)	1.0 (0.0-1.0)	0.001**	2.0 (1.0-4.0)	1.0 (1.0-2.0)	<0.001***
Number of employers in the last 7 days (%)	0.0 (0.0-1.0)	0.0 (0.0-0.0)	<0.001***	1.0 (1.0-2.0)	1.0 (1.0-1.0)	0.022*
Hours worked in the last 7 days (%)	0.0 (0.0-6.5)	0.0 (0.0-0.0)	0.001**	40.0 (30.0-50.0)	10.0 (2.8-3)	<0.001***

Notes: IQR: interquartile range. NA: not applicable. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] *p<0.050, **p<0.010, ***p<0.001***

Table A1.5.3: Demographic information for female university music and science students, professional musicians and university staff

	University student comparison			Staff/ professional comparison		
	Music students (n=95)	**Science students (n=165)**	**p-value**	**Musicians (n=127)**	**University staff (n=155)**	**p-value**
Age in years (median, IQR)	20.0 (19.0-22.0)	19.0 (18.0-22.0)	0.426	35.0 (21.0-48.0)	40.0 (31.0-52.0)	0.012*
Body mass index (median, IQR)	22.5 (19.5-25.2)	21.7 (20.0-23.9)	0.311	24.5 (21.4-26.5)	23.8 (21.3-27.9)	0.538
Typical daily sitting time (%)[a]			0.026*			<0.001***
<4 hours	17.9	6.7		22.8	9.0	
4-8 hours	52.6	60.4		55.9	38.1	
8+ hours	29.5	32.9		21.3	52.9	
Socioeconomic status (%)			0.051			0.015*
1	14.0	28.7		17.2	27.3	
2	28.0	27.4		23.0	22.1	
3	33.3	23.8		21.3	28.6	
4	24.7	20.1		38.5	22.1	
Current university student (%)	100.0	100.0	NA	46.5	18.1	<0.001***
Full time study (%)	90.5	97.0	0.035*	NA	NA	NA
Number of employers in the last 12 months (median, IQR)	2.0 (1.0-3.0)	1.0 (0.0-2.0)	<0.001***	2.0 (1.0-3.0)	1.0 (1.0-1.0)	<0.001***
Number of employers in the last 7 days (median, IQR)	1.0 (0.0-2.0)	0.0 (0.0-0.0)	<0.001***	2.0 (1.0-2.0)	1.0 (1.0-1.0)	<0.001***
Hours worked in the last 7 days (median, IQR)	7.4 (0.0-13.0)	0.0 (0.0-0.0)	<0.001***	13.0 (5.0-26.0)	37.0 (26.0-40.0)	<0.001***

Notes: IQR: interquartile range. NA: not applicable. [a]quartiles based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] *p<0.050, **p<0.010, ***p<0.001***

Table A1.5.4: 12 month prevalence (95% confidence interval) of musculoskeletal symptoms for university music and science students

	Music students			Science students		
	All	Female	Male	All	Female	Male
Overall	92.5 (87.1-95.7)	95.6 (88.7-98.3)	88.4 (78.4-94.1)	94.8 (91.3-97.0)	96.9 (92.6-98.7)	91.3 (83.5-95.6)
Combined regions						
Head/ orofacial	44.0 (36.5-51.9)	48.9 (38.7-59.2)	37.7 (27.0-49.7)	48.2 (42.1-54.4)	53.8 (46.0-61.5)	38.0 (28.7-48.4)
Upper limb	78.6 (71.5-84.3)	85.6 (76.6-91.5)	69.6 (57.7-79.3)	72.9 (67.1-78.1)	75.9 (68.6-82.0)	67.4 (57.1-76.2)
Neck/ trunk	78.0 (70.8-83.8)	82.2 (72.8-88.9)	72.5 (60.7-81.8)	83.7 (78.5-87.8)	86.1 (79.7-90.7)	79.3 (69.8-86.5)
Lower limb	34.0 (27.0-41.7)	36.7 (27.3-47.1)	30.4 (20.7-42.3)	63.7 (57.6-69.5)	65.2 (57.4-72.2)	60.9 (50.5-70.3)
Specific regions						
Head	27.0 (20.7-34.5)	30.0 (21.4-40.3)	23.2 (14.7-34.7)	39.8 (33.9-46.0	47.5 (39.8-55.3)	26.1 (18.1-36.1)
Orofacial	33.3 (26.4-41.1)	38.9 (29.3-49.4)	26.1 (17.0-37.8)	25.5 (20.5-31.3)	27.2 (20.8-34.7)	21.7 (14.4-31.4)
Neck	64.8 (57.0-71.9)	71.1 (60.9-79.6)	56.5 (44.6-67.7)	65.7 (59.6-71.4)	71.5 (64.0-78.0)	55.4 (45.1-65.3)
Shoulder	62.3 (54.4-69.5)	71.1 (60.9-79.6)	50.7 (39.0-62.4)	59.0 (52.8-64.9)	65.2 (57.4-72.2)	47.8 (37.8-58.1)
Elbow	21.4 (15.7-28.5)	21.1 (13.8-30.8)	21.7 (13.5-33.1)	15.1 (11.2-20.1)	12.7 (8.3-18.8)	19.6 (12.6-29.0)
Wrist/ hand	57.2 (49.4-64.7)	62.2 (51.7-71.7)	50.7 (39.0-62.4)	39.0 (33.2-45.2)	38.0 (30.7-45.8)	41.3 (31.7-51.7)
Upper back	47.2 (39.5-55.0)	47.8 (37.6-58.1)	46.4 (34.9-58.2)	47.4 (41.3-53.6)	48.1 (40.4-55.9)	45.7 (35.7-55.9)
Chest/ abdomen	18.2 (12.9-25.1)	20.0 (12.9-29.6)	15.9 (9.0-26.6)	19.1 (14.7-24.5)	21.5 (15.8-28.6)	14.1 (8.4-22.9)
Lower back	56.0 (48.1-63.5)	60.0 (49.5-69.6)	50.7 (39.0-62.4)	66.9 (60.9-72.5)	71.5 (64.0-78.0)	58.7 (48.3-68.3)
Hip/ thigh	17.0 (11.9-23.7)	20.0 (12.9-29.6)	13.0 (6.9-23.3)	33.5 (27.9-39.6)	36.7 (29.5-44.5)	27.2 (19.0-37.2)
Knee	21.4 (15.7-28.5)	24.4 (16.6-34.4)	17.4 (10.1-28.3)	35.9 (30.1-42.0)	37.3 (30.1-45.2)	33.7 (24.7-44.0)
Ankle/ foot	18.2 (12.9-25.1)	18.9 (12.0-28.4)	17.4 (10.1-28.3)	38.2 (32.4-44.4)	38.6 (31.3-46.5)	38.0 (28.7-48.4)

Table A1.5.5: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 12 month prevalence of musculoskeletal symptoms between university music and science students

	All		Female		Male	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Combined regions						
Upper limb			1.876 (0.939-3.756), p=0.075	1.858 (0.929-3.715), p=0.080		
Lower limb	0.293 (0.193-0.444), p<0.001***	0.295 (0.194-0.450), p<0.001***	0.309 (0.180-0.530), p<0.001***	0.310 (0.181-0.532), p<0.001***	0.281 (0.145-0.545), p<0.001***	0.273 (0.139-0.536), p<0.001***
Specific regions						
Head	0.560 (0.364-0.862), p=0.008**	0.597 (0.385-0.926), p=0.021*	0.474 (0.274-0.821), p=0.008**	0.480 (0.277-0.832), p=0.009**		
Orofacial	1.461 (0.946-2.257), p=0.088		1.702 (0.982-2.949), p=0.058	1.694 (0.976-2.938), p=0.061		
Elbow			1.846 (0.926-3.682), p=0.082	1.853 (0.928-3.699), p=0.080		
Wrist/ hand	2.089 (1.395-3.129), p<0.001***	2.000 (1.322-3.023), p=0.001**	2.690 (1.578-4.587), p<0.001***	2.672 (1.566-4.560), p<0.001***		
Lower back	0.628 (0.417-0.945), p=0.026*	0.662(0.438-1.002), p=0.051	0.597 (0.346-1.030), p=0.064	0.609 (0.352-1.054), p=0.077		
Hip/ thigh	0.407 (0.249-0.664), p<0.001***	0.409 (0.249-0.672), p<0.001***	0.431 (0.234-0.793), p=0.007**	0.476 (0.256-0.885), p=0.019*	0.402 (0.174-0.929), p=0.033*	0.334 (0.136-0.821), p=0.017*
Knee	0.487 (0.308-0.770), p=0.002**	0.498 (0.314-0.790), p=0.003**	0.543 (0.304-0.968), p=0.039*	0.546 (0.306-0.975), p=0.041*	0.414 (0.194-0.884), p=0.023*	0.427 (0.200-0.915), p=0.029*
Ankle/ foot	0.360 (0.224-0.580), p<0.001***	0.470 (0.279-0.793), p=0.005**	0.370 (0.200-0.687), p=0.002**	0.372 (0.200-0.690), p=0.002**	0.343 (0.162-0.727), p=0.005**	0.355 (0.167-0.754), p=0.007**

Notes: University science students were the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.5.6: 12 month prevalence (95% confidence interval) of musculoskeletal symptoms for professional musicians and university staff

	Professional musicians			University staff		
	All	Female	Male	All	Female	Male
Overall	87.9 (82.8-91.7)	94.1 (88.1-97.2)	80.9 (71.6-87.6)	97.6 (94.3-99.0)	97.4 (93.3-99.0)	98.1 (87.5-99.7)
Combined regions						
Head/ orofacial	36.0 (29.8-42.7)	45.4 (36.6-54.4)	24.7 (17.0-34.5)	43.6 (38.9-48.4)	56.8 (48.8-64.4)	35.8 (24.1-49.6)
Upper limb	77.6 (71.5-82.7)	84.0 (76.3-89.6)	69.9 (59.8-78.4)	78.2 (74.0-81.9)	79.4 (72.2-85.0)	77.4 (64.1-86.7)
Neck/ trunk	76.2 (70.0-81.4)	83.2 (75.3-88.9)	68.8 (58.7-77.4)	84.4 (80.6-87.5)	92.9 (87.6-96.0)	92.5 (81.4-97.2)
Lower limb	42.1 (35.6-48.8)	50.4 (41.5-59.3)	31.2 (22.6-41.3)	57.1 (52.3-61.8)	76.1 (68.8-82.2)	62.3 (48.5-74.3)
Specific regions						
Head	26.2 (20.7-32.5)	37.0 (28.7-46.0)	12.9 (7.5-21.4)	46.2 (39.5-53.0)	51.6 (43.7-59.4)	30.2 (19.4-43.8)
Orofacial	26.2 (20.7-32.5)	32.8 (24.9-41.7)	18.3 (11.6-27.5)	25.0 (19.6-31.3)	29.7 (23.0-37.4)	11.3 (5.2-23.0)
Neck	62.6 (55.9-68.9)	72.3 (63.5-79.6)	51.6 (41.5-61.6)	73.6 (67.1-79.1)	77.4 (70.2-83.3)	62.3 (48.6-74.2)
Shoulder	63.6 (56.9-69.8)	72.3 (63.5-79.6)	52.7 (42.5-62.6)	64.9 (58.2-71.1)	69.0 (61.3-75.8)	52.8 (39.5-65.8)
Elbow	20.1 (15.2-26.0)	20.2 (13.9-28.4)	20.4 (13.4-29.9)	19.2 (14.4-25.2)	19.4 (13.9-26.4)	18.9 (10.4-31.7)
Wrist/ hand	48.1 (41.5-54.9)	55.5 (46.4-64.2)	38.7 (29.3-49.0)	44.2 (37.6-51.1)	45.8 (38.1-53.7)	39.6 (27.4-53.3)
Upper back	43.5 (36.9-50.2)	51.3 (42.3-60.2)	34.4 (25.4-44.6)	44.7 (38.1-51.5)	47.1 (39.4-55.0)	37.7 (25.8-51.4)
Chest/ abdomen	14.5 (10.4-19.9)	16.8 (11.1-24.7)	11.8 (6.6-20.2)	14.9 (10.7-20.4)	14.2 (9.5-20.6)	17.0 (9.1-29.6)
Lower back	52.8 (46.1-59.4)	58.0 (48.9-66.6)	47.3 (37.4-57.5)	73.1 (66.6-78.7)	73.5 (66.0-79.9)	71.7 (58.2-82.2)
Hip/ thigh	22.0 (16.9-28.0)	28.6 (21.1-37.4)	12.9 (7.5-21.4)	43.8 (37.1-50.6)	48.4 (40.6-56.3)	30.2 (19.4-43.8)
Knee	22.9 (17.7-29.0)	26.9 (19.7-35.6)	18.3 (11.6-27.5)	49.0 (42.3-55.8)	52.3 (44.4-60.0)	39.6 (27.4-53.3)
Ankle/ foot	19.2 (14.4-25.0)	20.2 (13.-28.4)	18.3 (11.6-27.5)	34.1 (28.0-40.9)	37.4 (30.1-45.3)	24.5 (14.8-37.8)

Table A1.5.7: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 12 month prevalence of musculoskeletal symptoms between professional musicians and university staff

	All		Female		Male	
	Unadjusted	**Adjusted**	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Overall	0.181 (0.068-0.481), p=0.001**	0.360 (0.121-1.073), p=0.067			0.083 (0.011-0.640), p=0.017*	0.081 (0.010-0.628), p=0.016*
Combined regions						
Head/ orofacial	0.531 (0.359-0.83), p=0.001**	0.568 (0.376-0.858), p=0.007**	0.633 (0.391-1.023), p=0.062	0.574 (0.350-0.942), p=0.028*		
Neck/ trunk	0.248 (0.135-0.458), p<0.001***	0.442 (0.219-0.891), p=0.022*	0.378 (0.174-0.824), p=0.014*		0.180 (0.059-0.546), p=0.002**	0.303 (0.091-1.003), p=0.051
Lower limb	0.274 (0.182-0.412), p<0.001***	0.320 (0.209-0.489), p<0.001***	0.319 (0.190-0.534), p<0.001***	0.359 (0.209-0.616), p<0.001***	0.275 (0.135-0.557), p<0.001***	0.274 (0.134-0.562), p<0.001***
Specific regions						
Head	0.414 (0.275-0.622), p<0.001***	0.450 (0.292-0.695), p<0.001***	0.550 (0.338-0.896), p=0.016*	0.475 (0.284-0.795), p=0.005**	0.343 (0.147-0.796), p=0.013*	0.326 (0.138-0.767), p=0.010*
Neck	0.602 (0.398-0.911), p=0.016*					
Lower back	0.412 (0.274-0.619), p<0.001***	0.504 (0.329-0.774), p=0.002**	0.496 (0.298-0.826), p=0.007**	0.482 (0.288-0.807), p=0.006**	0.354 (0.172-0.730), p=0.005**	0.355 (0.172-0731), p=0.005**
Hip/ thigh	0.362 (0.237-0.553), p<0.001***	0.419 (0.270-0.650), p<0.001***	0.427 (0.257-0.709), p=0.001**	0.453 (0.271-0.758), p=0.003**	0.343 (0.147-0.796), p=0.013*	0.346 (0.148-0.805), p=0.014*
Knee	0.309 (0.203-0.469), p<0.001***	0.349 (0.227-0.535), p<0.001***	0.336 (0.201-0.561), p<0.001***	0.349 (0.206-0.593), p<0.001***	0.341 (0.159-0.729), p=0.006**	0.344 (0.160-0.738), p=0.006**
Ankle/ foot	0.457 (0.293-0.714), p=0.001**	0.513 (0.324-0.812), p=0.004**	0.423 (0.243-0.735), p=0.002**	0.445 (0.254-0.777), p=0.004**		

Notes: University staff were the reference group. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.5.8: 7 day prevalence (95% confidence interval) of musculoskeletal symptoms for university music and science students

	Music students			Science students		
	All	Female	Male	All	Female	Male
Overall	72.6 (65.2-78.9)	74.5 (64.6-82.3)	70.0 (58.2-79.6)	76.4 (70.9-81.2)	80.0 (73.2-85.4)	69.9 (59.8-78.4)
Chronic[a]	30.4 (23.8-38.0)	29.7 (21.1-39.9)	31.4 (21.6-43.2)	33.6 (28.0-39.7)	37.7 (30.5-45.5)	25.6 (17.6-35.6)
Chronic[a] of those with MSSs	42.2 (33.5-51.5)	40.3 (29.2-52.5)	44.9 (31.6-59.0)	44.4 (37.5-51.6)	47.6 (39.0-56.4)	37.1 (26.0-49.8)
Moderate-severe pain[b]	24.8 (17.4-33.9)	27.1 (17.3-39.8)	21.7 (12.1-36.0)	11.5 (7.6-17.1)	13.4 (8.4-20.9)	8.1 (3.4-18.0)
Combined regions						
Head/ orofacial	22.7 (16.9-29.8)	25.8 (17.9-35.7)	18.6 (11.1-29.5)	26.7 (21.6-32.4)	34.0 (27.0-41.6)	13.0 (7.5-21.7)
Upper limb	55.2 (47.5-62.7)	57.0 (46.7-66.7)	52.9 (41.1-64.3)	51.0 (44.8-57.1)	54.3 (46.6-64.9)	44.6 (34.7-54.9)
Neck/ trunk	51.5 (43.8-59.2)	51.6 (41.5-61.6)	51.4 (39.8-62.9)	65.1 (59.0-70.7)	68.5 (60.9-75.2)	58.7 (48.3-68.3)
Lower limb	17.8 (12.6-24.5)	19.4 (12.5-28.7)	15.7 (8.9-26.3)	43.9 (37.9-50.1)	45.7 (38.1-53.4)	40.2 (60.7-50.6)
Specific regions						
Head	14.1 (9.5-20.4)	15.1 (9.1-23.9)	12.9 (6.8-23.0)	21.2 (16.6-26.6)	27.2 (20.8-34.6)	9.8 (5.1-17.8)
Right	12.9 (8.5-19.0)	14.0 (8.3-22.7)	11.4 (5.8-21.3)	17.6 (13.4-22.8)	22.2 (16.5-29.3)	8.7 (4.4-16.5)
Left	11.0 (7.0-16.9)	10.8 (5.9-18.9)	11.4 (5.8-21.3)	19.6 (15.2-25.0)	25.3 (19.2-32.6)	8.7 (4.4-16.5)
Orofacial	16.6 (11.6-23.1)	19.4 (12.5-28.7)	12.9 (6.8-23.0)	11.0 (7.7-15.5)	13.0 (8.6-19.1)	6.5 (2.9-13.8)
Right	16.0 (11.1-22.5)	18.3 (11.6-27.5)	12.9 (6.8-23.0)	9.8 (6.7-14.1)	11.7 (7.6-17.7)	5.4 (2.3-12.5)
Left	14.1 (9.5-20.4)	16.1 (9.9-25.1)	11.4 (5.8-21.3)	8.6 (5.7-12.8)	9.9 (6.1-15.5)	5.4 (2.3-12.5)
Neck	35.6 (28.6-43.3)	38.7 (29.3-49.0)	31.4 (21.6-43.2)	42.7 (36.8-48.9)	48.1 (40.5-55.9)	32.6 (23.8-42.9)
Right	31.9 (25.2-39.5)	35.5 (26.4-45.8)	27.1 (18.0-38.8)	41.2 (35.3-47.3)	46.3 (38.7-54.0)	31.5 (22.8-42.8)
Left	32.5 (25.7-40.1)	36.6 (27.4-46.9)	27.1 (18.0-38.8)	35.7 (30.0-41.8)	39.5 (32.2-47.3)	28.3 (20.0-38.4)
Shoulder	36.8 (29.7-44.5)	40.9 (31.3-51.2)	31.4 (21.6-43.2)	37.3 (31.5-43.4)	45.1 (37.5-52.8)	22.8 (15.3-32.6)
Right	28.2 (21.8-35.7)	32.3 (23.5-42.5)	22.9 (14.4-34.2)	30.6 (25.2-36.5)	36.4 (29.3-44.1)	19.6 (12.6-29.0)
Left	30.1 (23.5-37.6)	36.6 (27.4-46.9)	21.4 (13.3-32.6)	30.6 (25.2-36.5)	38.3 (31.1-46.0)	16.3 (10.0-25.4)
Elbow	9.8 (6.1-15.5)	7.5 (3.6-15.0)	12.9 (6.8-23.0)	7.5 (4.8-11.4)	5.6 (2.9-10.4)	10.9 (5.9-19.1)
Right	8.0 (4.7-13.3)	6.5 (2.9-13.7)	10.0 (4.8-19.6)	5.1 (3.0-8.6)	3.7 (1.7-8.0)	7.6 (3.6-15.2)
Left	6.7 (3.8-11.8)	4.3 (1.6-11.0)	10.0 (4.8-19.6)	3.1 (1.6-6.2)	1.9 (0.6-5.6)	5.4 (2.3-12.5)
Wrist/ hand	34.4 (27.4-42.0)	34.4 (25.4-44.7)	34.3 (24.1-46.2)	21.2 (16.6-26.6)	20.4 (14.8-27.3)	22.8 (15.3-32.6)
Right	27.0 (20.7-34.4)	28.0 (19.7-38.0)	25.7 (16.8-37.3)	16.1 (12.1-21.1)	18.5 (13.2-25.3)	12.0 (6.7-20.4)
Left	22.7 (16.9-29.8)	23.7 (16.1-33.4)	21.4 (13.3-32.6)	10.2 (7.0-14.6)	8.6 (5.2-14.1)	13.0 (7.5-21.7)
Upper back	29.4 (22.9-36.9)	30.1 (21.6-40.2)	28.6 (19.2-40.3)	29.4 (24.1-35.3	30.2 (23.6-37.8)	27.2 (19.0-37.2)
Right	25.8 (19.6-33.1)	26.9 (18.8-36.8)	24.3 (15.6-35.7)	27.5 (22.3-33.3)	27.8 (21.4-35.2)	26.1 (18.1-36.1)
Left	25.2 (19.0-32.4)	24.7 (17.0-34.6)	25.7 (16.8-37.3)	26.3 (21.2-32.0)	26.5 (20.3-33.9)	25.0 (17.2-34.9)
Chest/ abdomen	10.4 (6.6-16.2)	8.6 (4.3-16.3)	12.9 (6.8-23.0)	8.2 (5.4-12.3)	8.6 (5.2-14.1)	7.6 (3.6-15.2)
Right	8.0 (4.7-13.3)	6.5 (2.9-13.7)	10.0 (4.8-19.6)	5.9 (3.6-9.5)	6.2 (3.3-11.1)	5.4 (2.3-12.5)
Left	8.6 (5.1-14.0)	7.5 (3.6-15.0)	10.0 (4.8-19.6)	6.7 (4.2-10.5)	7.4 (4.2-12.6)	5.4 (2.3-12.5)
Lower back	36.2 (29.1-43.9)	38.7 (29.3-49.0)	32.9 (22.8-44.7)	46.7 (40.6-52.8)	50.0 (42.3-57.7)	32.9 (22.8-44.7)
Right	34.4 (27.4-42.0)	37.6 (28.3-47.9)	30.0 (20.4-41.8)	45.5 (39.5-51.7)	49.4 (41.7-57.1)	38.0 (28.7-48.4)
Left	32.5 (25.7-40.1)	34.4 (25.4-44.7)	30.0 (20.4-41.8)	42.0 (36.0-48.1)	43.8 (36.4-51.6)	38.0 (28.7-48.4)

(continued)

		Music students			Science students		
		All	Female	Male	All	Female	Male
Hip/ thigh		8.0 (4.7-13.3)	8.6 (4.3-16.3)	7.1 (3.0-16.1)	20.0 (15.5-25.4)	22.2 (16.5-29.3)	15.2 (9.2-24.2)
	Right	6.7 (3.8-11.8)	6.5 (2.9-13.7)	7.1 (3.0-16.1)	15.7 (11.7-20.7)	17.9 (12.7-24.6)	10.9 (5.9-19.1)
	Left	3.1 (1.3-7.2)	4.3 (1.6-11.0)	1.4 (0.2-9.6)	15.3 (11.4-20.3)	17.3 (12.2-23.9)	10.9 (5.9-19.1)
Knee		7.4 (4.2-12.6)	7.5 (3.6-15.0)	7.1 (3.0-16.1)	22.7 (18.0-28.3)	24.1 (18.1-31.3)	20.7 (13.5-30.2)
	Right	4.3 (2.0-8.8)	3.2 (1.0-9.6)	5.7 (2.1-14.3)	14.5 (10.7-19.4)	16.7 (11.7-23.2)	10.9 (5.9-19.1)
	Left	4.3 (2.0-8.8)	4.3 (1.6-11.0)	4.3 (1.4-12.6)	17.3 (13.1-22.4)	18.5 (13.2-25.3)	15.2 (9.2-24.2)
Ankle/ foot		9.8 (6.1-15.5)	11.8 (6.6-20.2)	7.1 (3.0-16.1)	20.4 (15.9-25.8)	21.6 (15.9-28.6)	18.5 (11.8-27.8)
	Right	8.0 (4.7-13.3)	9.7 (5.1-17.6)	5.7 (2.1-14.3)	16.1 (12.1-21.1)	17.9 (12.7-24.6)	13.0 (7.5-21.7)
	Left	7.4 (4.2-12.6)	7.5 (3.6-15.0)	7.1 (3.0-16.1)	13.3 (9.7-18.1)	13.6 (9.1-19.8)	13.0 (7.5-21.7)

Notes: MSS: musculoskeletal symptom. [a]chronic referred to musculoskeletal symptoms that occurred on most days for at least the lasts 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain intensity on average ratings of 5-10 on an 11-point rating scale.

Table A1.5.9: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 7 day prevalence of musculoskeletal symptoms between university music and science students

	All		Female		Male	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall						
Moderate-severe pain[a]	2.523 (1.337-4.761), p=0.004**	1.996 (0.903-4.279), p=0.089	2.395 (1.099-5.220), p=0.028*	2.283 (1.040-5.012), p=0.040*	3.167 (1.001-10.019), p=0.050	3.446 (1.055-11.254), p=0.040*
Combined regions						
Neck/ trunk	0.570 (0.382-0.851), p=0.006**	0.629 (0.413-0.958), p=0.031*	0.490 (0.290-0.828), p=0.008**	0.549 (0.319-0.945), p=0.030*	0.277 (0.129-0.597), p=0.001**	0.229 (0.102-0.517), p<0.001***
Lower limb	0.276 (0.172-0.443), p<0.001***	0.274 (0.168-0.446), p<0.001***	0.285 (0.157-0.520), p<0.001***	0.322 (0.175-0.594), p<0.001***		
Specific regions						
Wrist/ hand	1.948 (1.253-3.029), p=0.003**	2.172 (1.378-3.424), p=0.001**	2.051 (1.155-3.640), p=0.014*	2.447 (1.349-4.436), p=0.003**		
Lower back	0.648 (0.433-0.970), p=0.035*	0.656 (0.436-0.986), p=0.043*	0.632 (0.376-1.061), p=0.082	0.471 (0.262-0.848), p=0.012*		
Hip/ thigh	0.347 (0.182-0.660), p=0.001**	0.395 (0.204-0.764), p=0.006**	0.329 (0.146-0.743), p=0.007**	0.332 (0.147-0.750), p=0.008**		0.376 (0.122-1.160), p=0.089
Knee	0.270 (0.140-0.521), p<0.001***	0.353 (0.165-0.756), p=0.007**	0.257 (0.110-0.601), p=0.002**	0.259 (0.111-0.607), p=0.002**	0.296 (0.104-0.836), p=0.022*	0.235 (0.076-0.727), p=0.012*
Ankle/ foot	0.425 (0.233-0.774), p=0.005**	0.550 (0.282-1.074), p=0.080	0.487 (0.234-1.012), p=0.054	0.485 (0.233-1.010), p=0.053	0.339 (0.119-0.971), p=0.044*	0.266 (0.085-0.831), p=0.023*

Notes: University science students were the reference group. [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain intensity on average ratings of 5-10 on an 11-point rating scale. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.5.10: 7 day prevalence (95% confidence interval) of musculoskeletal symptoms for professional musicians and university staff

		Professional musicians			University staff		
		All	Female	Male	All	Female	Male
Overall		71.5 (65.2-77.1)	79.7 (71.6-85.9)	61.5 (51.3-70.7)	87.0 (81.7-91.0)	86.5 (80.1-91.0)	88.7 (77.0-94.8)
Chronic[a]		38.6 (32.3-45.3)	44.1 (35.3-53.2)	31.6 (23.0-41.6)	44.4 (37.7-51.3)	43.1 (35.5-51.1)	48.1 (34.9-61.5)
Chronic[a] of those with MSSs		54.6 (46.6-62.4)	55.9 (45.7-65.7)	51.7 (39.0-64.3)	51.1 (43.8-58.4)	50.0 (41.5-58.5)	54.3 (40.0-68.1)
Moderate-severe pain[b]		24.7 (18.3-32.3)	30.3 (21.7-40.7)	16.1 (8.6-28.1)	18.8 (13.6-25.2)	19.1 (13.2-26.8)	17.8 (9.1-31.8)
Combined region							
Head/ orofacial		21.2 (16.2-27.2)	28.1 (20.8-36.8)	12.8 (7.4-21.2)	29.8 (24.0-36.4)	34.2 (27.1-42.0)	17.0 (9.0-29.7)
Upper limb		55.3 (48.6-61.8)	62.8 (53.8-71.0)	45.7 (35.9-55.9)	61.1 (54.2-67.5)	61.9 (54.0-69.3)	58.5 (44.8-71.0)
Neck/ trunk		53.0 (46.3-59.6)	60.3 (51.3-68.7)	44.7 (34.9-54.9)	76.4 (70.2-81.7)	77.4 (70.1-83.3)	73.6 (60.1-83.8)
Lower limb		23.5 (18.3-29.6)	24.0 (17.2-32.4)	22.3 (15.0-31.9)	60.0 (55.3-64.6)	60.0 (52.1-67.4)	49.1 (35.9-62.4)
Specific regions							
Head		15.2 (11.0-20.7)	21.5 (15.0-29.7)	7.4 (3.6-14.9)	23.6 (18.3-29.8)	27.1 (20.7-34.6)	13.2 (6.4-25.3)
	Right	13.8 (9.8-19.1)	19.0 (12.9-27.0)	7.4 (3.6-14.9)	19.2 (14.4-25.2)	21.3 (15.5-28.5)	13.2 (6.4-25.3)
	Left	12.4 (8.7-17.6)	16.5 (10.9-24.3)	7.4 (3.6-14.9)	20.7 (15.7-26.7)	23.2 (17.2-30.5)	13.2 (6.4-25.3)
Orofacial		13.8 (9.8-19.1)	18.2 (12.3-26.1)	8.5 (4.3-16.2)	11.5 (7.8-16.7)	13.5 (9.0-19.9)	5.7 (1.8-16.2)
	Right	11.5 (7.9-16.5)	15.7 (10.2-23.4)	6.4 (2.9-13.5)	9.6 (6.3-14.5)	11.0 (6.9-17.0)	5.7 (1.8-16.2)
	Left	11.1 (7.5-16.0)	15.7 (10.2-23.4)	5.3 (2.2-12.2)	7.2 (4.4-11.6)	9.0 (5.4-14.7)	1.9 (0.3-12.3)
Neck		37.8 (31.6-44.5)	47.1 (38.3-56.0)	26.6 (18.6-36.5)	51.4 (44.6-58.2)	52.3 (44.4-60.0)	49.1 (35.9-62.3)
	Right	31.3 (25.5-37.8)	39.7 (31.3-48.7)	21.3 (14.1-30.8)	47.1 (40.4-53.9)	48.4 (40.6-56.3)	43.4 (30.8-56.9)
	Left	34.6 (28.5-41.2)	43.0 (34.4-52.0)	24.5 (16.8-34.2)	41.3 (34.8-48.2)	41.9 (34.4-49.9)	39.6 (27.4-53.3)
Shoulder		41.9 (35.5-48.6)	50.4 (41.5-59.3)	30.9 (22.3-40.9)	44.2 (37.6-51.1)	46.5 (38.7-54.3)	37.7 (25.8-51.4)
	Right	30.9 (25.1-37.4)	37.2 (29.0-46.2)	22.3 (15.0-31.9)	38.5 (32.1-45.3)	40.0 (32.6-47.9)	34.0 (22.5-47.6)
	Left	31.3 (25.5-37.8)	41.3 (32.9-50.3)	18.1 (11.5-27.2)	31.3 (25.3-37.9)	34.2 (27.1-42.0)	22.6 (13.3-35.8)
Elbow		9.2 (6.0-13.9)	9.9 (5.7-16.7)	8.5 (4.3-16.2)	10.1 (6.7-15.0)	10.3 (6.4-16.2)	9.4 (4.0-20.8)
	Right	7.8 (4.9-12.3)	7.4 (3.9-13.7)	8.5 (4.3-16.2)	6.7 (4.0-11.1)	7.7 (4.4-13.2)	3.8 (0.9-13.9)
	Left	4.1 (2.2-7.8)	4.1 (1.7-9.6)	4.3 (1.6-10.8)	5.3 (2.9-9.3)	5.2 (2.6-10.0)	5.7 (1.8-16.2)
Wrist/ hand		28.6 (22.9-35.0)	30.6 (23.0-39.4)	25.5 (17.7-35.3)	26.9 (21.3-33.4)	27.1 (20.7-34.6)	26.4 (16.3-39.8)
	Right	21.7 (16.7-27.7)	24.8 (17.9-33.3)	17.0 (10.7-26.1)	22.6 (17.4-28.8)	23.9 (17.8-31.2)	18.9 (10.4-31.7)
	Left	18.4 (13.8-24.2)	19.8 (13.6-27.9)	17.0 (10.7-26.1)	12.0 (8.2-17.2)	12.3 (7.9-18.4)	11.3 (5.2-23.0)
Upper back		26.3 (20.8-32.6)	33.1 (25.2-42.0)	18.1 (11.5-27.2)	26.0 (20.4-32.4)	27.7 (21.2-35.3)	20.8 (11.9-33.8)
	Right	23.0 (17.9-29.1)	28.1 (20.8-36.8)	17.0 (10.7-26.1)	24.5 (19.1-30.8)	25.8 (19.5-33.3)	20.8 (11.9-33.8)
	Left	21.7 (16.7-27.7)	28.1 (20.8-36.8)	13.8 (8.2-22.4)	21.2 (16.1-27.3)	21.9 (16.1-29.2)	18.9 (10.4-31.7)
Chest/ abdomen		6.0 (3.5-10.1)	5.8 (2.8-11.7)	6.4 (2.9-13.5)	6.3 (3.7-10.5)	5.2 (2.6-10.0)	9.4 (4.0-20.8)
	Right	3.2 (1.5-6.6)	3.3 (1.2-8.5)	3.2 (1.0-9.5)	4.8 (2.6-8.7)	3.9 (1.7-8.4)	7.5 (2.9-18.5)
	Left	6.0 (3.5-10.1)	5.8 (2.8-11.7)	6.4 (2.9-13.5)	4.3 (2.3-8.1)	3.9 (1.7-8.4)	5.7 (1.8-16.2)
Lower back		35.5 (29.4-42.1)	40.5 (32.1-49.5)	29.8 (21.4-39.8)	51.9 (45.1-58.7)	52.3 (44.4-60.0)	50.9 (37.7-64.1)
	Right	33.2 (27.2-39.7)	38.0 (29.8-47.0)	27.7 (19.5-37.6)	48.1 (41.3-54.9)	48.4 (40.6-56.3)	47.2 (34.2-60.5)
	Left	33.2 (27.2-39.7)	37.2 (29.0-46.2)	28.7 (20.5-38.7)	44.7 (38.1-51.5)	43.2 (35.6-51.2)	49.1 (35.9-62.3)

(continued)

		Professional musicians			University staff		
		All	**Female**	**Male**	**All**	**Female**	**Male**
Hip/ thigh		12.9 (9.0-18.1)	14.0 (8.9-21.5)	10.6 (5.8-18.7)	30.8 (24.9-37.4)	36.1 (28.9-44.0)	15.1 (7.7-27.4)
	Right	11.1 (7.5-16.0)	12.4 (7.6-19.6)	8.5 (4.3-16.2)	22.1 (17.0-28.3)	26.5 (20.1-34.0)	9.4 (4.0-20.8)
	Left	7.4 (4.6-11.7)	8.3 (4.5-14.7)	5.3 (2.2-12.2)	22.1 (17.0-28.3)	25.8 (19.5-33.3)	11.3 (5.2-23.0)
Knee		10.6 (7.1-15.5)	9.1 (5.1-15.7)	12.8 (7.4-21.2)	30.8 (24.9-37.4)	31.6 (24.8-39.4)	28.3 (17.8-41.8)
	Right	6.5 (3.8-10.6)	5.8 (2.8-11.7)	7.4 (3.6-14.9)	19.2 (14.4-25.2)	20.0 (14.4-27.1)	17.0 (9.1-29.6)
	Left	6.9 (4.2-11.2)	6.6 (3.3-12.7)	7.4 (3.6-14.9)	20.2 (15.3-26.2)	20.6 (15.0-27.8)	18.9 (10.4-31.7)
Ankle/ foot		8.3 (5.3-12.8)	7.4 (3.9-13.7)	9.6 (5.0-17.4)	25.0 (19.6-31.3)	26.5 (20.1-34.0)	20.8 (11.9-33.8)
	Right	5.5 (3.2-9.5)	5.0 (2.2-10.6)	6.4 (2.9-13.5)	17.3 (12.7-23.1)	17.4 (12.2-24.2)	17.0 (9.1-29.6)
	Left	6.0 (3.5-10.1)	5.0 (2.2-10.6)	7.4 (3.6-14.9)	16.3 (11.9-22.0)	18.1 (12.8-24.9)	11.3 (5.2-23.0)

Notes: MSS: musculoskeletal symptom. [a]chronic referred to musculoskeletal symptoms that occurred on most days for at least the lasts 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain intensity on average ratings of 5-10 on an 11-point rating scale.

Table A1.5.11: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 7 day prevalence of musculoskeletal symptoms between professional musicians and university staff

	All		Females		Male	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Overall	0.374 (0.227-0.616), p<0.001***				0.204 (0.079-0.523), p=0.001**	0.369 (0.131-1.036), p=0.058
Chronic[a]				1.801 (0.979-3.316), p=0.059	0.498 (0.249-0.999), p=0.050	0.503 (0.250-1.010), p=0.053
Moderate-severe pain[b]			1.846 (0.986-3.459), p=0.056	2.033 (1.071-3.859), p=0.030*		
Combined regions						
Head/ orofacial	0.633 (0.408-0.984), p=0.042*			1.730 (0.931-3.216), p=0.083		
Neck/ trunk	0.347 (0.229-0.527), p<0.001***	0.542 90.335-0.875), p=0.012*	0.444 (0.263-0.749), p=0.002**		0.290 (0.139-0.604), p=0.001**	0.474 (0.210-1.072), p=0.073
Lower limb	0.230 (0.151-0.349), p<0.001***	0.276 (0.168-0.453), p<0.001***	0.210 (0.124-0.356), p<0.001***		0.299 (0.145-0.617), p=0.001**	0.292 (0.139-0.612), p=0.001**
Specific regions						
Head	0.582 (0.357-0.950), p=0.030*					
Neck	0.573 (0.390-0.844), p=0.005**				0.376 (0.186-0.763), p=0.007**	
Wrist/ hand				1.695 (0.921-3.117), p=0.090		
Lower back	0.509 (0.345—0.751), p=0.001**	0.678 (0.429-1.073), p=0.097	0.622 (0.384-1.006), p=0.053	0.637 (0.383-1.059), p=0.082	0.409 (0.204-0.820), p=0.012*	
Hip/ thigh	0.333 (0.203-0.546), p<0.001***	0.374 (0.225-0.624), p<0.001***	0.289 (0.157-0.531), p<0.001***	0.303 (0.164-0.560), p<0.001***		
Knee	0.267 (0.158-0.450), p<0.001***	0.284 (0.163-0.495), p<0.001***	0.216 (0.107-0.438), p<0.001***	0.170 (0.070-0.409), p<0.001***	0.371 (0.158-0.868), p=0.022*	0.371 (0.158-0.870), p=0.023*
Ankle/ foot	0.271 (0.153-0.482), p<0.001***	0.326 (0.166-0.637), p=0.001**	0.223 (0.104-0.481), p<0.001***	0.231 (0.106-0.503), p<0.001***	0.404 (0.156-1.051), p=0.063	0.262 (0.087-0.793), p=0.018*

Notes: University staff were the reference group. [a]chronic referred to musculoskeletal symptoms that occurred on most days for at least the lasts 3 months. [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain referred to pain intensity on average ratings of 5-10 on an 11-point rating scale. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with an odds ratio >1. Blue text indicates a statistically significant association (p<0.050), with an odds ratio <1. Black text indicates near-significant associations (0.050<p<0.100). *p<0.050, **p<0.010, ***p<0.001

Table A1.5.12: Musculoskeletal symptom outcome ratings (median, interquartile range) for music students, science students, professional musicians, and university staff

	Music students			Science students			Professional musicians			University staff		
	All	**Female**	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**
Pain intensity on average	3.0 (2.0-4.0)	3.0 (2.0-5.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-3.0)	3 (2-4)	4 (2-5)	2 (1-4)	2 (1-4)	2 (1-4)	2 (1-3)
Impact of MSSs on daily life	3.0 (2.0-6.0)	3.0 (2.0-6.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)	3.0 (2.0-4.0)	3 (2-6)	4 (2-6)	3 (2-5)	3 (2-6)	3 (2-6)	3 (2-6)
Emotional impact of MSSs	2.0 (0.0-5.0)	4.0 (1.0-7.0)	3.0 (1.0-5.0)	2.0 (1.0-4.0)	3.0 (1.0-5.0)	1.0 (0.5-3.0)	3 (1-6)	3 (1-6)	2 (0-4)	2 (1-5)	2 (1-5)	2 (0-5)

Notes: IQR: interquartile range. SD: standard deviation. MSS: musculoskeletal symptom. Ratings were only made by those who reported musculoskeletal symptoms in the last 7 days.

Table A1.5.13: Significant and near-significant (p<0.10) differences in the musculoskeletal symptom ratings between music and science students with musculoskeletal symptoms

	All (beta coefficients[a])		Males (odds ratio[b])
	Unadjusted	**Adjusted**	**Adjusted**
Emotional impact of MSSs	0.718 (0.291-1.146), p=0.001**	0.665 (0.137-1.193), p=0.014*	4.218 (1.888-9.424), p<0.001***

Notes: MSS: musculoskeletal symptom. Ratings were made by those who reported musculoskeletal symptoms in the last 7 days. [a]beta coefficients were reported for ordinal logistic regression of quartiles. [b]odds ratios were reported for binary logistic regression using a median cut-point (analysis as quartiles with ordered logistic regression violated the parallel lines assumption). Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.5.14: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) differences in the musculoskeletal symptom ratings between professional musicians and university staff with musculoskeletal symptoms

	Females	
	Unadjusted	**Adjusted**
Emotional impact of MSSs	0.433 (-0.055-0.920), p=0.082	0.436 (-0.057-0.928), p=0.083
Impact of MSSs on daily impact		0.464 (-0.030-0.958), p=0.066

Notes: MSS: musculoskeletal symptom. Ratings were made by those who reported musculoskeletal symptoms in the last 7 days. Only odds ratios with p<0.100 are shown. Orange text indicates a statistically significant association (p<0.050), with a beta coefficient >0. Blue text indicates a statistically significant association (p<0.050), with a beta coefficient of <0. Black text indicates near-significant associations (0.050<p<0.100).*p<0.050, **p<0.010, ***p<0.001

Table A1.5.15: 12 month prevalence (95% confidence interval) of musculoskeletal symptom consequences in the last 12 months amongst symptomatic university music and science students

	Music students			Science students		
	All	Female	Male	All	Female	Male
Work/ study						
Changes to work/ study	20.4 (14.5-27.9)	23.8 (15.9-34.1)	15.5 (8.2-27.3)	10.6 (7.2-15.5)	13.0 (8.4-19.8)	6.5 (2.7-14.8)
Leave from work/ study	23.9 (17.6-31.7)	28.6 (19.9-39.2)	17.2 (9.5-29.3)	16.3 (11.9-21.9)	19.7 (13.8-27.3)	9.1 (4.4-18.0)
Consulted a health professional	65.1 (59.2-70.5)	67.4 (56.8-76.5)	50.8 (38.4-63.1)	50.4 (44.1-56.8)	55.6 (47.6-63.3)	40.5 (30.5-51.3)
Medical professional	38.9 (33.2-44.9)	40.5 (30.5-51.3)	31.0 (20.4-44.1)	34.3 (28.2-40.9)	35.5 (27.9-43.9)	32.5 (22.9-43.7)
Psychologist/ counsellor	6.0 (3.7-9.6)	3.6 (1.1-10.6)	8.6 (3.6-19.2)	4.6 (2.5-8.4)	5.8 (2.9-11.2)	2.6 (0.6-9.9)
Physiotherapist/ occupational therapist	34.7 (29.2-40.7)	34.5 (25.1-45.3)	25.9 (16.2-38.7)	25.9 (20.5-32.2)	29.0 (22.0-37.1)	19.5 (12.1-29.9)
Personal trainer/ Pilates instructor/ yoga instructor	14.0 (10.3-18.7)	11.9 (6.5-20.8)	10.3 (4.7-21.3)	6.0 (3.5-10.1)	7.2 (3.9-13.0)	3.9 (1.3-11.5)
Chiropractor/ osteopath, massage therapist, Bowen therapist	26.8 (21.8-32.5)	25.0 (16.8-35.4)	19.0 (10.8-31.2)	15.3 (11.1-20.7)	18.1 (12.5-25.5)	10.4 (5.3-19.5)
Naturopath/ homeopath	3.4 (1.8-6.4)	3.6 (1.1-10.6)	3.4 (0.9-12.9)	0.5 (0.1-3.2)	0.7 (0.1-5.0)	0.0
Other	6.3 (3.3-11.8)	7.1 (3.2-15.1)	5.2 (1.7-15.0)	1.9 (0.7-4.8)	2.2 (0.7-6.6)	1.3 (0.2-8.8)
Self-management	83.7 (76.7-88.8)	89.5 (81.0-94.5)	75.4 (63.0-84.7)	80.7 (75.1-85.2)	83.0 (76.2-88.2)	76.2 (65.9-84.1)
Medication	28.9 (22.0-36.9)	31.0 (21.9-41.7)	25.9 (16.2-38.7)	43.1 (36.6-49.8)	52.2 (43.8-60.4)	27.3 (18.4-38.3)
Heat/ ice	40.1 (32.3-48.5)	44.0 (33.8-54.9)	34.5 (23.4-47.6)	47.7 (41.1-54.4)	50.7 (42.4-59.0)	41.6 (31.0-52.9)
Exercises/ stretches	76.8 (69.0-83.0)	81.0 (71.1-88.0)	70.7 (57.7-81.0)	74.5 (68.3-79.9)	75.4 (67.5-81.9)	74.0 (63.0-82.6)
Braces/ strapping/ taping	24.6 (18.2-32.5)	29.8 (20.9-40.4)	17.2 (9.5-29.3)	24.1 (18.8-30.2)	27.5 (20.7-35.6)	18.2 (11.0-28.5)
Other	3.5 (1.5-8.2)	4.8 (1.8-12.1)	1.7 (0.2-11.4)	3.7 (1.8-7.2)	5.0 (2.4-10.2)	1.3 (0.2-8.8)

Table A1.5.16: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 12 month prevalence of musculoskeletal symptom consequences between symptomatic university music and science students

	All		Female		Male	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Work/ study						
Changes to work/ study	2.154 (1.188-3.902), p=0.011*	2.182 (1.194-3.990), p=0.011*	2.083 (1.029-4.218), p=0.041*	2.050 (1.011-4.160), p=0.047*	2.645 (0.836-8.369), p=0.098	2.774 (0.843-9.135), p=0.093
Leave from work/ study	1.619 (0.954-2.747), p=0.074	1.707 (0.988-2.949), p=0.055				
Treatment						
Consult a health professional	1.509 (0.994-2.290), p=0.053		1.657 (0.954-2.879), p=0.073			

Notes: *p<0.050, **p<0.010, ***p<0.001

Table A1.5.17: 12 month prevalence (95% confidence interval) of musculoskeletal symptom consequences in the last 12 months amongst symptomatic professional musicians and university staff

	Professional musicians			University staff		
	All	Female	Male	All	Female	Male
Work/ study						
Changes to work/ study	13.5 (9.3-19.3)	17.1 (11.2-25.3)	8.2 (3.7-17.2)	7.7 (4.7-12.4)	8.8 (5.2-14.7)	4.2 (1.0-15.4)
Leave from work/ study	21.6 (16.2-28.2)	27.0 (17.6-36.1)	13.7 (7.5-23.7)	20.6 (15.5-26.9)	22.4 (16.4-29.9)	14.9 (7.2-28.2)
Workers' compensation	4.3 (2.2-8.4)	3.6 (1.4-9.3)	5.5 (2.1-13.8)	0.5 (0.0-3.5)	0.7 (0.1-4.7)	0.0
Treatment	69.8 (62.9-76.0)	76.8 (68.0-83.7)	60.5 (49.1-70.9)	68.7 (61.9-74.7)	71.3 (63.6-78.0)	60.8 (46.8-73.2)
Medical professional	41.6 (34.7-48.9)	45.9 (36.9-55.3)	35.6 (25.5-47.2)	38.3 (31.7-45.3)	39.9 (32.3-48.0)	33.3 (21.4-47.8)
Psychologist/ counsellor	5.4 (2.9-9.8)	5.4 (2.4-11.6)	5.5 (2.1-13.8)	3.1 (1.4-6.7)	4.1 (1.8-8.8)	0.0
Physiotherapist/ occupational therapist	40.0 (33.2-473)	44.1 (35.2-53.5)	34.2 (24.3-45.9)	42.3 (35.6-49.4)	46.6 (38.7-54.7)	29.2 (18.0-43.6)
Personal trainer/ Pilates instructor/ yoga instructor	17.3 (12.5-23.5)	22.5 (15.7-31.3)	9.6 (4.6-18.8)	21.9 (16.7-28.3)	25.7 (19.3-33.3)	10.4 (4.4-22.8)
Chiropractor/ osteopath/ massage therapist/ Bowen therapist	30.8 (24.5-37.9)	34.2 (26.0-43.6)	26.0 (17.2-37.3)	23.5 (18.0-29.9)	26.4 (19.9-34.1)	14.6 (7.1-27.7)
Naturopath/ homeopath	4.3 (2.2-8.4)	6.3 (3.0-12.7)	1.4 (0.2-9.2)	1.5 (0.5-4.7)	1.4 (0.3-5.3)	2.1 (0.3-13.6)
Other	7.6 (4.5-12.4)	8.1 (4.3-14.9)	6.8 (2.9-5.5)	2.0 (0.8-5.3)	2.7 (1.0-7.0)	0.0
Self-management	88.4 (82.9-92.2)	92.0 (85.2-95.8)	82.9 (72.7-89.8)	91.5 (86.8-94.7)	92.7 (87.2-95.9)	88.2 (76.1-94.7)
Medication	42.2 (35.2-49.4)	45.9 (36.9-55.3)	37.0 (26.7-48.6)	56.6 (49.6-63.4)	58.8 (50.7-66.5)	50.0 (36.1-63.9)
Heat/ ice	43.8 (36.8-51.1)	51.4 (42.1-60.6)	32.9 (23.1-44.5)	52.6 (45.5-59.5)	58.1 (50.0-65.8)	35.4 (23.2-49.9)
Exercises/ stretches	82.2 (75.9-87.1)	86.5 (78.7-91.7)	75.3 (64.1-83.9)	84.2 (78.4-88.7)	83.8 (76.9-88.9)	85.4 (72.3-92.9)
Braces/ strapping/ taping	23.8 (18.2-30.5)	26.1 (18.8-35.1)	20.5 (12.7-31.4)	18.4 (13.5-24.4)	19.6 (13.9-26.8	14.6 (7.1-27.7)
Other	7.6 (4.5-12.4)	8.1 (4.3-14.9)	5.5 (2.1-13.8)	6.6 (3.9-11.0)	8.1 (4.6-13.7)	2.1 (0.3-13.6)

Table A1.5.18: Odds ratio (95% confidence interval) for the significant or near-significant (p<0.10) differences in the 12 month prevalence of musculoskeletal symptom consequences between symptomatic professional musicians and university staff

	All		Female	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Work/ study				
Changes to work/ study	1.768 (0.911-3.429), p=0.092	1.964 (0.998-3.867), p=0.051	2.145 (1.009-4.557), p=0.047*	
Leave from work/ study		1.717 (0.951-3.099), p=0.073		2.103 (0.981-4.506), p=0.056

Notes: There were no significant differences in the musculoskeletal symptom consequences between male professional musicians and university; hence, males were omitted from the table above. *p<0.050, **p<0.010, ***p<0.001

A1.6: Supplementary Material for Chapter 6

Table A1.6.1 Agencies for musicians' claimed musculoskeletal disorders

Type of agency	Specific agencies
Machinery and (mainly) fixed plant	Electrical installation (n=1)
Mobile plant and transport	Self-propelled plant (n=1) Road transport (n=22) Air transport (n=1)
Powered equipment, tools and appliances	Workshop and worksite tools and equipment (n=1) Kitchen and domestic equipment (n=1) Office and electronic equipment (n=17) Pressure-based equipment, not elsewhere classified (n=1) Other powered equipment, tools and appliances (n=1)
Non-powered hand tools, appliances and equipment	Hand tools, non-powered, edged (n=1) Other hand tools (n=10) Fastening, packing and packaging equipment (n=10) Furniture and fittings (n=22) Other utensils (n=1) Ladders, mobile ramps and stairways, and scaffolding (n=2) Other non-powered equipment (n=216)
Materials and substances	Other materials and objects (n=48) Other substances (n=1)
Environmental agencies	Outdoor environment (n=31) Indoor environment (n=40)
Animal, human and biological agencies	Human agencies (n=15)
Other and unspecified agencies	Non-physical agencies (n=5) Other and unspecified agencies (n=96)

A1.7: Supplementary Material for Chapter 7

A1.7.1 Behavioural factors (quoted) listed as 'causes' of musicians' musculoskeletal symptoms

Musical factors

Muscle use/ movement

Bad embouchure
Technique
Poor technique
Incorrect technique
Playing technique
Technique during practice
Practiced wrong method
Inefficient physical movement in practice
Poor technique/ posture
Bad posture/ technique
Pressure from others causing tense playing
Too much tension when practising
Tensing of muscles: not being soft enough in my playing
Tension in muscles when playing
Tensing whilst playing
Tension when playing
Tension when playing (i.e. holding too tightly)
Playing with tension
Tension in shoulders and neck while playing
Shoulder not relaxed when playing the piano
Tensing of hand when playing long fast passages
Tight/ tense should while playing the piano
Not relaxing enough during muscle activity
Thumbs – playing for extended length of time – gripping instrument
Grip of jaw on mouth piece
Jaw tightness while playing
Strain in jaw while singing
Suboptimal vocal habits I developed as a coping mechanism for the muscular imbalances (which I am fixing)
Squeezing the neck on the double bass
Trombone grip
Repeated kicking of the kick pedal
Pedalling – big toe
Stretching exercises – arpeggios
Technical work Gr 8
Beethoven tremolo passages
Practice etiquette (taking breaks, standing, not doing too much repetition)
Past incorrect use of muscles during intensive music training and practice
RSI from playing live/ practicing
Repetitive strain due to instrument ergonomics
Constant use of musical instruments involving repetitive actions over many years & now being older

Posture/ position

Poor technique/ posture
Bad posture/ technique
Wrong hand position/ posture
Posture (playing or not)
Position – conducting/ playing – seated at desk
Poor posture while performing (lower back pain)
Bad posture when playing/teaching
Posture for playing piano while teaching singing
Music-related (posture whilst playing)
Posture while playing
Playing with poor posture
Long term incorrect playing posture
Posture when seated at piano
Position of trombone on shoulder
Sitting on a drum stool
Uncomfortable sitting angle in orchestra/ pit
Playing bassoon in the wrong position
Always looking down to look at scores
Incorrect posture when playing saxophone
Many years of playing and standing on parade (lower back)
Feet: marching and standing on parade
Knees: marching and standing on parade
Standing playing bass for extended periods of time
Practicing with standing
Sitting while practicing
Long periods of sitting (music-related)
Long hours of sitting in classes especially rehearsals
Long periods of standing while playing (feet)

(continued)

Drum kit – lower back (twisting body to play drums)
Posture/ playing instrument for long time periods without break
Practice etiquette (taking breaks, standing, not doing too much repetition)
Sitting to the right of left of the student rather than standing when teaching
Turning my head to the left when teaching for many years and now turning my head to the right when teaching
Holding my arms up while playing
Arm fixed in one position when playing
Holding flute up for a long time
Awkward playing position

Manual handling
Lifting/ moving harp
Carrying heavy (mock) rifle at opera rehearsal
Carrying trombone
Carrying trombone around for years
Carrying heavy items (backpack, instruments)
Carrying a heavy instrument
Carrying heavy instruments (e.g. bass guitar)
Probably lifting heavy cases
Repeated carrying of heavy instrument cases
Lifting keyboards (right shoulder)
Heavy lifting of pianos/ keyboards/ other objects when I was younger
Carrying saxophones/ gear around
French horn playing/ carrying/ supporting instrument
Constant weight from saxophones on shoulders while playing
Playing saxophone (alto) for long hours every day using a neck strap
Hanging baritone sax around the neck
The weight of the saxophone on neck for excessive periods of time
Weight of the instrument being focused on one area (right thumb/ wrist)
Weights (i.e. lifting amps)
Weight of instrument (EEb tuba) and carrying it (single strap support)
Weight of oboe (right hand, between wrist and pinky finger)
Playing saxophone (i.e. having a heavy instrument attached to a neck strap straining my neck)
Holding flute up for a long time
Holding instrument up for long time without rest
Many years of holding up a trumpet (left shoulder)

Work/ study
Teaching work
Long hours of sitting in classes and especially rehearsals
Bad posture when playing/teaching
Long periods of practicing/ teaching
Posture for playing piano while teaching singing
Sitting to the right or left of the student rather than standing when teaching
Turning my head to the left when teaching for many years and now turning my head to the right when teaching

Physical activity
Not enough stretching before or after practice
Not stretching before or after the musical activity
Lack of exercise/ stretches beforehand
Especially demanding dramatic physicalisation
Marching with an instrument
Many years of wearing army boots, marching and standing on parade
Feet: marching and standing on parade
Knees: marching and standing on parade
Attempting #1[a] without building up strength in the forearm first

Duration/ structure of musical activity
Practicing piano for many hours (after not being used to it)
Long hours of musical activity
Long hours of playing
Amount of hours spent practicing
Playing for too long
Practicing too much
Extended time playing the flute
Longevity of practice
Long hours of playing piano in youth
Practicing piano for a long time
Practising for too long at one sitting
Prolonged practice with few breaks
Practice without breaks
Practicing for too long at a stretch
Short rest periods between performances
Practicing every day
A lot of playing

(continued)

Duration of rehearsal
Length of concert
Excessive piano practice (Hanon)

Other
Repertoire choice
Repertoire
Big concert last week
Inefficient practicing
Ongoing rehearsal necessary
Practicing
Practice habits
Practicing too hard
Practicing incorrectly in my early years
Not warming up
Unsupervised practice
Conducting
Playing
Playing my instruments (lifelong)
Practice my instrument
Playing trombone
Playing viola for 50 years
Playing violin
Violin
Playing drums
Piano playing
Piano (didn't worsen or improve my condition, but kept it from healing)
Orchestra playing
Injury while performing/ workshopping
General physical demands of singing full time
Over playing
Over 40 years in the profession

Non-musical
Muscle use/ movement
Grinding teeth at night/ when stressed
Prolonged repetitive movements
Repetitive strain
Repetitive movement
Repetitive motion
Repetitive actions, poor posture and general genetic susceptibility (knees)
Overuse
Overuse of a muscle
Over-straining muscles
Overuse through using arm for muscle-testing
Continued use of shoulder
Tension-causes tightness in shoulders
Muscle tenseness
Not enough posterior chain usage
Too much anterior chain usage
Walking in a way that is not normal (for me)
Walking with heavy shoes on
Moving the wrong way
Rotating elbow
Twisting - hip
Performing physically awkward tasks

Posture/ position
Position – conducting/ playing – seated at desk
position
Too much time sitting and working on PhD
Prolonged periods of sitting over computer
Long hours sitting at desk job
Sitting a desk/ computer
Sitting at computer
Too much sitting down
Sitting
Long time sitting
Sitting down too much
Many hours sitting
Sitting all day
Sitting too long
Sitting for too long
Sitting for long periods at a time
Standing for long periods

(continued)

Standing for long periods of time
Standing for long amounts of time
Standing in the same position for a long time
Standing for extended periods of time
Standing for too long
Repetitive actions, poor posture and general genetic susceptibility (knees)
Hunching over
slouching
Poor shoes/ posture
Bad posture
Poor posture
Incorrect posture
Posture
Posture – back pain and headaches
Posture/ chair whilst sitting
Back posture
Wrist posture
Unrelaxed posture
Inattention to posture
Very ingrained bad posture I've had since childhood
Stress and study/ research demands means I'm constantly fighting between old and new postural habits
Staring at screens, or just activities involving pointing head in one direction, leading to stiffness of neck
Sustained time in those positions[b]
Bad sleeping position
Sleeping in an improper positing
Sleeping position
Sleeping posture
Sleeping in funky positions
Sleeping in strange positions which then hurts my neck
Sleeping in a weird position

Manual handling
Carrying a heavy bag for uni
Carrying heavy backpack
Carrying equipment
Heavy lifting
Lifting heavy equipment
Lifting equipment
Lifting heavy objects
Loading truck with low ceiling height
Weight in one arm
Pregnancy and just holding a baby
Carrying around children
Children – lifting them, lifting out of cars when asleep, when they use you as a play gym

Exercise/ sport
Gym
Rowing
Dance
Basketball
Playing golf
Tennis – caused both injury to my wrist and my knee
Running on a treadmill
Other non music related activities including cycling
Did the stairs at work
Early gymnastics and sports
High impact sports (long jump)
Shoulder exercises (chin ups)
Exercise injury – all injuries
Exercise
Recent exercise
Old sporting injuries?
Exercise – hurt my back/ hips running and it never recovered
Ongoing physical exercise – all injuries
Exercise amount
Hard impact exercise
Personal trainer exercises
Weights
Exercise and sleep regulation
Inactivity
Lack of stretching
Not stretching
Not stretching enough
Not enough exercise
Not exercising/ stretching enough

(continued)

Lack of strength training/ stretching
Lack of physical activity
Lack of resistance training
Lack of exercise
Not enough exercise
Not building/ maintaining associated muscles
Insufficient physical activity on a daily basis/ stress
Lack of exercise in pregnancy
Lack of time for strengthening/ relaxing exercises
Intense activity after periods of non-activity
Played sport for the first time in a while (not related to wrist/ arm soreness)
Cycling: returning to sport after several weeks off the bike due to flu
Having been sick recently, I haven't been stretching or doing yoga as much
Trauma related injuries after bicycle accident

Gardening/ domestic duties/ child care
Strenuous activities (gardening)
Domestic chores
House hold duties
Cleaning
Family/ housework
Pregnancy and just holding a baby
Carrying around children
Children – lifting tem, lifting out of cars when asleep, when they use you as a play gym

Work/ study
Working at desks
Working – non-musical
Intensive work period
Volume of work (amount)
Lack of breaks in work timetable
Nursing
A whole bunch of awkward ladder work for my job
Overwork/ poor ergonomics at my main place of work
Too much time sitting and working on PhD
Stress and study/ research demands means I'm constantly fighting between old and new postural habits
Long times spent studying, staring at screens causing headaches
Staring at screens, or just activities involving pointing head in one direction, leading to stiffness of neck
Prolonged periods of sitting over computer
Sitting at computer
Prolonged computer use
Computer use
Sitting a desk/ computer
Long hours sitting at desk job
Too much time on laptop
Typing/ mouse use
Keep eating and teach
Studying

Sleep
Exercise and sleep regulation
Sleep (lack thereof)
Sleep deprivation
Lack of sleep
Not enough sleep
Poor sleep patterns
Poor sleep
Poor sleeping habits
Sleeping incorrectly
Sleeping position
Sleeping posture
Sleeping in strange positions which then hurts my neck
Sleeping in a weird position
Sleeping in funky positions
Sleeping in an improper position
Bad sleeping position
Falling asleep on couch
Sleeping on my right side
Sleeping
Sleep

(continued)

Other
Not seeking treatment
Not stopping when it hurt initially
Not working on the problem until it was too late
Long time
Constant cracking
Poor diet
Possible diet
Wearing long hair down

Notes: [a]refers to Beethoven tremolo passages. [b]appears to relate to ergonomics. Spelling errors made by respondents were corrected here.

A1.7.2 Biological factors (quoted) listed as 'causes' of musicians' musculoskeletal symptoms

Getting older
Aging
My age
Age
Age related wear and tear
Age/ wear and tear
Constant use of musical instruments involving repetitive actions over any years and now being older
Arthritis
Nerve pain in neck
The jaw ball-and-socket joint itself isn't a 'normal' shape
Congenital
Born with hole in spine
Scoliosis (curvature of the spine)
Scoliosis
Spinal damage caused by thoracic kyphosis
Wisdom teeth causing jaw pain
Previous back injuries/ conditions
Exercise – hurt my back/ hips running and it never recovered
Initial whiplash injury in 1977. I was rear ended by another car on a main road
Childhood injuries
Multiple fracture of ankle
Old sporting injuries?
Past injuries
Previous injury
Injury (tore ankle ligaments a year ago and is still bad now!)
Trauma related injuries after bicycle accident
Residual discomfort from old injury
Had a back surgery before
Cramp in my hands on waking on cold mornings
Not sure, but think it is linked to a crush fracture due to osteoporosis
Developed osteopenia
Bursitis
Left shoulder bursitis and operation. Major reconstruction
Plantar fasciitis
Tendinitis
Inflammation of tendon
Flat arches
An "essential tremor"
Ehlers-Danlos syndrome
Hyperflexability
Hyper extensive joints
Hypermobility syndrome (the all over version)
Overly flexible joints
Big instrument, small hands
Weak wrists
Fitness
Muscle fatigue
Lack of abdominal strength
Lack of strength in core
Insufficient muscle fitness/ strength
General lack of fitness and suppleness
Poor fitness
Problems with hip alignment
Jammed lower neck/ ribs
General strain
Repetitive strain
Strain in jaw while singing
Over-straining muscles
Muscle tightness
Tightness in back muscles below neck
Poor muscular flexibility
Lack of flexibility
Tight/tense shoulders while playing piano
(continued)

RSI from playing live/ practicing
SLE lupus
Lupus flair (SLE)
Fibromyalgia
Lung damage from pulmonary embolisms. Muscular skeletal problems
Multiple pulmonary embolisms
Weight
Being overweight and unfit
Weight gain
Overweight
Excessive weight
Pregnancy
Pregnancy and just holding a baby
Menstrual pain
Growing pain
Other medical problems unrelated to music
Pre-existing conditions
Chronic sinus infection –worsens headaches and inhibits ability to sing
Genetics (back and neck)
heredity
Repetitive actions, poor posture and general genetic susceptibility (knees)
Lack of hydration
Acidity
Having been sick recently, I haven’t been stretching or doing yoga as much
Cycling: returning to sport after several weeks off the bike due to flu

Note: Spelling errors made by respondents were corrected here.

A1.7.3 Psychosocial factors (quoted) listed as ‘causes’ of musicians’ musculoskeletal symptoms

Anxiety
Depression
Nervousness
Stress
Stress above concerts and audition
Work related stress
Work stress
Insufficient physical activity on a daily basis/ stress
Stress and study/research demands means I’m constantly fighting between old and new postural habits
Grinding teeth at night/ when stressed
Tension while stressed
Stress/ tension
Tension and stress
Very busy schedule and very stressful
Psychosomatic pain
Inattention to posture
Family/ housework
Children – lifting them, lifting out of cars when asleep, when they use you as a play gym
Pressure from others causing tense playing
Lack of knowledge

Note: Spelling errors made by respondents were corrected here.

A1.7.4 External, physical factors (quoted) listed as 'causes' of musicians' musculoskeletal symptoms

Using a footstool when playing instead of a different type of guitar support
Sitting on a drum stool
Piano pedal
Heavy bag
Heavy backpack
Repeated carrying of heavy instrumental cases
Carrying heavy backpack
Carrying a heavy bag for uni
Carrying heavy items (backpack, instruments)
Carrying a heavy instrument
Carrying heavy instruments (e.g. bass guitar)
Carrying heavy (mock) rifle at opera rehearsal
Lifting heavy equipment
Lifting heavy objects
Probably lifting heavy cases
Heavy lifting of pianos/ keyboards/ other objects when I was younger
Weight of equipment
Weight of instrument (EEb tuba) and carrying it (single strap support)
Weight of instrument
Weights (i.e. lifting amps)
The weight of the saxophone on my neck for excessive periods of time
Weight of instrument being focused on one area (right thumb/wrist)
Weight of oboe (right hand, between wrist and pinky finger)
Pressure on neck from saxophone neck sling over approx. 40 years
Playing saxophone (i.e. having a heavy instrument attached to a neck strap straining my neck)
Playing saxophone (alto) for long hours every day using a neck strap
Big instrument, small hands
Large unwieldy instruments
Loading truck with low ceiling height
Walking with heavy shoes on
Many years of wearing army boots, marching and standing on parade (both feet)
Shoes maybe
Poor shoes/ posture
Uncomfortable sitting angle in orchestra/ pit
Chair you sit on whilst practicing
Posture/ chair whilst sitting
No back support
Ergonomics
My other job work station set up
Overwork/ poor ergonomics at my main place of work
Wrong set up
Repetitive strain due to instrument ergonomics
Incorrect instrument setup
Bed
Weather
Cramp in hands on waking on cold mornings
Windy days – wind load on drum

Note: Spelling errors made by respondents were corrected here.

A1.7.5 Other factors (quoted) listed as 'causes' of musicians' musculoskeletal symptoms

Tense
Tension
Over tensing
Holding tension
Tension while stressed
Tension and stress
Stress/ tension
Tension-causes tightness in shoulders
Tiredness
Not able to rest
Physical impact
Fall
Falling over
Motor accident 36 years ago
Car accident as a child, chronic condition
Trauma related injuries after bicycle accident

Note: Spelling errors made by respondents were corrected here.

A1.8: Supplementary Material for Chapter 8

Please refer to Appendix 1.4 for the demographic information related to Chapter 8.

A1.8.1 Body mass index

Table A1.8.1: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
7 days		
Overall		
Chronic+[a]	1.053 (0.994-1.116), p=0.082	
Combined regions		
Lower limb	1.062 (1.006-1.122), p=0.030*	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Lower limb	1.060 (0.998-1.127), p=0.058	
Priority regions		
Upper back	1.061 (1.008-1.116), p=0.022*	1.061 (1.007-1.118), p=0.026*
Lower back	1.046 (0.995-1.100), p=0.078	
7 days		
Overall		
Chronic[b]	1.047 (0.994-1.102), p=0.085	
Chronic+[a]	1.057 (0.998-1.120), p=0.058	
Consequences of musculoskeletal symptoms[c]		
Consult musician	0.931 (0.874-0.991), p=0.025*	

Notes: [a]Chronic+ refer to musculoskeletal symptoms or music-related musculoskeletal disorders that had been present on most days for at least the last 3 months, of the musicians who reported musculoskeletal symptoms or music-related musculoskeletal disorders in the last 7 days. [b]Chronic music-related musculoskeletal disorders refer to music-related musculoskeletal disorders that had been present on most days for at least the last 3 months. [c]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.2: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	0.916 (0.832-1.008), p=0.072	0.907 (0.811-1.015), p=0.089
Priority regions		
Neck	0.923 (0.855-0.997), p=0.041*	0.908 (0.835-0.988), p=0.026*
7 days		
Priority regions		
Neck		0.915 (0.828-1.010), p=0.079
Consequences of musculoskeletal symptoms[a]		
Consult musician	0.886 (0.787-0.998), p=0.047*	

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.3: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Lower limb	1.067 (0.998-1.140), p=0.058	
Priority regions		
Upper back	1.074 (1.003-1.149), p=0.040*	1.131 (1.033-1.240), p=0.008**
7 days		
Overall		
Chronic[a]	1.074 (1.002-1.150), p=0.043*	
Moderate-severe pain[b]	1.073 (0.987-1.166), p=0.097	
Combined regions		
Lower limb	1.069 (0.993-1.150), p=0.077	
Priority regions		
Upper back	1.067 (0.995-1.143), p=0.069	
Lower limb	1.097 (1.016-1.184), p=0.018*	
Priority regions		
Upper back	1.110 (1.034-1.192), p=0.004**	1.113 (1.014-1.222), p=0.024*
Lower back	1.071 (1.000-1.147), p=0.048*	
Music-related musculoskeletal disorders		
7 days		
Overall		
Chronic[a]	1.073 (1.003-1.149), p=0.042*	
Combined regions		
Lower limb	1.078 (0.987-1.177), p=0.094	
Priority regions		
Upper back	1.112 (1.032-1.199), p=0.006**	1.130 (1.025-1.246), p=0.014*

Notes: [a]Chronic refers to musculoskeletal symptoms/ music-related musculoskeletal disorders that had been present on most days for at least the last 3 months. [b]refers only to those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain intensity refers to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.4: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial	1.086 (1.003-1.176), p=0.043*	1.099 (0.998-1.211), p=0.056
Consequences of musculoskeletal symptoms[a]		
Work/ study		
Leave from work/ study	1.083 (1.000-1.172), p=0.049*	
Leave from musical work/ study	1.088 (0.998-1.185), p=0.056	

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.5: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Priority regions		
Upper back	1.060 (0.990-1.134), p=0.094	1.088 (0.990-1.196), p=0.079
7 days		
Priority regions		
Upper back	1.065 (0.995-1.139), p=0.071	

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.6: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between body mass index and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Priority regions		
Upper back		1.080 (1.003-1.163), p=0.041*
7 days		
Combined regions		
Lower limb	1.051 (0.992-1.113), p=0.093	
Priority regions		
Wrist/ hand	0.918 (0.845-0.996), p=0.040*	0.894 (0.812-0.984), p=0.002*
Upper back		1.057 (0.993-1.124), p=0.081
Music-related musculoskeletal disorders		
12 months		
Priority regions		
Upper back		1.061 (0.989-1.138), p=0.099
7 days		
Priority regions		
Upper back	1.046 (0.991-1.105), p=0.099	1.057 (1.004-1.113), p=0.034*

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

A1.8.2 Typical daily sitting time

Table A1.8.7: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	4-8: 3.432 (1.423-8.276), p=0.006** >8: 3.042 (1.069-8.653), p=0.037*	
Combined regions		
Upper limb	4-8: 1.812 (0.932-3.522), p=0.080	
Neck/ trunk	4-8: 1.811 (0.920-3.564), p=0.080	
Priority regions		
Wrist/ hand	4-8: 1.740 (0.953-3.176), p=0.071	
Upper back	4-8: 1.812 (0.976-3.365), p=0.060	
7 days		
Overall	4-8: 2.086 (1.132-3.843), p=0.018* >8: 2.233 (1.091-4.570), p=0.028*	4-8: 2.304 (1.156-4.591), p=0.018* >8: 2.555 (1.141-5.725), p=0.023*
Chronic[a]	>8: 2.080 (1.012-4.273), p=0.046*	
Priority regions		
Neck	4-8: 1.862 (0.993-3.489), p=0.052	
Wrist/ hand	4-8: 2.086 (1.028-4.236), p=0.042* >8: 2.046 (0.934-4.481), p=0.073	
Music-related musculoskeletal disorders		
12 months		
Overall	>8: 2.110 (1.083-4.111), p=0.028*	4-8: 2.002 (1.068-3.829), p=0.031* >8: 2.570 (1.236-5.343), p=0.012*
Combined regions		
Upper limb	>8: 1.751 (0.905-3.390), p=0.096	
Priority regions		
Shoulder	>8: 2.000 (0.995-4.019), p=0.052	
Wrist/ hand	>8 2.557 (1.239-5.275), p=0.011*	>8: 2.948 (1.255-6.922), p=0.013*
Upper back	4-8: 1.841 (0.902-3.754), p=0.093	
Consequences of musculoskeletal symptoms		
Current treatment[b]	>8: 0.462 (0.184-1.158), p=0.099	

Notes: <4 hours of daily sitting time was the reference. [a]Chronic musculoskeletal symptoms refer to musculoskeletal symptoms that had been present on most days for at least the last 3 months. [b]among those reporting musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.8: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	4-8: 3.259 (1.101-9.652), p=0.033*	
	>8: 3.444 (0.908-13.068), p=0.069	
7 days		
Overall		
Moderate-severe pain[a]	>8: 0.174 (0.029-1.052), p=0.057	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial	4-8: 0.357 (0.115-1.108), p=0.075	4-8: 0.267 (0.077-0.931), p=0.038*
	>8: 0.163 (0.031-0.863), p=0.033*	>8: 0.104 (0.017-0.639), p=0.015*
7 days		
Overall		
Chronic[b]	4-8: 0.399 (0.140-1.142), p=0.087	
Combined regions		
Upper limb	4-8: 0.323 (0.125-0.834), p=0.020*	
	>8: 0.412 (0.138-1.169), p=0.094	
Lower limb	4-8: 0.191 (0.042-0.866), p=0.032*	
Priority regions		
Neck	4-8: 0.377 (0.130-1.090), p=0.072	
	>8: 0.288 (0.076-1.084), p=0.066	
Wrist/ hand	4-8: 0.317 (0.112-0.900), p=0.031*	
Consequences of musculoskeletal symptoms[c]		
Current treatment	>8: 0.239 (0.050-1.139), p=0.072	

Notes: <4 hours of daily sitting time was the reference. [a]pain intensity ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. [b]chronic music-related musculoskeletal disorders refer to music-related musculoskeletal disorders that had been present on most days for at least the last 3 months. [c]among musicians who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

In addition, there was a near-significant association between typical daily sitting time and the emotional impact of musculoskeletal symptoms among male, symptomatic musicians in the unadjusted analysis (4-8 hours: beta coefficient -0.991, 95% confidence interval -2.105-0.123, p=0.081).

Table A1.8.9: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	4-8: 5.667 (0.987-32.533), p=0.052	
Priority region		
Wrist/ hand	4-8: 1.975 (0.885-4.405), p=0.097	
Upper back	4-8: 2.240 (0.974-5.151), p=0.058 >8: 2.904 (1.135-7.433), p=0.026*	4-8: 6.108 (1.307-28.544), p=0.021* >8: 8.021 (1.562-41.198), p=0.013*
Lower back	4-8: 2.032 (0.910-4.540), p=0.084	
7 days		
Overall	4-8: 3.701 (1.552-8.828), p=0.003** >8: 2.652 (0.992-7.090), p=0.052	4-8: 5.589 (1.967-15.879), p=0.001** >8: 3.941 (1.227-12.663), p=0.021*
Chronic[a]	4-8: 3.128 (1.235-7.923), p=0.016* >8: 3.149 (1.137-8.717), p=0.027*	4-8: 5.120 (1.741-15.059), p=0.003** >8: 5.423 (1.668-17.631), p=0.005**
Combined regions		
Upper limb	4-8: 2.275 (1.040-4.974), p=0.040*	4-8: 5.315 (1.829-15.444), p=0.002** >8: 3.058 (0.978-9.557), p=0.055
Neck/ trunk	4-8: 2.163 (0.991-4.722), p=0.053	
Lower limb	4-8: 2.540 (0.889-7.259), p=0.082	
Priority regions		
Neck	4-8: 3.392 (1.466-7.847), p=0.004**	4-8: 7.088 (2.239-22.442), p=0.001** >8: 2.846 (0.830-9.756), p=0.096
Wrist/ hand	4-8:4.714 (1.531-14.520), p=0.007** >8: 5.194 (1.561-17.282), p=0.007**	
Upper back	4-8: 2.672 (1.004-7.113), p=0.049* >8: 3.253 (1.122-9.429), p=0.030*	
Music-related musculoskeletal disorder		
12 months		
Overall	4-8: 1.969 (0.907-4.274), p=0.087 >8: 4.057 (1.583-10.394), p=0.004**	4-8: 2.619 (1.117-6.141), p=0.027* >8: 5.280 (1.896-14.704), p=0.001**
Combined regions		
Upper limb	>8: 3.497 (1.391-8.794), p=0.008**	>8: 4.661 (1.671-12.996), p=0.003**
Neck/ trunk	>8: 2.162 (0.885-5.279), p=0.091	
Priority regions		
Shoulder	>8: 3.900 (1.520-10.005), p=0.005**	4-8: 2.963 (0.941-9.329), p=0.063 >8: 10.108 (2.703-37.804), p=0.001**
Wrist/ hand	4-8: 2.497 (0.937-6.655), p=0.067 >8: 6.798 (2.359-19.589), p<0.001***	4-8: 3.097 (0.908-10.557), p=0.071 >8: 7.887 (2.073-30.000), p=0.002**
Upper limb	>8: 4.864 (1.594-14.839), p=0.005**	>8: 9.344 (2.102-41.527), p=0.003**
Lower back	4-8: 3.787 (1.223-11.723), p=0.021* >8: 4.267 (1.272-14.317), p=0.019*	
7 days		
Overall	4-8: 2.019 (0.890-4.579), p=0.093 >8: 2.589 (1.031-6.498), p=0.043*	4-8: 2.391 (0.998-5.729), p=0.051 >8: 3.566 (1.336-9.516), p=0.011*
Chronic[a]	4-8: 3.093 (1.092-8.765), p=0.034* >8: 3.310 (1.069-10.248), p=0.038*	4-8: 3.826 (1.287-11.377), p=0.016* >8: 4.186 (1.285-13.637), p=0.018*
Combined regions		
Upper limb	4-8: 2.175 (0.890-5.317), p=0.088 >8: 3.021 (1.131-8.067), p=0.027*	4-8: 2.231 (0.862-5.774), p=0.098 >8: 4.270 (1.461-12.482), p=0.008**
Neck/ trunk	4-8: 2.411 (0.903-6.441), p=0.079 >8: 3.253 (1.122-9.429), p=0.030*	>8: 4.482 (1.201-16.727), p=0.026*
Priority regions		
Neck	>8: 2.987 (0.959-9.302), p=0.059	
Shoulder	4-8: 2.540 (0.889-7.259), p=0.082 >8: 3.310 (1.069-10.248), p=0.038*	
Wrist/ hand	4-8: 4.819 (1.062-21.873), p=0.042* >8: 6.563 (1.363-31.601), p=0.019*	4-8: 4.990 (1.069-23.286), p=0.041* >8: 6.183 (1.243-30.753), p=0.026*
Upper back	>8: 4.753 (1.236-18.268), p=0.023*	
Lower back	>8: 6.563 (1.363-31.601), p=0.019*	>8: 12.605 (1.444-110.021), p=0.022*

Notes: <4 hours of daily sitting time was the reference. [a]Chronic musculoskeletal symptoms or music-related musculoskeletal disorders refer to musculoskeletal symptoms or music-related musculoskeletal disorders that had been present on most days for at least the last 3 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.10: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	4-8:4.200 (0.966-18.252), p=0.056	4-8: 12.853 (2.036-81.137), p=0.007**
Priority regions		
Wrist/ hand	4-8: 2.778 (1.093-7.056), p=0.032*	4-8: 3.002 (1.060-8.506), p=0.039*
7 days		
Overall	4-8: 3.007 (1.223-7.393), p=0.016* >8: 3.123 (1.136-8.588), p=0.027*	4-8: 5.501 (1.967-15.382), p=0.001** >8: 4.756 (1.571-14.399), p=0.006**
Priority regions		
Neck	4-8: 2.906 (1.006-8.393), p=0.049* >8: 2.640 (0.850-8.200), p=0.093	4-8: 7.583 (1.636-35.147), p=0.010* >8: 6.310 (1.296-30.724), p=0.023*
wrist/ hand	4-8: 3.797 (1.209-11.925), p=0.022* >8: 3.153 (0.935-10.632), p=0.064	
Music-related musculoskeletal disorders		
12 months		
Overall	>8: 3.506 (1.312-9.372), p=0.012*	
Combined regions		
Upper limb	>8: 2.684 (1.018-7.079), p=0.046*	
Priority regions		
Wrist/ hand	>8: 3.360 (1.157-9.759), p=0.026*	
7 days		
Overall	>8: 2.527 (0.905-7.061), p=0.077	
Combined regions		
Neck/ trunk		>8: 3.844 (1.089-13.570), P=0.036*
Consequences from musculoskeletal symptoms[a]		
Work/ study		
Changes to work/ study	>8: 0.251 (0.068-0.930), p=0.039*	
Leave from work/ study	>8: 0.353 (0.108-1.149), p=0.084	

Notes: <4 hours of daily sitting time was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.11: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in self-employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	4-8: 0.407 (0.153-1.088), p=0.073	
Priority regions		
Shoulder	>8: 3.958 (1.010-15.5200, p=0.048*	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial	>8: 0.152 (0.029-0.802), p=0.026*	4-8: 0.228 (0.065-0.796), p=0.020* >8: 0.044 (0.006-0.357), p=0.003**
7 days		
Combined regions		
Head/ orofacial	>0.130 (0.014-1.183), p=0.070	>8: 0.035 (0.002-0.615), p=0.022*
Consequences of musculoskeletal symptoms[a]		
Consult other musicians	4-8: 0.339 (0.111-1.031), p=0.057	

Notes: <4 hours of daily sitting time was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. There were no significant or near-significant (p<0.10) associations after adjusting for confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.12: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between typical daily sitting time and musculoskeletal symptom outcomes in employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	4-8: 3.000 (1.093-8.232), p=0.033*	
Combined regions		
Upper limb	4-8: 2.103 (0.919-4.816), p=0.079	
Priority regions		
Shoulder	>8: 3.054 (1.119-8.332), p=0.029*	
7 days		
Overall	4-8: 2.040 (0.955-4.359), p=0.066	
Music-related musculoskeletal disorders		
12 months		
Overall	>8: 2.188 (0.871-5.496), p=0.096	
Priority regions		
Shoulder	>8: 2.407 (0.952-6.088), p=0.063	
Combined regions		
Wrist/ hand	>8: 2.946 (1.065-8.152), p=0.037*	4-8: 2.719 (0.939-7.873), p=0.065 >8: 4.555 (1.362-15.232), p=0.014*
7 days		
Combined regions		
Head/ orofacial		
Consequences of musculoskeletal symptoms[a]		
Current treatment	>8: 0.258 (0.074-0.902), p=0.034*	>8: 0.214 (0.055-0.828), p=0.026*

Notes: <4 hours of daily sitting time was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. There were no significant or near-significant (p<0.10) associations after adjusting for confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

In addition, there was a significant association between typical daily sitting time and the emotional impact of musculoskeletal symptoms among employed professional, symptomatic musicians in the unadjusted analysis (4-8: beta coefficient -0.889, 95% confidence interval -1.751- -0.047, p=0.039), which was near-significant after adjusting for confounders (>8: beta coefficient -0.935, 95% confidence interval -1.978-0.108, p=0.079.

A1.8.3 Musical activity time

Table A1.8.13: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	10-20: 2.736 (1.037-7.223), p=0.042* >20: 3.198 (1.216-8.412), p=0.018*	
Combined regions		
Upper limb	10-20: 1.893 (0.972-3.687), p=0.061 >20: 2.004 (1.055-3.808), p=0.034*	
Priority regions		
Neck	10-20: 2.097 (1.159-3.793), p=0.014* >20: 1.784 (1.022-3.115), p=0.042*	
Shoulder	10-20: 1.740 (0.978-3.097), p=0.060 >20: 2.198 (1.250-3.865), p=0.006**	
Wrist/ hand	>20: 1.989 (1.151-3.436), p=0.014*	
7 days		
Overall	10-20: 2.079 (1.110-3.892), p=0.022* >20: 1.799 (1.002-3.231), p=0.049*	
Combined regions		
Head/ orofacial	>20: 2.400 (1.219-4.727), p=0.011*	
Upper limb	10-20: 1.970 (1.119-3.468), p=0.019*	
Lower limb		>20: 0.495 (0.229-1.070), p=0.074
Priority regions		
Wrist/ hand	>20: 1.726 (0.951-3.131), p=0.073	
Upper back	>20: 1.666 (0.911-3.049), p=0.098	
Music-related musculoskeletal disorders		
12 months		
Overall	10-20: 2.054 (1.164-3.625), p=0.013* >20: 1.983 (1.149-3.422), p=0.014*	10-20: 2.287 (1.223-4.278), p=0.010* >20: 1..931 (1.032-3.612), p=0.039*
Combined regions		
Head/ orofacial	10-20: 2.274 (0.985-5.253), p=0.054 >20: 2.863 (1.295-6.328), p=0.009**	
Upper limb	10-20: 2.382 (1.345-4.219), p=0.003** >20: 2.478 (1.431-4.291), p=0.001**	10-20: 2.013 (1.049-3.862), p=0.035* >2.304 (1.198-4.434), p=0.012*
Priority regions		
Neck	10-20: 1.724 (0.951-3.123), p=0.073 >20: 1.839 (1.040-3.252), p=0.036*	
Shoulder	10-20: 1.812 (0.986-3.327), p=0.055 >20: 2.766 (1.553-4.926), p=0.001**	10-20: 2.013 (0.969-4.182), p=0.061 >20: 3.059 (1.514-6.181), p=0.002**
Wrist/ hand	10-20: 2.145 (1.136-4.050), p=0.019* >20: 2.657 (1.448-4.874), p=0.002**	10-20: 2.193 (1.064-4.518), p=0.033* >20: 2.366 (1.159-4.830), p=0.018*
Lower back	10-20: 2.015 (1.081-3.756), p=0.027*	
7 days		
Overall	10-20: 2.184 (1.217-3.921), p=0.009** >20: 2.321 (1.322-4.073), p=0.003**	10-20: 2.075 (1.094-3.938), p=0.025* >20: 2.646 (1.392-5.030), p=0.003**
Combined regions		
Head/ orofacial	>20: 2.779 (1.103-7.006), p=0.030*	
Upper limb	10-20: 2.732 (1.433-5.209), p=0.002** >20: 3.023 (1.627-5.619), p<0.001***	10-20: 2.609 (1.302-5.228), p=0.007** >20: 3.512 (1.759-7.013), p<0.001***
Neck/ trunk	>20: 2.350 (1.286-4.293), p=0.005**	10-20: 1.955 (0.973-3.926), p=0.060 >20: 2.858 (1.446-5.649), p=0.003**
Priority regions		
Neck	>20: 2.468 (1.239-4.914), p=0.010*	>20: 3.117 (1.468-6.618), p=0.003**
Shoulder	10-20: 1.959 (0.926-4.144), p=0.079 >20: 3.624 (1.822-7.211), p<0.001***	>20: 3.745 (1.715-8.179), p=0.001**
Wrist/ hand	10-20: 2.185 (0.997-4.790), p=0.051 >20: 2.621 (1.245-5.520), p=0.011*	
Upper back	>20: 2.158 (1.034-4.503), p=0.041*	
Lower back	10-20: 1.997 (0.925-4.308), p=0.078	
Consequences of musculoskeletal symptoms[a]		
Work/ study		
Changes to musical work/ study	>20: 2.837 (0.974-8.264), p=0.056	
Leave from musical work/ study	>20: 2.407 (1.030-5.629), p=0.043*	
Management		
Engaged in Self-management	10-20: 2.474 (1.019-6.007), p=0.045*	10-20: 2.665 (1.052-6.753), p=0.039*
Consulted another musician	10-20: 3.438 (1.529-7.728), p=0.003** >20: 4.437 (2.029-9.703), p<0.001***	10-20: 2.938 (1.257-6.864), p=0.013* >20: 2.992 (1.304-6.866), p=0.010*

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.14: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	10-20: 3.628 (0.958-13.733), p=0.058	
Combined regions		
Neck/ trunk	10-20: 2.460 (0.918-6.592), p=0.073	
Priority regions		
Neck	10-20: 2.687 (1.133-6.371), p=0.025*	
Shoulder	10-20: 2.286 (0.982-5.323), p=0.055	
Wrist/ hand	10-20: 2.608 (1.114-6.105), p=0.027*	
Lower back	10-20: 2.759 (1.172-6.494), p=0.020*	
7 days		
Overall	10-20: 3.027 (1.186-7.726), p=0.020*	10-20: 2.888 (1.099-7.587), p=0.031*
Combined regions		
Head/ orofacial	10-20: 2.843 (1.210-6.677), p=0.016*	
Priority regions		
Wrist/ hand	10-20: 3.805 (1.493-9.694), p=0.005**	10-20: 6.347 (1.834-21.968), p=0.004** >20: 3.622 (1.008-13.017), p=0.049*
Lower back	10-20: 3.071 (1.279-7.378), p=0.012*	10-20: 3.093 (1.241-7.710), p=0.015*
Music-related musculoskeletal disorders		
12 months		
Overall	10-20: 2.710 (1.141-6.434), p=0.024*	10-20: 2.834 (1.164-6.897), p=0.022**
Combined regions		
Upper limb	10-20: 3.352 (1.407-7.983), p=0.006** >20: 2.120 (0.919-4.887), p=0.078	10-20: 3.311 (1.236-8.868), p=0.017* >20: 3.012 (1.114-8.139), p=0.030*
Priority regions		
Shoulder	>20: 2.123 (0.872-5.170), p=0.097	10-20: 2.296 (0.870-6.062), P=0.093 >20: 2.843 (1.076-7.512), P=0.035*
Wrist/ hand	10-20: 6.171 (2.232-17.063), p<0.001*** >20: 2.654 (0.942-7.478), p=0.065	10-20: 10.042 (2.952-34.157), P<0.001*** >20: 4.510 (1.259-16.151), P=0.021*
Upper back	10-20: 2.333 (0.918-5.933), p=0.075	
Lower back	10-20: 2.350 (0.960-5.752), p=0.061	
7 days		
Overall	10-20: 3.308 (1.361-8.042), p=0.008** >20: 2.163 (0.905-5.167), p=0.083	10-20: 4.002 (1.564-10.241), P=0.004** >20: 2.397 (0.935-6.150), P=0.069
Combined regions		
Head/ orofacial	10-20: 8.333 (0.933-74.458), p=0.058 >20: 7.237 (0.813-64.435), p=0.076	10-20: 7.323 (0.786-68.220), P=0.080 >20: 8.448 (0.872-81.826), P=0.065
Upper limb	10-20: 4.364 (1.626-11.713), p=0.003** >20: 2.323 (0.853-6.327), p=0.099	10-20: 5.173 (1.782-15.018), P=0.003** >20: 3.746 (1.202-11.672), P=0.023*
Neck/ trunk	10-20: 2.157 (0.878-5.300), p=0.094	
Priority regions		
Shoulder	10-20: 2.976 (0.978-9.057), p=0.055	10-20: 3.417 (1.042-11.204), P=0.043* >20 4.133 (1.185-14.423), P=0.026*
Wrist/ hand	10-20: 5.304 (1.701-16.535), p=0.004**	10-20: 6.242 (1.876-20.769), P=0.003**
Upper back	10-20: 2.976 (0.978-9.057), p=0.055	
Lower back	10-20: 2.444 (0.877-6.817), p=0.088	
Consequences of musculoskeletal symptoms[a]		
Work/ study		
Changes to musical work/ study	>20: 6.897 (0.764-62.217), p=0.085	
Leave from work/ study	10-20: 3.288 (0.915-11.816), p=0.068	
Management		
Consult another musician	10-20: 4.680 (1.154-18.975), p=0.031* >20: 6.217 (1.569-24.631), p=0.009**	10-20: 4.346 (1.042-18.130), P=0.044* >20: 5.304 (1.303-21.591), P=0.020*

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.15: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Upper limb	>20: 3.056 (1.068-8.738), p=0.037*	
Priority regions		
Neck	>20: 2.126 (0.924-4.891), p=0.076	
Shoulder	>20: 2.841 (1.203-6.708), p=0.017*	
7 days		
Combined region		
Head/ orofacial	>20: 3.378 (1.405-8.123), p=0.007**	>20: 3.091 (1.081-8.834), p=0.035*
Music-related musculoskeletal disorders		
12 months		
Overall	>20: 1.926 (0.909-4.082), p=0.087	
Combined regions		
Head/ orofacial	>20: 3.133 (1.141-8.606), p=0.027*	
Upper limb	>20: 2.451 (1.158-5.185), p=0.019*	
Priority regions		
Neck	>20: 2.007 (0.945-4.262), p=0.070	
Shoulder	>20: 2.970 (1.367-6.455), p=0.006**	
Wrist hand	>20: 2.303 (1.060-5.002), p=0.035*	
7 days		
Overall	>20: 2.139 (1.007-4.543), p=0.048*	
Combined regions		
Head/ orofacial		10-20: 0.079 (0.007-0.849), p=0.036*
Upper limb	>20: 3.106 (1.380-6.991), p=0.006**	
Neck/ trunk	>20: 3.225 (1.378-7.545), p=0.007**	
Priority regions		
Neck	>20: 4.044 (1.574-10.392), p=0.004**	>20: 7.569 (2.494-22.967), p=0.001***
Shoulder	>20: 3.953 (1.601-9.761), p=0.003**	>20: 3.448 (1.175-10.116), p=0.024*
Wrist/ hand	>20: 2.838 (1.086-7.412), p=0.033*	>20: 3.402 (1.207-9.592), p=0.021*
Upper back		>20: 2.747 (0.885-8.530), p=0.081
Lower back	>20: 2.743 (0.917-8.207), p=0.071	
Consequences of musculoskeletal symptoms[a]		
Work/ study		
Leave from musical work/ study	>20: 2.763 (0.986-7.737), p=0.053	
Management		
Self-management	10-20: 4.500 (0.902-22.444), p=0.067	
Consult another musician	10-20: 2.802 (1.024-7.669), p=0.045* >20: 3.317 (1.264-8.707), p=0.015*	

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.16: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcome ratings for female musicians

	Unadjusted	Adjusted
MRMD severity w-scores[a]	10-20: -16.321 (-32.600- -0.041), p=0.049*	10-20: -23.635 (-40.044- -7.259), p=0.005**
Impact of MSSs on daily life[b]	>20: 2.216 (0.875-5.613), p=0.093	10-20: 3.651 (1.196-11.145), p=0.023* >20: 3.542 (1.206-10.404), p=0.020*

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days. The w-scores were derived from the Rasch analysis (Appendix 2.10). [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with a beta coefficient >0. Blue text indicates a significant (p<0.05) association with a beta coefficient <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.17: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	10-20: 4.218 (0.828-21.481), p=0.083 >20: 3.590 (0.875-14.723), p=0.076	10-20: 5.151 (0.822-32.274), p=0.080 >20: 8.368 (1.450-48.297), p=0.018*
Combined regions		
Upper limb	10-20: 2.625 (0.949-7.259), p=0.063	
Neck/ trunk	10-20: 2.823 (0.970-8.218), p=0.057	
Priority regions		
Neck	10-20: 2.902 (1.195-7.046), p=0.019*	
Shoulder	10-20: 3.600 (1.521-8.519), p=0.004** >20: 2.600 (1.187-5.693), p=0.017*	10-20: 4.092 (1.511-11.080), p=0.006** >20: 3.321 (1.319-8.360), p=0.011*
Lower back	10-20: 2.250 (0.980-5.167), p=0.056	
7 days		
Overall	10-20: 2.287 (0.955-5.478), p=0.063 >20: 2.614 (1.137-6.008), p=0.024*	
Combined regions		
Upper limb	10-20: 2.600 (1.141-5.926), p=0.023*	
Priority regions		
Shoulder	10-20: 2.256 (0.969-5.254), p=0.059	
Wrist/ hand	10-20: 2.414 (1.006-5.792), p=0.048*	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Upper limb	10-20: 2.175 (0.947-4.994), p=0.067 >20: 2.183 (0.992-4.804), p=0.052	
Priority region		
Shoulder	>20: 2.11 (0.955-5.115), p=0.064	
Wrist/ hand	10-20: 2.509 (0.997-6.317), p=0.051 >20: 2.692 (1.115-6.502), p=0.028*	
Consequences of musculoskeletal symptoms[a]		
Management		
Treatment from a health professional		10-20: 2.762 (0.996-7.656), p=0.051 >20: 2.947 (1.084-8.015), p=0.034*
Self-management	>20: 2.611 (0.898-7.587), p=0.078	10-20: 3.141 (0.898-10.989), p=0.073 >20: 4.834 (1.391-16.801), p=0.013*
Consult another musician	10-20: 2.755 (1.000-7.592), p=0.050 >20: 4.439 (1.678-11.743), p=0.003**	10-20: 2.751 (0.994-7.619), p=0.051 >20: 4.373 (1.646-11.620), p=0.003**

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.18: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted
Musculoskeletal symptoms	
12 months	
Overall	
Combined regions	
Head/ orofacial	>20: 2.912 (0.869-9.754), p=0.083
Music-related musculoskeletal disorders	
7 days	
Combined regions	
Upper limb	>20: 3.040 (1.095-8.436), p=0.033*
Neck/ trunk	>20: 2.719 (1.007-7.339), p=0.048*
Priority regions	
Neck	>20: 4.552 (1.378-15.034), p=0.013*
Shoulder	>20: 4.911 (1.488-16.208), p=0.009**

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. The findings from the adjusted analyses were not reported, as none were significant nor near-significant. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.19: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical activity time (in the last 7 days) and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	10-20: 2.600 (0.856-7.898), p=0.092	
	>20: 3.756 (1.251-11.273), p=0.018*	
Combined regions		
Upper limb	>20: 2.613 (1.122-6.087), p=0.026*	
Priority regions		
Neck	10-20: 2.031 (0.906-4.554), p=0.085	
	>20: 2.181 (1.042-4.564), p=0.038*	
Shoulder	>20: 2.910 (1.373-6.165), p=0.005**	
Wrist/ hand	>20: 2.182 (1.072-4.442), p=0.031*	
Upper back	>20: 2.092 (1.026-4.267), p=0.042*	
7 days		
Overall	10-20: 2.494 (1.070-5.808), p=0.034*	
	>20: 1.913 (0.915-4.001), p=0.085	
Combined regions		
Head/ orofacial	>20: 2.971 (1.156-7.639), p=0.024*	
Upper limb	10-20: 2.303 (1.061-4.996), p=0.035*	
	>20: 2.188 (1.080-4.432), p=0.030*	
Priority regions		
Shoulder	>20: 2.278 (1.102-4.706), p=0.026*	
Upper back	>20: 2.424 (1.070-5.490), p=0.034*	
Music-related musculoskeletal disorders		
12 months		
Overall	10-20: 3.318 (1.503-7.326), p=0.003**	10-20: 2.448 (0.994-6.030), p=0.052
	>20: 2.870 (1.392-5.916), p=0.004**	>20: 3.306 (1.374-7.957), p=0.008**
Combined regions		
Head/ orofacial	10-20: 3.200 (1.041-9.836), p=0.042*	>20: 4.440 (1.382-14.262), p=0.012*
	>20: 3.728 (1.296-10.727), p=0.015*	
Upper limb	10-20: 3.661 (1.640-8.171), p=0.002**	10-20: 3.267 (1.269-8.412), p=0.014*
	>20: 4.027 (1.907-8.501), p<0.001***	>20: 4.179 (1.648-10.598), p=0.003**
Neck/ trunk	10-20: 2.657 (1.220-5.786), p=0.014*	10-20: 3.360 (1.345-8.388), p=0.009**
	>20: 2.267 (1.112-4.622), p=0.024*	>20: 4.024 (1.649-9.820), p=0.002**
Priority regions		
Neck	10-20: 3.606 (1.5558.359), p=0.003**	10-20: 3.268 (1.203-8.877), p=0.020*
	>20: 3.547 (1.615-7.791), p=0.002**	>20: 4.772 (1.737-13.112), p=0.002**
Shoulder	10-20: 3.435 (1.456-8.105), p=0.005**	10-20: 2.963 (1.072-8.190), p=0.036*
	>20: 5.227 (2.336-11.698), p<0.001***	>20: 5.803 (2.120-15.890), p=0.001**
Wrist/ hand	10-20: 2.800 (1.080-7.263), p=0.034*	10-20: 3.769 (1.297-10.951), p=0.015*
	>20: 3.898 (1.609-9.443), p=0.003**	>20: 5.436 (1.933-15.290), p=0.001**
Upper back	10-20: 3.341 (1.302-8.575), p=0.012*	10-20: 3.789 (1.365-10.517), p=0.011*
	>20: 3.898 (1.609-9.443), p=0.003**	>20: 5.034 (1.877-13.494), p=0.001**
7 days		
Overall	10-20: 3.520 (1.539-8.050), p=0.003**	
	>20: 3.783 (1.747-8.191), p=0.001**	
Chronic[a]	10-20: 2.350 (0.958-5.763), p=0.062	
	>20: 2.206 (0.949-5.128), p=0.066	
Combined regions		
Head/ orofacial	>20: 4.345 (1.183-15.956), p=0.027*	
Upper limb	10-20: 5.210-1.877-14.456), p=0.002**	10-20: 3.828 (1.282-11.523),p=0.017*
	>20: 7.605 (2.900-19.946), p<0.001***	>20: 6.576 (2.220-19.481), p=0.001**
Neck/ trunk	10-20: 2.881 (1.183-7.014), p=0.020*	
	>20: 3.977 (1.743-9.076), p=0.001**	
Priority regions		
Neck	10-20: 2.933 (0.942-9.133), p=0.063	>20: 6.857 (2.082-22.588), p=0.002**
	>20: 5.878 (2.086-16.566), p=0.001**	
Shoulder	10-20: 6.324 (1.684-23.751), p=0.006**	10-20: 3.560 (0.851-14.895), p=0.082
	>20: 13.610 (3.889-47.631), p<0.001***	>20: 11.268 (2.783-45.616), p=0.001**
Wrist/ hand	>20: 3.728 (1.296-10.727), p=0.015*	>20: 4.760 (1.526-14.849), p=0.007**
Upper back	10-20: 3.737 (1.107-12.618), p=0.034*	
	>20: 5.096 (1.630-15.929), p=0.005**	
Consequences of musculoskeletal symptoms[b]		
Management		
Engaging in self-management	10-20: 4.649 (0.929-23.271), p=0.062	
Consulting another musician	10-20: 4.550 (1.358-15.241), p=0.014*	10-20: 0.299 (0.111-0.805), p=0.017*
	>20: 5.363 (1.693-16.987), p=0.004**	>20: 0.315 (0.105-0.941), p=0.039*

Notes: Musical activity time refers to hours of musical activity in the last 7 days. <10 hours of musical activity was the reference. [a]chronic music-related musculoskeletal disorders refer to disorders that were experienced on most days for at least the last 3 months. [b]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

For symptomatic, employed professionals musicians, there were also significant or near-significant associations in the unadjusted analyses between musical activity time and the emotional impact of musculoskeletal symptoms (10-20: beta coefficient 0.824, 95% confidence interval -0.003-1.650, p=0.051; >20: beta coefficient 0.892, 95% confidence interval 0.093-1.691, p=0.029), and the impact of musculoskeletal symptoms on daily life (>20: beta coefficient 0.812, 95% confidence interval 0.012-1.611, p=0.047).

A1.8.4 Level of musical career satisfaction

Table A1.8.20: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	0.963 (0.936-0.991), p=0.011*	
Neck/ trunk	0.964 (0.926-1.004), p=0.076	
7 days		
Overall		
Chronic[a]		0.953 (0.912-0.995), p=0.029*
Chronic+[b]	0.960 (0.925-0.997), p=0.034*	
Combined regions		
Upper limb		1.038 (1.005-1.073), p=0.022*
Priority regions		
Neck	0.972 (0.944-1.000), p=0.049*	
Wrist/ hand	1.044 (1.006-1.084), p=0.024*	
Lower back	0.969 (0.942-0.997), p=0.031*	0.973 (0.944-1.003), p=0.078

Notes: [a]Chronic musculoskeletal symptoms refer to musculoskeletal symptoms that had been present on most days for at least the last 3 months. [b]Chronic+ refers to chronic musculoskeletal symptoms among those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.21: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
7 days		
Overall		
Chronic+[a]	0.954 (0.903-1.008), p=0.092	
Priority regions		
Wrist/ hand		1.064 (0.999-1.133), p=0.054
Lower back		0.963 (0.924-1.003), P=0.070
Music-related musculoskeletal disorders		
7 days		
Priority regions		
Lower back		0.960 (0.917-1.005), P=0.079

Notes: [a]Chronic+ refer to musculoskeletal symptoms that had been present on most days for at least the last 3 months, among the musicians who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.22: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	0.948 (0.907-0.990), p=0.017*	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial	0.953 (0.909-0.999), p=0.045*	0.941 (0.890-0.995), p=0.031*
Consequences of musculoskeletal symptoms[a]		
Work/ study		
Changes to work/ study	0.959 (0.912-1.008), p=0.097	0.958 (0.911-1.008), p=0.096

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8. 23: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	0.965 (0.930-1.001), p=0.059	
Upper limb	1.044 (1.004-1.085), p=0.031*	1.046 (0.997-1.097), p=0.065
Priority regions		
Shoulder	1.039 (1.001-1.078), p=0.043*	
7 days		
Overall	1.039 (1.001-1.078), p=0.044*	1.058 (1.015-1.103), p=0.008**
Chronic+[a]	0.956 (0.908-1.007), p=0.088	0.954 (0.903-1.008), p=0.095
Combined regions		
Upper limb	1.047 (1.007-1.089), p=0.020*	1.065 (1.021-1.112), P=0.004**
Priority regions		
Wrist/ hand	1.069 (1.014-1.126), p=0.012*	1.089 (1.029-1.151), p=0.003**
Music-related musculoskeletal disorders		
7 days		
Combined regions		
Head/ orofacial	0.951 (0.905-0.998), p=0.042*	0.889 (0.830-0.951), P=0.001**
Consequences from musculoskeletal symptoms[b]		
Work/ study		
Changes to work/ study		0.957 (0.916-1.000), p=0.051

Notes: [a]Chronic+ musculoskeletal symptoms refer to musculoskeletal symptoms that had been present on most days for at least the last 3 months, among the musicians who reported musculoskeletal symptoms in the last 7 days. [b]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.24: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Neck/trunk		0.840 (0.690-1.022), p=0.081
Priority regions		
Neck		0.900 (0.806-1.004), p=0.060
Lower back	0.946 (0.895-1.001), p=0.054	
7 days		
Combined regions		
Head/ orofacial		0.943 (0.882-1.009), p=0.091
Priority regions		
Wrist/ hand		
Lower back		
Music-related musculoskeletal disorders		
7 days		
Priority regions		
Wrist/ hand	1.056 (0.991-1.125), p=0.091	
Consequences of musculoskeletal symptoms[a]		
Consult a health professional	0.864 (0.748-0.996), p=0.044*	0.870 (0.754-1.005), p=0.058

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.25: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical career satisfaction and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Neck/trunk	0.932 (0.871-0.998), p=0.045*	0.908 (0.815-1.011), p=0.079
7 days		
Priority regions		
Neck	0.948 (0.909-0.989), p=0.013*	
Wrist/ hand	1.048 (0.992-1.107), p=0.092	1.066 (1.003-1.134), p=0.038*
Lower back	0.965 (0.926-1.006), p=0.091	

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

A1.8.5 Level of musical social support

Table A1.8.26: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial		0.981 (0.967-0.995), p=0.007**
Priority regions		
Shoulder	0.990 (0.979-1.001), p=0.083	0.981 (0.968-0.994), p=0.006**
Lower back	0.989 (0.977-1.001), p=0.072	
7 days		
Overall		
Chronic+[a]	0.989 (0.977-1.001), p=0.082	
Moderate-severe pain[b]	0.981 (0.966-0.996), p=0.015*	0.982 (0.966-0.999), p=0.042*
Priority regions		
Shoulder	0.990 (0.979-1.001), p=0.080	0.986 (0.973-0.999), p=0.042*
Music-related musculoskeletal disorders		
12 months		
Priority regions		
Shoulder		0.979 (0.965-0.993), p=0.004**
7 days		
Overall		
Chronic[c]	0.986 (0.973-0.999), p=0.029*	
Chronic+[a]	0.985 (0.972-0.999), p=0.030*	
Combined regions		
Head/ orofacial		0.974 (0.953-0.995), p=0.018*
Lower limb	0.981 (0.962-1.000), p=0.050	
Priority regions		
Shoulder	0.988 (0.976-1.001), p=0.076	
Lower back	0.986 (0.972-1.000), p=0.053	
Consequences of musculoskeletal symptoms[d]		
Consult musicians	1.013 (1.000-1.027), p=0.045*	

Notes: [a]Chronic+ refer to musculoskeletal symptoms present on most days for at least the last 3 months, among the musicians who reported musculoskeletal symptoms in the last 7 days. [b]pain ratings were only made by those who reported musculoskeletal symptoms in the last 7 days, and moderate-severe referred to ratings of 5-10 on an 11-point rating scale. [c]Chronic refers to musculoskeletal symptoms present on most days for at least the last 3 months. [d]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.27: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for male musicians

	Unadjusted
Music-related musculoskeletal disorders	
7 days	
Overall	
Chronic[a]	0.980 (0.959-1.001), p=0.060
Chronic+[b]	0.966 (0.939-0.995), p=0.021*
Combined regions	
Lower limb	0.969 (0.938-1.001), p=0.060

Notes: [a]Chronic refer to musculoskeletal symptoms present on most days for at least the last 3 months. [b]Chronic+ refer to musculoskeletal symptoms present on most days for at least the last 3 months, among the musicians who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.28: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial		
Upper back	0.987 (0.973-1.002), p=0.088	0.978 (0.961-0.996), p=0.016*
7 days		
Overall		
Moderate-severe pain[a]	0.979 (0.959-0.999), p=0.041*	0.982 (0.962-1.003), p=0.091
Combined regions		
Head/ orofacial		0.979 (0.958-1.001), p=0.057
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial		0.973 (0.949-0.998), p=0.032*
Neck/ trunk	0.984 (0.969-0.998), p=0.030*	0.983 (0.966-1.000), p=0.053
Priority regions		
Neck	0.981 (0.966-0.997), p=0.017*	0.980 (0.962-0.997), p=0.022*
Shoulder	0.984 (0.969-0.999), p=0.042*	0.977 (0.957-0.996), p=0.020*
Upper back	0.983 (0.966-1.001), p=0.059	
Lower back	0.979 (0.962-0.997), p=0.019*	0.968 (0.947-0.989), p=0.004**
7 days		
Combined regions		
Neck/ trunk	0.983 (0.967-1.000), p=0.046*	0.980 (0.960-1.000), p=0.052
Priority regions		
Shoulder		0.978 (0.957-0.999), p=0.054
Upper back	0.978 (0.958-0.998), p=0.033*	
Lower back	0.980 (0.960-1.001), p=0.061	0.972 (0.948-0.997), p=0.027*
Consequences of musculoskeletal symptoms[b]		
Consult musicians	1.016 (1.000-1.033), p=0.052	

Notes: [a]pain intensity ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. [b]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.29: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial		0.977 (0.958-0.996), p=0.016*
Priority regions		
Shoulder		0.972 (0.952-0.992), P=0.006**
7 days		
Overall		
Moderate-severe pain[a]	0.978 (0.956-1.001), p=0.061	0.976 (0.952-1.002), p=0.068
Combined regions		
Head/ orofacial		0.976 (0.955-0.998), P=0.033*
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial		0.972 (0.949-0.995), P=0.019*
Priority regions		
Neck	0.976 (0.959-0.994), p=0.009**	0.975 (0.957-0.993), P=0.006**
Shoulder	0.980 (0.963-0.997), p=0.022*	0.973 (0.955-0.992), P=0.006**
Upper back	0.982 (0.964-1.000), p=0.053	
7 days		
Overall		
Chronic[b]	0.982 (0.963-1.002), p=0.080	0.978 (0.958-0.999), P=0.042*
Chronic+[c]	0.970 (0.942-0.999), p=0.042*	0.972 (0.943-1.002), P=0.068
Priority regions		
Neck	0.980 (0.960-1.001), p=0.063	0.978 (0.956-1.000), P=0.048*
Shoulder	0.982 (0.963-1.001), p=0.064	0.973 (0.951-0.995), P=0.016*
Upper back	0.980 (0.959-1.001), p=0.062	0.973 (0.950-0.996), P=0.024*
Musculoskeletal symptom consequences[d]		
Work/ study		
Changes to work/ study	0.980 (0.959-1.003), p=0.086	

Notes: [a]pain intensity ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Moderate-severe pain refers to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. [b]Chronic music-related musculoskeletal disorders refer to music-related musculoskeletal disorders present on most days for at least the last 3 months. [c]Chronic+ music-related musculoskeletal disorders refer to music-related musculoskeletal disorders present on most days for at least the last 3 months, among the musicians who reported music-related musculoskeletal disorders in the last 7 days. [d]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.30: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted	Adjusted
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Lower limb	0.979 (0.955-1.004), p=0.094	
7 days		
Combined regions		
Head/ orofacial		0.949 (0.912-0.986), p=0.008**
Lower limb	0.967 (0.936-0.998), p=0.038*	
Musculoskeletal symptom consequences[a]		
Consult musicians	1.017 (0.997-1.038), p=0.093	

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.31: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Upper limb	0.987 (0.972-1.002), p=0.085	
Neck/ trunk	0.987 (0.973-1.002), p=0.079	0.979 (0.956-1.003), p=0.083
Music-related musculoskeletal disorders		
7 days		
Combined regions		
Head/ orofacial	0.979 (0.956-1.003), p=0.088	0.956 (0.926-0.987), p=0.006**

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.32: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) associations between musical social support and musculoskeletal symptom outcomes ratings

	Unadjusted	Adjusted
All musicians		
MRMD severity w-scores[a]	-0.235 (-0.450- -0.020), p=0.032*	-0.243 (-0.477- -0.009), p=0.042*
Impact of MSSs on daily life[b]	-0.018 (-0.030- -0.007), p=0.002**	-0.020 (-0.032- -0.007), p=0.003**
Male musicians		
MRMD severity w-scores[a]	-0.336 (-0.642- -0.029), p=0.033*	
Impact of MSSs on daily life[b]	-0.025 (-0.043- -0.007), p=0.008**	-0.025 (-0.046- -0.003), p=0.027*
University music students		
MRMD severity w-scores[a]	-0.578 (-0.883- -0.274), p<0.001***	-0.661 (-0.972- -0.349), p<0.001***
Impact of MSSs on daily life[b]	-0.026 (-0.043- -0.008), p=0.0.003**	-0.026 (-0.045- -0.007), p=0.006**
Employed professional musicians		
Impact of MSSs on daily life[b]	-0.016 (-0.031- -0.001), p=0.042*	
Self-employed professional musicians		
Emotional impact of MSSs[b]	0.022 (0.003-0.041), P=0.025*	

Notes: MRMD: music-related musculoskeletal disorder. MSS: musculoskeletal symptom. [a]ratings were only made by those who reported music-related musculoskeletal disorders in the last 7 days, and the w-scores were derived from the Rasch analysis (Appendix 2.10). [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with a beta coefficient >0. Blue text indicates a significant (p<0.05) association with a beta coefficient <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

In addition, ratings of the daily impact of musculoskeletal symptom for female musicians were analysed using binary logistic regression (median cut-point), with a near-significant association in the unadjusted analysis (odds ratio 0.984, 95% confidence interval 0.996-1.003, p=0.095), and significant association in the adjusted analysis (adjusted odds ratio 0.976, 95% confidence interval 0.995-0.997, p=0.025). Similarly, the emotional impact of musculoskeletal symptoms for university music students were analysed using binary logistic regression (median cut-point), with significant associations in the unadjusted (odds ratio 0.983, 95% confidence interval 0.963-1.003, p=0.092), and adjusted analyses (adjusted odds ratio 0.974, 95% confidence interval 0.953-0.996, p=0.020).

A1.8.6: Level of psychosocial stress

Table A1.8.33: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.031 (1.000-1.063), p=0.049*	
Combined regions		
Head/ orofacial	1.021 (1.002-1.040), p=0.029*	
Upper back		1.024 (0.996-1.053), p=0.089
Priority regions		
Wrist/ hand	1.035 (1.014-1.056), p=0.001**	1.042 (1.021-1.064), p<0.001***
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Lower limb		1.032 (1.004-1.060), p=0.026*
Priority regions		
Wrist/ hand		1.021 (1.000-1.043), p=0.050
7 days		
Priority regions		
Wrist/ hand	1.026 (1.003-1.050), p=0.024*	

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

There was also a significant association between stress and emotional impact of musculoskeletal symptoms among symptomatic musicians in the unadjusted analysis (beta coefficient 0.022, 95% confidence interval 0.003-0.041, p=0.025).

Table A1.8.34: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.055 (1.012-1.099), p=0.012*	
Combined regions		
Upper limb	1.044 (1.011-1.078), p=0.009**	
Neck/ trunk	1.039 (1.006-1.074), p=0.020*	
Priority regions		
Neck	1.031 (1.002-1.062), p=0.037*	
Shoulder	1.029 (1.000-1.059), p=0.048*	
Wrist/ hand	1.060 (1.026-1.095), p<0.001***	1.057 (1.023-1.093), p=0.001**
7 days		
Overall	1.035 (1.004-1.066), p=0.027*	1.034 (1.001-1.068), p=0.041*
Chronic[a]	1.037 (1.005-1.069), p=0.024*	1.052 (1.017-1.089), p=0.004**
Combined regions		
Upper limb	1.041 (1.010-1.072), p=0.009**	1.042 (1.009-1.076), p=0.012*
Neck/ trunk	1.028 (0.999-1.058), p=0.058	
Lower limb	1.034 (0.997-1.072), p=0.069	1.046 (1.005-1.088), p=0.027*
Priority region		
Neck	1.038 (1.005-1.072), p=0.023*	1.042 (1.006-1.078), p=0.021*
Shoulder	1.030 (0.998-1.063), p=0.068	
Wrist/ hand	1.055 (1.019-1.093), p=0.003**	1.503 (1.167-1.936), p=0.002**
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Lower limb	1.047 (1.001-1.095), p=0.044*	1.065 (1.013-1.119), P=0.014*
Priority regions		
Shoulder	1.037 (1.005-1.070), p=0.025*	1.046 (1.010-1.083), P=0.012*
Upper back	1.028 (0.996-1.061), p=0.086	
7 days		
Combined regions		
Upper limb	1.034 (1.000-1.068), p=0.047*	
Priority regions		
Wrist/ hand	1.042 (1.004-1.082), p=0.032*	1.046 (1.003-1.090), P=0.036*
Consequences from musculoskeletal symptoms[b]		
Work/ study		
Leave from musical work/ study	1.057 (1.003-1.114), p=0.040*	

Notes: [a]Chronic musculoskeletal symptoms refer to musculoskeletal symptoms present on most days for at least the last 3 months. [b]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.35: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Priority regions		
Wrist/ hand	1.026 (1.001-1.051), p=0.038*	1.030 (1.003-1.058), p=0.030*
7 days		
Overall		
Moderate-severe pain[a]	1.044 (0.993-1.097), p=0.091	
Priority region		
Wrist/ hand	1.025 (0.999-1.051), p=0.058	1.030 (1.001-1.060), p=0.039*
Music-related musculoskeletal disorders		
12 months		
Priority regions		
Neck	0.979 (0.956-1.003), p=0.083	
Shoulder	0.977 (0.954-1.001), p=0.061	0.971 (0.943-0.999), p=0.042*
Wrist/ hand		1.029 (0.999-1.059), p=0.055
Upper back	0.974 (0.948-1.001), p=0.059	0.959 (0.928-0.991), p=0.011*
Consequences from musculoskeletal symptoms		
Management		
Current treatment[b]	0.978 (0.953-1.004), p=0.094	

Notes: [a]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days, and moderate-severe pain refers to ratings of 5-10 on an 11-point numeric rating scale. [b]among those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

For symptomatic, female musicians, there was also a significant association between stress and the emotional impact of musculoskeletal symptoms (unadjusted: beta coefficient 0.055, 95% confidence interval 0.018-0.091, p=0.003; adjusted: 0.037, 95% confidence interval 0.000-0.074, p=0.049).

Table A1.8.36: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	1.021 (0.997-1.046), p=0.084	
Priority regions		
Neck	1.022 (0.997-1.048), p=0.082	
Wrist/ hand	1.036 (1.011-1.062), p=0.005**	1.043 (1.014-1.073), p=0.003**
7 days		
Priority regions		
Wrist/ hand	1.030 (1.005-1.057), p=0.020*	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Lower limb		1.040 (1.000-1.081), P=0.050
7 days		
Priority regions		
Wrist/ hand		1.030 (0.999-1.062), P=0.060

Notes: Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.37: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall		
Combined regions		
Head/ orofacial	1.050 (1.017-1.084), p=0.003**	
Upper limb	1.072 (1.023-1.125), p=0.004**	1.083 (1026-1.143), p=0.004**
Neck/ trunk	1.064 (1.018-1.112), p=0.006**	
Priority regions		
Neck	1.053 (1.016-1.092), p=0.005**	
Shoulder	1.039 (1.005-1.074), p=0.025*	
Wrist/ hand		
Upper back	1.037 (1.007-1.0690, p=0.017*	1.041 (1.004-1.080), p=0.030*
Lower back	1.028 (0.998-1.059), p=0.070	
7 days		
Overall		
Chronic[a]	1.026 (0.996-1.057), p=0.095	
Chronic+[b]	1.033 (0.996-1.070), p=0.077	
Combined regions		
Head/ orofacial	1.030 (0.998-1.063), p=0.065	
Upper limb	1.034 (1.003-1.066), p=0.033*	
Neck/ trunk	1.032 (1.001-1.065), p=0.004*	
Priority regions		
Neck	1.035 (1.005-1.066), p=0.024*	
Shoulder	1.041 (1.010-1.073), p=0.010*	
Wrist/ hand		
Upper back	1.029 (0.998-1.062), p=0.071	
Lower back	1.029 (0.999-1.060), p=0.054	
Music-related musculoskeletal disorders		
12 months		
Overall		
Combined regions		
Head/ orofacial	1.039 (1.004-1.075), p=0.027*	1.061 (1.015-1.110), p=0.009**
Upper limb	1.034 (1.002-1.068), p=0.037*	1.043 (1.006-1.081), p=0.024*
Neck/ trunk	1.051 (1.016-1.087), p=0.004**	1.067 (1.027-1.109), p=0.001**
Lower limb		
Priority regions		
Neck	1.046 (1.014-1.080), p=0.005**	1.067 (1.026-1.109), p=0.001**
Shoulder	1.046 (1.014-1.079), p=0.005**	1.064 (1.023-1.106), p=0.002**
Wrist/ hand	1.031 (1.001-1.062), p=0.045*	1.041 (1.005-1.078), p=0.023*
Upper back	1.033 (1.003-1.064), p=0.033**	1.056 (1.017-1.078), p=0.004**
Lower back	1.040 (1.009-1.072), p=0.012*	1.063 (1.025-1.102), p=0.001**
7 days		
Overall	1.026 (0.969-1.057), p=0.094	
Chronic[a]	1.034 (1.003-1.066), p=0.032*	
Combined regions		
Upper limb	1.034 (1.004-1.066), p=0.026*	
Neck/ trunk	1.034 (1.004-1.065), p=0.028*	
Priority regions		
Neck	1.028 (0.998-1.059), p=0.070	
Shoulder	1.028 (0.998-1.060), p=0.068	
Wrist/ hand		
Upper back	1.028 (0.996-1.061), p=0.083	
Lower back	1.051 (1.015-1.088), p=0.005**	1.053 (1.000-1.108), p=0.049*
Consequences of musculoskeletal symptoms[c]		
Work/ study		
Changes to work/ study	1.040 (0.996-1.085), p=0.075	
Changes to musical work/ study		
Leave from work/ study	1.067 (1.025-1.109), p=0.001**	1.078 (1.023-1.135), p=0.005**
Leave from musical work/ study	1.089 (1.039-1.141), p<0.001***	1.066 (1.008-1.127), p=0.026*
Management		
Consulted a health professional		
Consulted another musician	1.035 (1.002-1.070), p=0.040*	

Notes: [a]Chronic refers to musculoskeletal symptoms present on most days for at least the last 3 months. [b]Chronic+ refers to musculoskeletal symptoms present on most days for at least the last 3 months, among the musicians who reported musculoskeletal symptoms in the last 7 days. [c]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

For symptomatic, self-employed musicians, there was a near-significant association between stress and the impact of musculoskeletal symptoms on daily life in the unadjusted analysis (beta coefficient 0.030, 95% confidence interval -0.000-0.061, p=0.051), and a significant association with the emotional impact of musculoskeletal symptoms (beta coefficient 0.064, 95% confidence interval 0.030-0.098, p<0.001).

Table A1.8.38: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between stress and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.050 (1.008-1.094), p=0.021*	
Combined regions		
Head/ orofacial	1.035 (1.008-1.062), p=0.010*	
Upper limb	1.059 (1.023-1.095), p=0.001**	1.044 (1.000-1.091), p=0.050
Neck/ trunk	1.055 (1.020-1.091), p=0.002**	
Priority regions		
Neck	1.047 (1.017-1.078), p=0.002**	
Shoulder	1.032 (1.005-1.061), p=0.020*	
Wrist/ hand	1.022 (0.997-1.048), p=0.079	
Upper back	1.028 (1.003-1.055), p=0.030*	1.034 (1.005-1.065), P=0.023*
7 days		
Overall	1.031 (1.003-1.060), p=0.031*	
Chronic[a]	1.045 (1.017-1.074), p=0.002**	
Chronic+[b]	1.040 (1.008-1.073), p=0.014*	
Moderate-severe pain[c]	1.030 (0.996-1.066), p=0.088	
Combined regions		
Head/ orofacial	1.026 (0.996-1.056), p=0.094	
Upper limb	1.046 (1.019-1.075), p=0.001**	
Neck/ trunk	1.052 (1.023-1.081), p<0.001***	1.040 (1.005-1.077), p=0.024*
Priority regions		
Neck	1.042 (1.015-1.070), p=0.002**	
Shoulder	1.037 (1.011-1.064), p=0.006**	
Wrist/ hand	1.033 (1.005-1.061), p=0.022*	1.041 (1.008-1.074), p=0.014*
Upper back	1.038 (1.009-1.068), p=0.009**	
Lower back	1.041 (1.014-1.070), p=0.003**	
Music-related musculoskeletal disorders		
12 months		
Overall	1.028 (1.002-1.055), p=0.036*	1.044 (1.012-1.077), p=0.007**
Combined regions		
Head/ orofacial	1.038 (1.007-1.070), p=0.017*	1.054 (1.016-1.095), p=0.006**
Upper limb	1.031 (1.006-1.058), p=0.017*	1.050 (1.016-1.085), p=0.003**
Neck/ trunk	1.049 (1.021-1.078), p=0.001**	1.076 (1.040-1.113), p<0.001***
Lower limb		1.040 (1.002-1.079), p=0.038*
Priority regions		
Neck	1.047 (1.020-1.076), p=0.001**	1.072 (1.035-1.110), p<0.001***
Shoulder	1.032 (1.006-1.058), p=0.016*	1.063 (1.025-1.102), p=0.001**
Wrist/ hand	1.031 (1.004-1.059), p=0.024*	1.042 (1.008-1.077), p=0.014*
Upper back		1.036 (1.002-1.070), p=0.035*
Lower back	1.042 (1.014-1.070), p=0.003**	1.057 (1.023-1.091), p=0.001**
7 days		
Overall	1.024 (0.998-1.049), p=0.066	
Chronic[a]	1.032 (1.004-1.060), p=0.025*	
Combined regions		
Upper limb	1.029 (1.002-1.056), p=0.033*	
Neck/ trunk	1.032 (1.006-1.060), p=0.016*	1.042 (1.010-1.074), p=0.010*
Priority regions		
Neck		1.045 (1.008-1.082), p=0.015*
Wrist/ hand		1.031 (0.995-1.069), p=0.094
Upper back	1.027 (0.996-1.057), p=0.084	1.041 (1.001-1.083), p=0.047*
Lower back	1.051 (1.018-1.085), p=0.002**	1.060 (1.021-1.101), p=0.003**
Consequences of musculoskeletal symptoms[d]		
Work/ study		
Changes to work/ study	1.040 (1.002-1.078), p=0.036*	
Changes to musical work/ study	1.039 (0.998-1.082), p=0.064	
Leave from work/ study	1.046 (1.013-1.080), p=0.006*	
Leave from musical work/ study	1.050 (1.014-1.088), p=0.006**	
Management		
Consulted a health professional	1.029 (1.000-1.060), p=0.053	1.040 (1.007-1.075), p=0.019*
Consulted another musician	1.038 (1.007-1.070), p=0.015*	

Notes: [a]chronic referred to musculoskeletal symptoms/ music-related musculoskeletal disorders that were experienced on most days for at least the last 3 months. [b]chronic+ referred to musculoskeletal symptoms/ music-related musculoskeletal disorders that were experienced on most days for at least the last 3 months, among those who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. [c]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days, and moderate-severe pain referred to a pain intensity rating on average of 5-10 on a numeric rating scale. [d]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

For symptomatic, employed musicians, the association between stress and the emotional impact of musculoskeletal symptoms (beta coefficient 0.048, 95% confidence interval 0.020-0.075, p=0.001), and the impact of musculoskeletal symptoms on daily life (beta coefficient 0.038, 95% confidence interval 0.011-0.066, p=0.006) in the unadjusted analyses.

A1.8.7 Level of psychological distress

Table A1.8.39: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and musculoskeletal symptom outcomes for all musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.041 (1.014-1.069), p=0.003**	
Combined regions		
Head/ orofacial	1.033 (1.018-1.048), p<0.001***	1.028 (1.011-.046), p=0.001**
Upper limb	1.029 (1.012-1.047), p=0.001**	1.028 (1.006-1.051), p=0.013*
Neck/ trunk	1.032 (1.014-1.050), p<0.001***	1.032 (1.012-1.052), p=0.002**
Priority regions		
Neck	1.032 (1.017-1.048), p<0.001***	1.041 (1.022-1.060), p<0.001***
Shoulder	1.029 (1.014-1.044), p<0.001***	1.038 (1.019-1.057), p<0.001***
Wrist/ hand	1.020 (1.007-1.034), p=0.003**	
Upper back	1.017 (1.003-1.030), p=0.015*	1.014 (0.999-1.029), p=0.075
Lower back	1.013 (1.000-1.026), p=0.057	
7 days		
Overall	1.027 (1.011-1.043), p=0.001**	1.030 (1.012-1.048), p=0.001**
Chronic[a]	1.019 (1.005-1.033), p=0.008**	1.029 (1.013-1.046), p=0.001**
Chronic+[b]		1.018 (0.998-1.039), p=0.073
Moderate/ severe pain[c]	1.017 (0.998-1.037), p=0.078	1.022 (1.001-1.044), p=0.042*
Combined regions		
Head/ orofacial	1.026 (1.010-1.043), p=0.002**	1.033 (1.013-1.053), p=0.001**
Upper limb	1.028 (1.014-1.042), p<0.001***	1.035 (1.019-1.053), p<0.001***
Neck/ trunk	1.027 (1.013-1.042), p<0.001***	1.033 (1.016-1.049), p<0.001***
Priority regions		
Neck	1.027 (1.013-1.042), p<0.001***	1.033 (1.016-1.050), p<0.001***
Shoulder	1.030 (1.016-1.045), p<0.001***	1.032 (1.015-1.049), p<0.001***
Wrist/ hand	1.014 (1.000-1.029), p=0.051	
Upper back	1.021 (1.006-1.036), p=0.007**	1.018 (1.001-1.035), p=0.040*
Lower back	1.020 (1.006-1.034), p=0.006**	1.018 (1.002-1.034), p=0.028*
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Head/ orofacial	1.017 (0.999-1.034), p=0.063	1.018 (0.998-1.038), p=0.078
Upper limb	1.015 (1.002-1.029), p=0.025*	1.021 (1.005-1.037), p=0.012*
Neck/ trunk		1.023 (1.006-1.039), p=0.006**
Priority regions		
Neck	1.012 (0.998-1.026), p=0.088	1.018 (1.002-1.034), p=0.029*
Shoulder	1.016 (1.003-1.030), p=0.020*	1.023 (1.006-1.041), p=0.009**
Wrist/ hand	1.015 (1.001-1.029), p=0.042*	
7 days		
Overall		1.018 (1.002-1.034), p=0.025*
Chronic[a]	1.014 (0.999-1.029), p=0.073	1.028 (1.009-1.046), p=0.003*
Combined regions		
Upper limb	1.019 (1.004-1.033), p=0.011*	1.025 (1.008-1.043), p=0.004**
Priority regions		
Neck	1.014 (0.998-1.030), p=0.091	1.025 (1.006-1.045), p=0.010*
Shoulder	1.016 (1.000-1.031), p=0.048*	1.022 (1.002-1.042), p=0.028*
Wrist/ hand	1.014 (0.997-1.030), p=0.098	
Consequences of musculoskeletal symptoms[d]		
Work/ study		
Changes to work/ study	1.019 (1.000-1.039), p=0.048*	
Changes to musical work/ study		
Leave from work/ study	1.028 (1.010-1.046), p=0.002**	1.030 (1.010-1.050), p=0.003**
Leave from musical work/ study	1.029 (1.009-1.049), p=0.004**	1.030 (1.008-1.052), p=0.006**
Management		
Consulted another musician	1.024 (1.008-1.041), p=0.003**	

Notes: [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. [c]ratings of pain intensity were only made by those who reported musculoskeletal symptoms in the last 7 days, and moderate-severe pain refer to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. [d]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.40: Odds ratios (95% confidence intervals) for the significant and near-significant ($p<0.10$) associations between distress and musculoskeletal symptom outcomes for male musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.038 (1.005-1.073), p=0.025*	1.038 (1.002-1.076), p=0.039*
Combined regions		
Head/orofacial	1.036 (1.013-1.061), p=0.002**	1.033 (1.008-1.058), p=0.009**
Upper limb	1.029 (1.005-1.053), p=0.018*	1.042 (1.012-1.072), p=0.005**
Neck/ trunk	1.036 (1.010-1.062), p=0.006**	1.036 (1.009-1.064), p=0.009**
Lower limb	1.021 (0.999-1.043), p=0.065	1.030 (1.006-1.054), p=0.015*
Priority regions		
Neck	1.026 (1.004-1.048), p=0.018*	1.031 (1.008-1.056), p=0.010*
Shoulder	1.033 (1.011-1.055), p=0.003**	1.039 (1.014-1.065), p=0.002**
Wrist/ hand	1.020 (0.999-1.041), p=0.058	
Upper back	1.027 (1.006-1.049), p=0.012*	1.030 (1.005-1.056), p=0.017*
7 days		
Overall	1.022 (1.000-1.045), p=0.052	
Chronic[a]	1.028 (1.006-1.051), p=0.013*	
Chronic+[b]	1.027 (0.999-1.055), p=0.058	1.041 (1.009-1.074), p=0.013*
Moderate-severe pain[c]	1.047 (1.007-1.088), p=0.021*	1.050 (1.009-1.093), p=0.016*
Combined regions		
Upper limb	1.031 (1.009-1.053), p=0.005**	
Neck/ trunk	1.024 (1.003-1.046), p=0.023*	1.024 (1.002-1.047), p=0.035*
Priority region		
Neck	1.019 (0.997-1.042), p=0.086	
Shoulder	1.033 (1.009-1.056), p=0.006**	1.039 (1.014-1.064), p=0.002**
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Upper limb	1.019 (0.998-1.040), p=0.072	1.025 (0.999-1.051), p=0.061
Neck/ trunk		1.020 (0.998-1.043), p=0.072
Priority regions		
Shoulder	1.026 (1.004-1.049), p=0.020*	
Upper back	1.031 (1.008-1.055), p=0.008**	1.034 (1.009-1.060), P=0.007**
7 days		
Overall		
Chronic[a]	1.022 (0.997-1.048), p=0.088	1.035 (1.007-1.064), P=0.014*
Combined region		
Upper limb	1.029 (1.006-1.053), p=0.014*	1.045 (1.016-1.074), P=0.002**
Priority regions		
Shoulder	1.028 (1.002-1.054), p=0.034*	1.045 (1.014-1.078), P=0.005**
Wrist/hand	1.023 (0.997-1.049), p=0.079	
Musculoskeletal symptom consequences		
Work/study[d]		
Leave from work/ study	1.046 (1.012-1.082), p=0.008**	1.054 (1.017-1.092), P=0.004**
Leave from musical work/ study	1.046 (1.008-1.085), p=0.018*	1.056 (1.014-1.099), P=0.008**
Management		
Current treatment[e]	1.030 (0.999-1.061), p=0.058	1.036 (1.004-1.070), P=0.028*

Notes: [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. [c]ratings of pain intensity were only made by those who reported musculoskeletal symptoms in the last 7 days, and moderate-severe pain refer to pain intensity on average ratings of 5-10 on an 11-point numeric rating scale. [d]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. [e]among those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant ($p<0.05$) association with an odds ratio of >1. Blue text indicates a significant ($p<0.05$) association with an odds ratio of <1. Black text indicates a near-significant association ($0.05 \le p<0.10$). *$p<0.050$, **$p<0.010$, ***$p<0.001$.

Table A1.8.41: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and musculoskeletal symptom outcomes for female musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	1.027 (1.008-1.046), p=0.006**	1.022 (1.001-1.044), p=0.044*
Neck/ trunk	1.024 (0.998-1.050), p=0.073	1.026 (0.996-1.057), p=0.095
Priority regions		
Neck	1.034 (1.012-1.058), p=0.003**	1.038 (1.012-1.064), p=0.003**
Shoulder	1.018 (0.997-1.038), p=0.092	1.023 (0.998-1.048), p=0.072
Lower back	1.016 (0.997-1.035), p=0.092	
7 days		
Overall	1.025 (1.002-1.049), p=0.030*	1.043 (1.013-1.074), p=0.004**
Combined regions		
Head/ orofacial	1.031 (1.009-1.053), p=0.005**	1.042 (1.013-1.071), p=0.004**
Upper limb	1.021 (1.002-1.041), p=0.029*	1.029 (1.005-1.053), p=0.019*
Neck/ trunk	1.029 (1.009-1.049), p=0.004**	1.039 (1.016-1.063), p=0.001**
Priority regions		
Neck	1.030 (1.011-1.050), p=0.002**	1.051 (1.025-1.077), p<0.001***
Shoulder	1.024 (1.005-1.043), p=0.013*	1.033 (1.009-1.057), p=0.006**
Upper back	1.022 (1.002-1.042), p=0.031*	
Lower back	1.024 (1.005-1.043), p=0.014*	1.029 (1.007-1.051), p=0.009**
Music-related musculoskeletal disorders		
12 months		
Priority regions		
Lower back		1.028 (1.002-1.053), p=0.031*
7 days		
Combined regions		
Head/orofacial		1.036 (0.999-1.074), p=0.059
Musculoskeletal symptom consequences[a]		
Work/ study		
Leave from work/study	1.018 (0.997-1.039), p=0.096	
Management		
Consult musicians	1.028 (1.007-1.049), p=0.009**	

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.42: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and musculoskeletal symptom outcomes for university music students

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.034 (0.997-1.073), p=0.070	1.045 (1.002-1.091), p=0.041*
Combined regions		
Head/ orofacial	1.032 (1.012-1.053), p=0.002**	1.037 (1.015-1.060), p=0.001**
Upper limb	1.021 (0.998-1.045), p=0.070	1.027 (1.000-1.054), p=0.050
Neck/ trunk	1.026 (1.002-1.049), p=0.031*	1.025 (1.000-1.050), p=0.049*
Priority regions		
Neck	1.029 (1.009-1.050), p=0.005**	1.026 (1.005-1.048), p=0.014*
Shoulder	1.023 (1.003-1.043), p=0.023*	1.029 (1.006-1.053), P=0.014*
Wrist/ hand	1.022 (1.003-1.042), p=0.023*	
7 days		
Overall		1.026 (1.002-1.050) , p=0.032*
Combined regions		
Head/ orofacial	1.028 (1.005-1.052), p=0.017*	1.030 (1.006-1.055), p=0.014*
Upper limb	1.020 (1.001-1.039), p=0.040*	1.031 (1.009-1.053), P=0.005**
Neck/ trunk	1.018 (0.999-1.037), p=0.063	1.024 (1.003-1.046), p=0.027*
Priority regions		
Neck	1.020 (1.000-1.041), p=0.045*	1.022 (1.001-1.044), p=0.039*
Shoulder	1.022 (1.002-1.042), p=0.030*	1.027 (1.005-1.049), p=0.016*
Wrist/ hand	1.021 (1.001-1.041), p=0.043*	1.033 (1.010-1.056), p=0.005**
Upper back		1.018 (0.997-1.039), p=0.095
Lower back	1.017 (0.998-1.037), p=0.085	
Music-related musculoskeletal disorders		
12 months		
Combined regions		
Neck/ trunk		1.020 (0.999-1.041), P=0.057
Priority regions		
Lower back		1.021 (0.998-1.045), P=0.075
Musculoskeletal symptom consequences[a]		
Work/ study		
Leave from work/ study	1.021 (0.997-1.046), p=0.087	1.031 (1.004-1.060), p=0.025*

Notes: [a]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.43: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and musculoskeletal symptom outcomes for self-employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Combined regions		
Head/ orofacial	1.049 (1.022-1.077), p<0.001***	1.056 (1.021-1.091), p=0.001**
Upper limb	1.033 (1.000-1.066), p=0.047*	
Neck/ trunk	1.041 (1.008-1.075), p=0.016*	1.060 (1.013-1.110), p=0.012*
Priority regions		
Neck	1.058 (1.026-1.090), p<0.001***	1.077 (1.035-1.121), p<0.001***
Shoulder	1.036 (1.009-1.063), p=0.009**	1.038 (1.007-1.071), p=0.017*
Wrist/ hand	1.024 (1.001-1.048), p=0.045*	
Lower back	1.024 (1.000-1.048), p=0.048*	1.027 (1.000-1.054), p=0.049*
7 days		
Overall	1.039 (1.007-1.071), p=0.016*	1.039 (1.006-1.073), p=0.019*
Chronic[a]	1.037 (1.011-1.063), p=0.005**	1.041 (1.013-1.070), p=0.004**
Chronic+[b]	1.028 (1.000-1.057), p=0.048*	1.032 (1.002-1.063), p=0.037*
Combined regions		
Head/ orofacial	1.038 (1.011-1.065), p=0.006**	1.044 (1.012-1.077),p=0.007**
Upper limb	1.037 (1.012-1.064), p=0.004**	1.034 (1.006-1.063), p=0.018*
Neck/ trunk	1.037 (1.011-1.063), p=0.005**	1.040 (1.012-1.069), p=0.005**
Priority regions		
Neck	1.049 (1.022-1.076), p<0.001***	1.057 (1.027-1.088), p<0.001**
Shoulder	1.044 (1.018-1.071), p=0.001**	1.043 (1.013-1.074), p=0.005**
Wrist/ hand	1.025 (1.001-1.050), p=0.044*	1.026 (0.998-1.055), p=0.071
Upper back	1.024 (0.999-1.049), p=0.059	1.034 (1.004-1.065), p=0.026*
Lower back	1.022 (0.999-1.046), p=0.063	1.026 (1.000-1.053), p=0.048*
Music-related musculoskeletal disorder		
12 months		
Priority regions		
Neck	1.035 (1.010-1.060), p=0.006**	
Shoulder	1.028 (1.005-1.053), p=0.019*	
7 days		
Overall	1.034 (1.009-1.060), p=0.007**	1.040 (1.013-1.068), p=0.004**
Chronic[a]	1.041 (1.015-1.068), p=0.002**	1.049 (1.019-1.079), p=0.001**
Chronic+[b]	1.029 (0.995-1.063), p=0.096	1.036 (0.996-1.078), p=0.077
Combined regions		
Head/ orofacial		1.047 (1.005-1.090), p=0.028*
Upper limb	1.040 (1.015-1.066), p=0.002**	1.044 (1.014-1.075), p=0.004**
Neck/ trunk	1.036 (1.011-1.062), p=0.004**	1.037 (1.009-1.067), p=0.010*
Priority regions		
Neck	1.041 (1.015-1.068), p=0.002**	1.049 (1.017-1.082), p=0.002**
Shoulder	1.040 (1.014-1.067), p=0.002**	1.048 (1.014-1.083), p=0.006**
Wrist/ hand		1.038 (1.007-1.071), p=0.018*
Upper back	1.025 (0.999-1.051), p=0.055	1.034 (1.002-1.067), p=0.035*
Lower back	1.037 (1.009-1.066), p=0.008**	1.037 (0.999-1.076), p=0.056
Musculoskeletal symptoms consequences[c]		
Work/ study		
Changes to work/ study	1.029 (0.995-1.065), p=0.093	
Leave from work/ study	1.050 (1.018-1.082), p=0.002**	
Leave from musical work/ study	1.062 (1.025-1.100), p=0.001**	1.037 (0.998-1.078), p=0.060
Management		
Engage in self-management	1.049 (1.000-1.101), p=0.051	1.051 (1.001-1.103), p=0.047*
Consult a musician	1.026 (1.000-1.053), p=0.050	

Notes: [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms/ music-related musculoskeletal disorders, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. [c]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.44: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and musculoskeletal symptom outcomes for employed professional musicians

	Unadjusted	Adjusted
Musculoskeletal symptoms		
12 months		
Overall	1.051 (1.015-1.089), p=0.005**	1.055 (1.010-1.103), p=0.017*
Combined regions		
Head/ orofacial	1.037 (1.017-1.058), p<0.001***	1.029 (1.007-1.052), p=0.008**
Upper limb	1.050 (1.022-1.078), p<0.001***	1.038 (1.004-1.074), p=0.030*
Neck/ trunk	1..050 (1.022-1.079), p<0.001***	1.073 (1.030-1.116), p=0.001**
Priority regions		
Neck	1.056 (1.031-1.082), p<0.001***	1.063 (1.035-1.093), p<0.001***
Shoulder	1.052 (1.028-1.076), p<0.001***	1.057 (1.028-1.086), p<0.001**
Wrist/ hand	1.018 (1.000-1.036), p=0.053	
Upper back	1.022 (1.004-1.041), p=0.017*	
Lower back	1.024 (1.005-1.043), p=0.012*	1.025 (1.004-1.046), p=0.021*
7 days		
Overall	1.046 (1.022-1.071), p<0.001***	1.048 (1.020-1.077), p=0.001**
Chronic[a]	1.040 (1.019-1.060), p<0.001***	1.049 (1.025-1.074), p<0.001***
Chronic+[b]	1.026 (1.003-1.050), p=0.024*	1.037 (1.010-1.065), p=0.007**
Combined regions		
Head/ orofacial	1.030 (1.008-1.053), p=0.006**	1.025 (1.000-1.050), p=0.049*
Upper limb	1.046 (1.025-1.068), p<0.001***	1.044 (1.021-1.068), p<0.001***
Neck/ trunk	1.045 (1.024-1.066), p<0.001***	1.040 (1.013-1.067), p=0.003***
Priority regions		
Neck	1.040 (1.020-1.060), p<0.001***	1.045 (1.021-1.070), p<0.001***
Shoulder	1.050 (1.029-1.072), p<0.001***	1.051 (1.026-1.077), p<0.001***
Wrist/ hand	1.018 (0.999-1.038), p=0.065	
Upper back	1.034 (1.013-1.055), p=0.001**	1.027 (1.003-1.052), p=0.025*
Lower back	1.030 (1.011-1.050), p=0.002**	1.031 (1.009-1.053), p=0.005**
Music-related musculoskeletal disorder		
12 months		
Combined region		
Head/ orofacial	1.025 (1.002-1.047), p=0.030*	
Upper limb	1.016 (0.998-1.034), p=0.073	
Priority regions		
Neck	1.022 (1.004-1.041), p=0.018*	
Shoulder	1.023 (1.005-1.042), p=0.013*	
7 days		
Overall	1.020 (1.002-1.038), p=0.033*	1.027 (1.005-1.050), p=0.016*
Chronic[a]	1.025 (1.005-1.045), p=0.012*	1.034 (1.011-1.058), p=0.004**
Chronic+[b]	1.028 (0.997-1.060), p=0.082	1.035 (0.999-1.072), p=0.054
Combined regions		
Upper limb	1.027 (1.008-1.047), p=0.005**	1.030 (1.006-1.054), p=0.015*
Neck/ trunk	1.019 (1.001-1.038), p=0.042*	
Priority regions		
Neck	1.021 (1.001-1.042), p=0.043*	
Shoulder	1.024 (1.004-1.044), p=0.018	1.036 (1.008-1.066), p=0.013*
Lower back	1.019 (0.998-1.042), p=0.080	
Musculoskeletal symptoms consequences[c]		
Work/ study		
Changes to work/ study	1.035 (1.008-1.063), p=0.010*	1.036 (1.006-1.066), p=0.018*
Changes to musical work/ study	1.028 (0.998-1.059), p=0.068	1.034 (1.001-1.069), p=0.043*
Leave from work/ study	1.039 (1.015-1.064), p=0.001**	1.047 (1.019-1.075), p=0.001**
Leave from musical work/ study	1.042 (1.016-1.069), p=0.002**	1.052 (1.021-1.083), p=0.001**
Management		
Engage in self-management	1.051 (1.013-1.090), p=0.007**	1.064 (1.022-1.108), p=0.003**
Consult a musician	1.029 (1.008-1.052), p=0.008**	

Notes: [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms/ music-related musculoskeletal disorders, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. [c]in the last 12 months, of those who reported musculoskeletal symptoms in the last 12 months. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.8.45: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) associations between distress and ratings of musculoskeletal symptom outcomes

	Unadjusted	Adjusted
All musicians		
Emotional impact of MSSs[a]	0.042 (0.026-0.905), p<0.001***	0.041 (0.024-0.058), p<0.001***
Impact of MSSs on daily life[a]	0.027 (0.011-0.042), p=0.001**	0.026 (0.009-0.042), p=0.002**
Male musicians		
Emotional impact of MSSs[a]	0.052 (0.026-0.078), p<0.001***	0.044 (0.017-0.072), p=0.002**
Impact of MSSs on daily life[a]	0.045 (0.020-0.071), p<0.001***	0.047 (0.018-0.076), p=0.001**
Female musicians		
Emotional impact of MSSs[a]		0.034 (0.012-0.057), p=0.003**
Student musicians		
Impact of MSSs on daily life[a]	0.019 (-0.002-0.041), p=0.080	
Self-employed musicians		
Emotional impact of MSSs[a]	0.056 (0.030-0.082), p<0.001***	0.054 (0.025-0.084), p<0.001***
Impact of MSSs on daily life[a]	0.026 (0.003-0.049), p=0.029*	0.021 (-0.004-0.046), p=0.094
Employed musicians		
Emotional impact of MSSs[a]	0.037 (0.017-0.057), p<0.001***	0.043 (0.019-0.067), p<0.001***
Impact of MSSs on daily life[a]	0.031 (0.011-0.051), p=0.002**	0.023 (0.001-0.046), p=0.044*
MRMD severity w-scores[b]	0.288 (-0.055-0.931), p=0.098	

Notes: MSS: musculoskeletal symptoms. [a]ratings were only made by those who reported MSSs in the last 7 days. [b]ratings were only made for those who reported music-related musculoskeletal disorders in the last 7 days, and the w-scores were derived from the Rasch analysis (Appendix 2.10). Orange text indicates a significant (p<0.05) association with a beta coefficient >0. Blue text indicates a significant (p<0.05) association with a beta coefficient <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

In addition, for symptomatic, university music students, the emotional impact of musculoskeletal symptoms was analysed as a binary outcome, with a median cut-point, as analysing the data as quartiles with ordered logistic regression violated the parallel lines assumption. The association was significant in the unadjusted analysis (odds ratio 1.027, 95% confidence interval 1.002-1.053, p=0.036), and was near-significant in the adjusted analysis (adjusted odds ratio 1.027, 95% confidence interval 0.999-1.055, p=0.056).

A1.9: Supplementary material for Chapter 9

A1.9.1 Prevalence and profile of musculoskeletal symptoms

Table A1.9.1: Prevalence (95% confidence interval) of musculoskeletal symptoms and music-related musculoskeletal disorders among employed musicians

	12 month prevalence		7 day prevalence	
	Musculoskeletal symptoms	Music-related musculoskeletal disorders	Musculoskeletal symptoms	Music-related musculoskeletal disorders
Overall	89.2 (81.8-93.8)	61.8 (52.3-70.5)	71.2 (62.0-78.9)	44.5 (35.5-54.0)
Chronic[a]	NA	NA	38.7 (30.1-48.2)	27.3 (19.7-36.4)
Chronic+[b]	NA	NA	54.4 (43.3-65.1)	59.2 (44.9-72.1)
Combined regions				
Head/ oral	30.0 (22.1-39.3)	18.2 (12.0-26.6)	20.0 (13.5-28.6)	13.6 (8.3-21.5)
Upper limb	76.4 (67.4-83.4)	50.9 (41.5-60.2)	54.7 (43.3-62.0)	31.8 (23.7-41.2)
Trunk	81.8 (73.4-88.0)	54.5 (45.1-63.7)	57.3 (47.8-66.3)	35.5 (27.0-44.9)
Lower limb	45.5 (36.3-54.9)	18.2 (12.0-26.6)	23.6 (16.6-32.6)	10.0 (5.6-17.3)
Priority regions				
Neck	70.0 (60.7-77.9)	41.8 (32.9-51.3)	40.9 (32.0-50.4)	23.6 (16.6-32.6)
Shoulder	63.6 (54.2-72.2)	40.0 (31.2-49.5)	40.0 (31.2-49.5)	24.5 (17.3-33.5)
Wrist/ hand	42.7 (33.7-52.2)	28.2 (20.5-37.4)	24.5 (17.3-33.5)	18.2 (12.0-26.6)
Upper back	40.9 (32.0-50.4)	25.5 (18.1-34.5)	21.8 (15.0-30.6)	18.2 (12.0-26.6)
Lower back	58.2 (48.7-67.1)	36.4 (27.8-45.8)	38.2 (29.5-47.7)	19.1 (12.7-27.6)

Notes: [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms/ music-related musculoskeletal disorders, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. NA: not applicable

Table A1.9.2: Median (interquartile range) for ratings regarding musculoskeletal symptoms made by employed musicians

Rating	Median (interquartile range)
Pain intensity	3 (2-4)
Music-related musculoskeletal disorder severity	2 (1-5)
Impact of musculoskeletal symptoms on daily life	3 (2-5)
Emotional impact of musculoskeletal symptoms	2 (0-6)

Table A1.9.3: Prevalence (95% confidence interval) of musculoskeletal symptom consequences among symptomatic employed musicians

Consequence	Prevalence
Work/ study in the last 12 months[a]	
Changes to work/ study	8.2 (4.1-15.7)
Changes from musical work/ study	7.3 (3.5-14.6)
Leave from work/study	21.6 (14.5-31.1)
Leave from musical work/ study	15.6 (9.6-24.4)
Workers' compensation claim	6.2 (2.8-13.2)
Workers' compensation claim for musical employment	4.1 (1.5-10.6)
Consulting a health professional in the last 12 months[a]	72.7 (63.0-80.7)
Medical professional	42.3 (32.8-52.4)
Psychologist/ counsellor	8.2 (4.1-15.7)
Physiotherapist/ occupational therapist	43.3 (33.7-53.4)
Personal trainer/ Pilates instructor/ yoga instructor	20.6 (13.6-29.9)
Chiropractor/ osteopath, massage therapist, Bowen therapist	34.0 (25.2-44.1)
Naturopath/ homeopath	3.1 (1.0-9.3)
Alexander technique practitioner/ Feldenkrais practitioner/ body mapping teacher	4.1 (1.5-10.6)
Other	5.2 (2.1-11.9)
Self-management in the last 12 months[a]	90.9 (83.3-95.2)
Medication	47.4 (37.6-57.4)
Heat/ ice	46.4 (36.6-56.4)
Exercises/ stretches	88.7 (80.6-93.7)
Braces/ strapping/ taping	22.7 (15.4-32.2)
Other	8.2 (4.1-15.7)
Consulting other musicians in the last 12 months[a]	19.6 (12.8-28.8)
Current treatment[b]	40.2 (30.1-51.3)

Notes: [a]of those with musculoskeletal symptoms in the last 12 months, [b]of those with musculoskeletal symptoms in the last 7 days

A1.9.2 Association between organisational, psychosocial factors and musculoskeletal symptom outcomes

A1.9.2.1 Effort-reward imbalance

Table A1.9.4: Odds ratios (95% confidence intervals for the significant and near-significant (p<0.10) associations between effort-reward imbalance and musculoskeletal symptom outcomes in the unadjusted and adjusted models, for employed musicians

	Unadjusted models	Adjusted models
Musculoskeletal symptoms		
7 days		
Overall		
Chronic[a]	3.715 (1.647-8.381), p=0.002**	3.733 (1.4679.499), p=0.006**
Chronic+[b]	4.412 (1.666-11.685), p=0.003**	9.132 (2.271-36.716), p=0.002**
Combined regions		
Head/ orofacial	2.696 (1.034-7.032), p=0.043*	3.984 (1.345-11.806), p=0.013*
Neck/ trunk	2.009 (0.901-4.480), p=0.088	
Music-related musculoskeletal disorders		
12 months		
Overall	3.194 (1.353-7.538), p=0.008**	2.741 (1.078-6.966), p=0.034*
Combined regions		
Head/ orofacial	2.625 (0.971-7.096), p=0.057	3.655 (1.119-11.936), p=0.032*
Upper back	3.343 (1.488-7.507), p=0.003**	3.141 (1.193-8.272), p=0.021*
Neck/ trunk	2.586 (1.159-5.772), p=0.020*	2.318 (0.924-5.818), p=0.073
Lower back	4.054 (1.403-11.713), p=0.010*	3.471 (1.150-10.474), p=0.027*
Priority regions		
Neck	2.457 (1.115-5.415), p=0.026*	
Shoulder	2.410 (1.090-5.327), p=0.030*	
Wrist/ hand		2.812 (1.105-7.153), p=0.030*
Lower back	2.333 (1.044-5.215), p=0.039*	2.423 (1.058-5.549), p=0.036*
7 days		
Overall	2.758 (1.249-6.088), p=0.012*	3.292 (1.365-7.939), p=0.008**
Chronic[a]	6.391 (2.474-16.493), p<0.001***	9.390 (2.785-31.657), p<0.001***
Chronic+[b]	9.000 (2.392-33.866), p=0.001**	89.563 (5.024-1596.518), p=0.002**
Combined regions		
Head/ orofacial	5.000 (1.475-16.947), p=0.010*	4.386 (0.957-20.100), p=0.057
Upper limb	2.077 (0.910-4.741), p=0.083	
Neck/ trunk	3.000 (1.324-6.799), p=0.008**	3.353 (1.284-8.754), p=0.013*
Lower limb	6.889 (1.387-34.223), p=0.018*	5.816 (1.129-29.951), p=0.035*
Priority regions		
Neck	2.793 (1.115-6.999), p=0.028*	
Lower back	2.625 (0.971-7.096), p=0.057	4.355 (1.271-14.927), p=0.019*
Consequences		
Management		
Consult a health professional	2.947 (1.061-8.189), p=0.038*	
Ratings		
Impact of MSSs on daily live	1.162 (0.346-1.978), p=0.005**	
Emotional impact of MSSs	0.810 (0.011-1.608), p=0.047*	

Notes: MSS: musculoskeletal symptom, [a]Chronic musculoskeletal symptoms/ music-related musculoskeletal disorders refer to musculoskeletal symptoms/ music-related musculoskeletal disorders present on most days for at least the last 3 months. [b]Chronic+ refer to chronic musculoskeletal symptoms/ music-related musculoskeletal disorders, among the musicians who reported musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. All musculoskeletal symptom outcomes without a significant or near-significant (p<0.10) association with effort-reward imbalance were omitted from the above table. Orange text indicates a significant (p<0.05) association with an odds ratio of >1, while blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.5: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) associations between effort-reward imbalance and musculoskeletal symptom ratings (unadjusted), for employed musicians

	Unadjusted
Impact of musculoskeletal symptoms on daily life	1.162 (0.346-1.978), p=0.005**
Emotional impact of musculoskeletal symptoms	0.810 (0.011-1.608), p=0.047*

Notes: Ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. There were no associations between effort-reward imbalance and musculoskeletal symptom ratings in the adjusted analyses; hence, only the unadjusted findings are reported. Orange text indicates a significant (p<0.05) association with a beta coefficient of >0. Blue text indicates a significant (p<0.05) association with a beta coefficient of <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

A1.9.2.2 Effort

Table A1.9.6: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between effort and musculoskeletal symptom and music-related musculoskeletal disorder prevalence in the unadjusted and adjusted models, for employed musicians

	Unadjusted	Adjusted (Analysis 2[a])	Adjusted (Analysis 3[a])
Musculoskeletal symptoms			
7 days			
Overall			
Chronic[b]	1.021 (1.004-1.038), p=0.017*		
Chronic+[c]	1.018 (0.999-1.037), p=0.064		
Combined regions			
Head/ orofacial	1.018 (0.999-1.038), p=0.063		
Priority regions			
Lower back	1.017 (1.000-1.034), p=0.046*	1.019 (1.002-1.036), p=0.031*	
Music-related musculoskeletal disorders			
12 months			
Overall	1.033 (1.013-1.054), p=0.001**	1.032 (1.010-1.055), p=0.004**	1.032 (1.010-1.055), p=0.004**
Combined regions			
Head/ orofacial	1.020 (1.000-1.040), p=0.047*		
Upper limb	1.031 (1.012-1.051), p=0.001**	1.030 91.009-1.051), p=0.006**	1.030 91.009-1.051), p=0.006**
Neck/ trunk	1.021 (1.004-1.039), p=0.017*		
Lower limb	1.020 (1.000-1.041), p=0.045*	1.023 (1.002-1.044), p=0.035*	1.023 (1.002-1.044), p=0.035*
Priority regions			
Neck	1.016 (1.000-1.033), p=0.056		
Shoulder	1.018 (1.001-1.034), p=0.038*		
Wrist/ hand	1.027 (1.008-1.045), p=0.005**	1.028 (1.008-1.048), p=0.006**	1.028 (1.008-1.048), p=0.006**
Lower back	1.019 (1.002-1.036), p=0.030*	1.019 (1.002-1.037), p=0.025*	1.019 (1.002-1.037), p=0.025*
7 days			
Overall	1.027 (1.009-1.045), p=0.003**	1.031 (1.011-1.051), p=0.002**	1.031 (1.011-1.051), p=0.002**
Chronic[b]	1.036 (1.016-1.057), p<0.001***	1.033 (1.010-1.057), p=0.006**	1.033 (1.010-1.057), p=0.006**
Chronic+[c]	1.037 (1.007-1.068), p=0.016*	1.087 (1.022-1.157), p=0.008**	1.052 (1.005-1.102), p=0.028*
Combined regions			
Head/ orofacial	1.022 (1.000-1.045), p=0.046*		
Upper limb	1.025 (1.007-1.043), p=0.007**	1.025 (1.002-1.048), p=0.032*	1.025 (1.002-1.048), p=0.032*
Neck/ trunk	1.021 (1.004-1.038), p=0.017*		
Lower limb	1.025 (1.000-1.050), p=0.051	1.030 (1.002-0.058), p=0.035*	1.030 (1.002-0.058), p=0.035*
Priority regions			
Neck	1.018 (0.999-1.036), p=0.058		
Shoulder	1.016 (0.998-1.034), p=0.082		
Wrist/ hand	1.018 (0.998-1.038), p=0.080		
Lower back	1.027 (1.007-1.048), p=0.008**	1.038 (1.013-1.063), p=0.003**	1.038 (1.013-1.063), p=0.003**

Notes: [a]Analysis 2 included effort, reward, elements of safety climate, and potential confounders, and Analysis 3 included effort, the reward sub-scales, elements of safety climate, and potential confounders. [b]chronic refers to musculoskeletal symptoms/ music-related musculoskeletal disorders on most days for at least the last 3 months among all participants. [c]chronic+ refers to musculoskeletal symptoms/ music-related musculoskeletal disorders experienced on most days for at least the last 3 months among only musicians reporting musculoskeletal symptoms/ music-related musculoskeletal disorders in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.7: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations in the unadjusted analyses between effort and the consequences of musculoskeletal symptoms in the last 12 months in the unadjusted models, for symptomatic employed musicians

	Unadjusted
Changes to study/ work	1.028 (1.000-1.056), p=0.051
Changes to musical study/work	1.025 (0.996-1.054), p=0.098
Leave from study/work	1.024 (1.004-1.044), p=0.017*
Leave from musical study/ work	1.028 (1.006-1.051), p=0.013*
Management	
Consult a health professional	1.017 (0.997-1.037), p=0.099

Notes: Effort was not associated with any of them musculoskeletal symptom consequences after adjusting for confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.8: Beta coefficients (95% confidence intervals) for the significant and near-significant (p<0.10) associations between effort and musculoskeletal symptom outcomes for symptomatic employed musicians

	Unadjusted	Adjusted (Analysis 2[a])	Adjusted (Analysis 3[a])
Impact of musculoskeletal symptoms on daily life	0.014 (-0.001-0.029), p=0.074	0.017 (0.001-0.033), p=0.035*	0.017 (0.001-0.033), p=0.035*
Emotional impact of musculoskeletal symptoms	0.013 (-0.002-0.028), p=0.097	0.023 (0.003-0.042), p=0.021*	0.023 (0.003-0.042), p=0.021*

Notes: Ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. [a]Analysis 2 included effort, reward, elements of safety climate, and potential confounders, and Analysis 3 included effort, the reward sub-scales, elements of safety climate, and potential confounders. Orange text indicates a significant (p<0.05) association with a beta coefficient of >0. Blue text indicates a significant (p<0.05) association with a beta coefficient of <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

A1.9.2.3 Reward sub-scales

Table A1.9.9: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between reward, and the reward-subscales and musculoskeletal symptom and music-related musculoskeletal disorder prevalence for symptomatic, employed musicians

	Reward	Job security		Promotion
	Unadjusted	Unadjusted	Adjusted	Unadjusted
Musculoskeletal symptoms				
12 months				
Overall		1.067 (0.998-1.141), p=0.059		
Combined regions				
Upper limb		1.080 (1.023-1.140), p=0.006**	1.111 (1.029-1.200), p=0.007**	
Lower limb	0.959 (0.917-1.003), p=0.066			
Priority regions				
Neck	0.971 (0.939-1.003), p=0.073			
Shoulder		1.040 (0.998-1.084), p=0.063	1.083 (1.019-1.151), p=0.010*	0.972 (0.941-1.003), p=0.078
Lower back		0.950 (0.910-0.992), p=0.020*		
7 days				
Priority regions				
Lower back			0.942 (0.899-0.987), p=0.012*	
Music-related musculoskeletal disorders				
12 months				
Combined regions				
Upper limb				0.968 (0.938-1.000), p=0.047*
Lower limb				0.956 (0.916-0.998), p=0.042*
Priority regions				
Shoulder				0.962 (0.930-0.995), p=0.025*
7 days				
Combined regions				
Lower limb				0.954 (0.903-1.007), p=0.088

Notes: Reward was not associated with any of the musculoskeletal symptom outcomes reported in the above table, the adjusted analyses and were therefore removed. Esteem was omitted from the above table, as it was not associated with any of the musculoskeletal outcomes reported in the above table. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.10: Odds ratios (95% confidence intervals) for the significant and near-significant (p<0.10) associations between reward, and the reward-subscales and musculoskeletal symptom consequences for symptomatic, employed musicians

	Reward	Job security		Promotion		Esteem
	Unadjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted
Work/ study						
Leave from study/ work		0.951 (0.903-1.001), p=0.056	0.944 (0.890-1.002), p=0.058			
Management						
Consult a health professional	0.963 (0.930-0.997), p=0.033*			0.964 (0.930-0.999), p=0.042*		0.986 (0.969-1.002), p=0.094
Engaged in self-management				0.956 (0.909-1.004), p=0.074	0.923 (0.855-0.995), p=0.038*	
Consult a musician					1.060 (0.999-1.124), p=0.054	

Notes: Reward, security and esteem were not associated with any of the musculoskeletal symptom outcomes reported in the above table, in the adjusted analyses and were therefore removed. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.11: Beta coefficients (95% confidence intervals) in the unadjusted analyses for the significant or near-significant (p<0.10) associations between reward or reward subscales, and musculoskeletal symptom ratings

	Effort-reward imbalance	Reward	Promotion		Esteem
	Unadjusted	Unadjusted	Unadjusted	Adjusted	Unadjusted
Impact of musculoskeletal symptoms on daily life		0.959 (0.923-0.998), p=0.037*	0.944 (0.904-0.986) p=0.009**	0.947 (0.901-0.996), p=0.035*	
Emotional impact of musculoskeletal symptoms	2.882 (1.136-7.311), p=0.026*	0.970 (0.935-1.006), p=0.009			0.984 (0.968-1.001), p=0.069

Notes: ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with an odds ratio of >0. Blue text indicates a significant (p<0.05) association with an odds ratio of <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

A1.9.2.4 Safety climate

Table A1.9.12: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) associations between perceptions of the workplaces' communication of occupational health and safety and musculoskeletal symptom outcomes, for employed musicians

	Unadjusted	Adjusted (Analyses 1-2)	Adjusted (Analysis 3)
Musculoskeletal symptoms			
Neck in the last 12 months	0.993 (0.986-1.000), p=0.048*		
Music-related musculoskeletal disorders			
Neck in the last 7 days	0.990 (0.981-0.998), p=0.020*		
Consequences of musculoskeletal symptoms[a]			
Work/ study			
Leave from work/ study		1.009 (0.999-1.018), p=0.076	1.013 (1.002-1.044), p=0.023*
Management			
Engaged in self-management	1.014 (1.000-1.028), p=0.050	1.026 (1.007-1.046), p=0.007**	1.029 (1.006-1.052), p=0.014*
Consulting a musician	0.991 (0.982-1.001), p=0.074		

Notes: [a]in the last 12 months, among those who reported musculoskeletal symptoms in the last 12 months. Analysis 1 included effort-reward imbalance, the safety climate variables, and potential confounders. Analysis 2 included effort and reward, the safety climate variables, and potential confounders. Analysis 3 included effort, the reward sub-scales, safety climate variables, and potential confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.13: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) associations between perceptions of the workplaces' prioritisation of occupational health and safety and musculoskeletal symptom outcomes, for employed musicians

	Prioritisation			
	Unadjusted	Adjusted (Analysis 1)	Adjusted (Analysis 2)	Adjusted (Analysis 3)
Musculoskeletal symptoms				
Neck in the last 12 months	0.988 (0.978-0.998), p=0.016*	0.989 (0.978-1.000), p=0.044*	0.989 (0.978-1.000), p=0.044*	0.989 (0.978-1.000), p=0.044*
Music-related musculoskeletal disorders				
Neck in the last 12 months	0.992 (0.983-1.001), p=0.075			
Wrist/ hand in the last 12 months			0.991 (0.980-1.002), p=0.097	0.991 (0.980-1.002), p=0.097
Neck in the last 7 days	0.989 (0.978-0.999), p=0.039*			
Consequences of musculoskeletal symptoms[a]				
Management				
Consulting a musician	0.987 (0.974-0.999), p=0.034*	0.981 (0.965-0.997), p=0.022*	0.981 (0.965-0.997), p=0.022*	0.975 (0.957-0.993), p=0.006**

Notes: [a]in the last 12 months, among those who reported musculoskeletal symptoms in the last 12 months. Analysis 1 included effort-reward imbalance, the safety climate variables, and potential confounders. Analysis 2 included effort and reward, the safety climate variables, and potential confounders. Analysis 3 included effort, the reward sub-scales, safety climate variables, and potential confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.14: Odds ratios (95% confidence intervals) for the significant or near-significant (p<0.10) associations between perceptions of involvement in the workplaces' occupational health and safety and musculoskeletal symptom outcomes, for employed musicians

	Unadjusted	Adjusted (Analyses 1-3)
Musculoskeletal symptoms in the lower back in the last 12 months	0.983 (0.970-0.996), p=0.010*	0.977 (0.963-0.992), p=0.003**
Music-related musculoskeletal disorders in the upper back in the last 12 months		1.028 (1.006-1.049), p=0.011*

Notes: Analysis 1 included effort-reward imbalance, the safety climate variables, and potential confounders. Analysis 2 included effort and reward, the safety climate variables, and potential confounders. Analysis 3 included effort, the reward sub-scales, safety climate variables, and potential confounders. Orange text indicates a significant (p<0.05) association with an odds ratio of >1. Blue text indicates a significant (p<0.05) association with an odds ratio of <1. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

Table A1.9.15: Beta coefficients (95% confidence intervals) for the significant or near-significant (p<0.10) associations between perceptions of involvement in the workplaces' occupational health and safety and musculoskeletal symptom outcomes, for employed musicians

	Involvement	Prioritisation
	Unadjusted	Unadjusted
Music-related musculoskeletal disorder severity w-scores[a]	-0.211 (-0.434-0.012), p=0.063	
Emotional impact of musculoskeletal symptoms[b]	0.983 (0.968-0.997), p=0.022*	0.988 (0.977-0.999), p=0.032*

Notes: [a]ratings were only made for those who reported music-related musculoskeletal disorders in the last 7 days, and w-scores were derived from the Rasch analysis (Appendix 2.10). [b]ratings were only made by those who reported musculoskeletal symptoms in the last 7 days. Orange text indicates a significant (p<0.05) association with a beta coefficient of >0. Blue text indicates a significant (p<0.05) association with a beta coefficient of <0. Black text indicates a near-significant association (0.05≤p<0.10). *p<0.050, **p<0.010, ***p<0.001.

APPENDIX 2: MANUSCRIPTS

Appendix 2 includes the manuscripts (published and in preparation), related to this thesis.

For consistency with the rest of the thesis, the referencing style of manuscripts presented here aligns with the thesis and is not necessarily the same as that of the journals. The reference lists for each manuscript have been amalgamated with that of the main body of the thesis and is reported in the References section.

Library note: The following pages have been removed

Appendix 2.1 thesis pages 373-378 (pdf page 385-390)
Appendix 2.2 thesis pages 379-402 (pdf page 391-414)
Appendix 2.3 thesis pages 403-414 (pdf page 415-426)
Appendix 2.4 thesis pages 415-438 (pdf page 427-450)
Appendix 2.5 thesis pages 439-476 (pdf page 451-488)
Appendix 2.6 thesis pages 477-478 (pdf page 489-490)
Appendix 2.7 thesis pages 479-480 (pdf page 491-492)
Appendix 2.8 thesis pages 481-482 (pdf page 493-494)
Appendix 2.12 thesis pages 509-526 (pdf page 521-538)
Appendix 2.17 thesis pages 595-610 (pdf page 607-622)
Appendix 2.18 thesis page 611 (page 623

A2.9 Should pain ratings be combined? Rasch analysis of pain ratings using numeric rating scales for pain at its worst, on average, and at its least

Abstract

Background: As musculoskeletal disorders are one of the leading causes of years lived with disability, having accurate pain intensity measures is vital in order to understand risk factors for and interventions to address pain intensity. One of the measures commonly used involves asking participants to rate their pain intensity at its worst, on average and at its least for the last 7 days on numeric rating scales, with the three ratings summed to produce a composite measure. The utility of this composite measure has not been examined using modern psychometric approaches.

The purpose of this study was to examine the utility of this pain intensity measure for use with professional musicians, university music students, university science students, and university staff who reported experiencing musculoskeletal symptoms in the last 7 days.

Methods: Data were collected using a questionnaire, as part of a broader study. Rasch analysis was used to examine the utility of the composite measure, and differential item functioning (DIF) investigated with regards to age, gender, socioeconomic status, student status or whether the participant was a professional or university musician.

Results: The pain intensity data fit the partial credit model; however, there was DIF for whether the participant was a student or not for Item 1. After removing Item 1, there was however DIF for whether the participant was a musician or not; hence no solution was found.

When analysing only the musicians' data, DIF was again detected for Item 2, regarding whether the participant was a student or not. Removal of Item 2 resulted in category disordering. Despite applying multiple strategies to address the disordering, no solution was identified.

Conclusion: Despite the recommendation for the three items to be combined, using Rasch analysis we found that this was not a valid approach for our study population. This study highlights the importance of using Rasch analysis to examine the utility of measures.

Keywords: musician, university, Rasch, psychometrics, pain, musculoskeletal

Background

Pain is a symptom of many conditions, including primary pain conditions, like low back pain and arthritis, as well as post-surgical pain and pain from diseases such as cancer. Pain has been defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[80] Pain may impact adversely on the individual and the broader community. In the 2015 Global Burden of Diseases study, lower back and neck pain were identified as one of the leading causes of disability globally.[513] Chronic pain, that is "pain that persists beyond normal tissue healing time, which is assumed to be three months"[710], has been estimated to affect 35-51% of the adult population in the United Kingdom.[711] As pain is a subjective experience, self-reported measures of pain are considered the 'gold standard'.[401] Pain intensity, defined as "how much a person hurts"[403], is a common measure used in both intervention and observational research. Pain intensity is a core domain of pain measurement for various groups.[401, 712-714]

This validation study forms part of a larger investigation into the musculoskeletal symptoms (MSSs) experienced by university music students and professional musicians, which included science students and university staff as reference groups. Musculoskeletal symptoms, including pain, are reported to be experienced by the majority of musicians[50, 51, 287], impairing their ability to undertake their musical activities[60, 63, 192, 218, 286, 400, 521], as well as impacting on other aspects of their lives.[60, 63, 192, 232, 287] While there are a large number of studies regarding musicians[559], few have investigated the intensity of pain.[619] In our study we were also interested in comparing these musicians with a reference group of university staff and students, as this was another evidence gap identified.[559]

Pain intensity scales

Pain intensity scales are used frequently for both clinical and research purposes. The most common pain scales used are the visual analogue scale (VAS), numeric rating scale (NRS) and verbal rating scale (VRS)[402, 403]; where the NRS appears to be the most frequently used in general[494, 676], while others appear to more frequently used for specific patient groups.[493]

The NRS has been recommended over the VAS and verbal numeric rating scales.[401] The NRS is preferred by respondents[401, 492] and researchers, given its ease of use[403], and has less missing or incomplete data when compared with the VAS.[401-403, 493] The NRS can also be used with a wider range of populations than the VAS, as it does not rely upon a certain degree of motor control, and it can also be completed verbally; an advantage for telephone interviews or when working with people who are unable to write.[403] The NRS most commonly has 11-points from 0 to 10[493], and while there has been great variation in the anchors used[493], the recommended anchors are 0 “no pain” and 10 “pain as bad as you can imagine”.[401] The format of the Brief Pain Inventory[383] has been recommended.[401]

The 11-point NRS has been reported to be a valid and reliable measure of pain intensity, in both paediatric[676] and adult populations[402], however the results may be impacted by differences in the anchors used, and the recall periods assessed.[679] The type of pain rating (e.g. at its worst, on average, least, current) should be included and reported.[494]

In the case of current pain ratings, which reduce recall bias, these may be susceptible to diurnal variation, as well as changes due to aggravating and easing activities.[403, 405, 406] Without strict control of these potential effect modifiers/ confounding variables the results may be inaccurate. Two approaches have been proposed to address these issues. The first, involves collecting data on current pain ratings at multiple points during a set recall period, and then pooling the results[715]; while the second asks for different types of pain ratings, e.g. at its worst, least, on average and/or current, over a set recall period.[404-406] The latter approach imposes less burden on the study participant, and may therefore be a more suitable measure for many studies. While this combination of scales does, in theory, address the potential problems with validity and reliability described above, there needs to be evidence that summing these scales is also a valid approach.

Study purpose

The present study is part of a larger study where we were interested in musculoskeletal symptom outcomes, including pain intensity, in musicians. Musculoskeletal disorders are the most common and costly condition for musicians’ workers’ compensation claims[558], and the majority of musicians’ experience musculoskeletal symptoms[50-52], often with a range of consequences.[60, 63, 64, 287] In order to attempt to better understand, and ultimately reduce this burden, we were interested in: 1. Comparing different types of musicians (e.g. student and professional musicians); 2. Comparing musicians and a reference group (non-music university staff and science students); and, 3. Investigating the association between various potential risk factors and musculoskeletal symptom outcomes, including pain intensity. These research topics have not previously been explored adequately.[559]

Pain intensity was measured in this study using three of the items from the Brief Pain Inventory Pain Intensity Subscale[459] – pain at its worst, on average and at its least in the last 7 days. This selection was made following a review[619] of the musculoskeletal symptom outcome measures used with musicians, and the Brief Pain Inventory[716] specifically. We are unaware of any published studies reporting analysis using Rasch analysis for the combination of different types of pain intensity ratings (e.g. at its worst, on average, and at its least), over a 7 day recall period. Recently, a study reported using transformed data from the Brief Pain Inventory Pain Intensity Subscale[717], however findings of the Rasch analysis itself was not reported. In keeping with current best practice, Rasch analysis needs to be applied to our pain intensity scales, in order to sum the three scales, to ensure internal consistency of the scale, the absence of differential item functioning (or item bias), and to produce a linear, interval level scale.[420, 429]

The purpose of this present study was to examine the summed pain intensity scale, used with professional musicians, university music students, university science students and non-music university staff, in terms of internal consistency, and differential item functioning, and to produce a linear, interval level scale. The study population were university science and music students, university non-music staff, and professional musicians.

Methods

The study had ethics approval from The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and the Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006).

To be eligible for inclusion, musicians had to be aged 18 years or older, and enrolled in a music degree (undergraduate or postgraduate), or be a professional musician. We defined professional musicians as those who were employed as a musician, or those who were members of the Music Teachers' Association or Musicians' Union. Our reference groups were university science students, and university staff from the Faculties of Humanities, Science and Health Science, and had to be aged 18 years or older.

It has been suggested that for polytomous scales there should be at least 10 participants in each response category.[409] As we had no existing data available that indicated the distribution of responses across the 11-points of each scale we were not able to estimate an appropriate sample size *a priori*. Instead, we aimed to collect responses from as many people as possible to maximise the likelihood of meeting this criteria.

Musicians were recruited from two universities, two state-based music teachers' associations, the musicians' union, three orchestras, five military bands, and two opera companies, all from two Australian states. Recruitment was performed by email from the first author and/ or a face-to-face session with the first author. The differences in recruitment were due to logistical considerations or to comply with organisational policy. In both cases, a brief description of the project was provided, along with an Information Sheet and a copy of the questionnaire. The questionnaire was available in paper or online formats (Survey Monkey; www.surveymonkey.com). With the exception of groups where organisational policy did not permit the use of Survey Monkey, participants recruited via the face-to-face sessions were provided with a link and quick-response (QR) code directing them to the survey. Those recruited via email were invited to request a paper copy of the questionnaire, which would be posted to them. A reply-paid envelope was provided with all paper questionnaires. Non-musicians were recruited using email only. Where permitted by organisational policy, a prize draw was offered as an incentive for participation.

Two questionnaire packages were used; one for musicians and another for non-musicians, however the pain intensity rating scales were the same. Skip logic was used so that only those reporting ache, pain or discomfort in the last 7 days, using a modified version of the Nordic Musculoskeletal Questionnaire[67], were asked to complete the pain intensity rating scales.

Based on the recommendations described above, and the pain rating scales used in other studies of musicians[619], we measured pain intensity at its worst, on average, and at its least over the last 7 days, using an 11-point NRS. The anchors and wording was selected in keeping with the current recommendations[401], and the Brief Pain Inventory[383], however we did alter the average scale by specifying that this rating was for the last 7 days, as per current recommendations[401] and reporting guidelines[494] (Figure 1).

The following scales relate to your PAIN in the last 7 days

Please rate your pain by circling the one number that best describes your pain at its WORST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *0 = No pain* *10 = Pain as bad as you can imagine*
Please rate your pain by circling the one number that best describes your pain at its LEAST in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *0 = No pain* *10 = Pain as bad as you can imagine*
Please rate your pain by circling the one number that best describes your pain on AVERAGE in the last 7 days	0 1 2 3 4 5 6 7 8 9 10 *0 = No pain* *10 = Pain as bad as you can imagine*

Figure 1: Pain intensity scales

Data from Survey Monkey were exported into Microsoft Excel, and data from the paper questionnaires were manually entered. Manually entered data were double entered, in order to detect any errors in data entry. Initial data cleaning and coding were conducted in Excel before being exported into Stata 14.[411] Regarding this study, data cleaning involved ensuring that participants met the inclusion criteria, and that they were correctly classified as either musicians or non-musicians. We also considered the rating scales to ensure that ratings at their least were not higher than on average or at its worst, and that ratings on average were not higher than at its worst. Where this was the case, the participant's data for all three scales was recoded as missing.

Within Stata 14[411] we classified participants as younger or older, using a median cut-point. Similarly, a median cut-point was used to classify musicians' socioeconomic status, as per the Index of Relative Socioeconomic Advantage and Disadvantage. [376] Participant identification number, and data regarding gender, age category, whether they were a musician or not, their socioeconomic status classification, and responses to each of the pain intensity scales were exported into ConQuest[430] for the Rasch analysis.

Data analysis

To determine the validity and reliability of the combined scale, we used Rasch analysis, rather than focusing on methods which fall within Classical Test Theory (CTT). Rasch analysis should be used whenever items are combined (e.g. summed)[420, 429], and has a number of advantages over the CTT methods, including that the findings are applicable beyond the sample being studied, and examining the scales internal construct validity, including category ordering, unidimensionality, and differential item functioning.[429, 441] If the data fit the Rasch model, it can be transformed into a linear, interval scale[428], allowing for valid assessment of the change in pain intensity and the use of parametric statistics.[429] A more detailed description of the differences between CTT and Rasch analysis are reported elsewhere.[420, 429, 718]

Two polytomous scale models are available in the suite of RMMs, the Rating scale model (RSM)[422] and Partial credit model (PCM).[425] Unlike the PCM, the RSM assumes items are equally discriminating, have the same rating scale structure and the same number of response categories[432], and that the categories are equidistant for each item.[429] The PCM was therefore used in this study, as the nature of the measure meant that empty cells were expected (e.g. we were unlikely to have any respondents who rated their pain at its least as 10, and as only symptomatic participants were included no respondents would have rated their pain at its least as zero).

Rasch analysis is an iterative process, whereby issues are identified, attempts made to rectify any issues, before the analysis is re-run.[428] The level of significance was 0.05 for all analyses. From the selected model, the fit statistics were examined. In ConQuest[430] these are the unweighted and weighted fit mean square. Items were flagged as being potentially mis-fitting if the weighted fit mean square value outside of the range 0.60-1.40[437, 438], or where the t-statistic, derived from the cube root transformation, was outside the range -1.96 to 1.96.[428] As this was not a 'high-stakes' test items falling outside of these ranges were not necessarily excluded, but other factors first considered. The chi-square test statistic was also examined as an overall fit statistic[420], as was the separation reliability, which is a measure of overall error and discrimination power.[416]

To ensure that the items were correctly ordered, we looked for an increase in the category estimates for each item, the mean predictive values, point biserial correlations, item deltas and item thresholds.[428, 429, 439, 440] Where disordering was evident, we considered collapsing the categories[420, 429, 440, 441], particularly if there were small numbers of participants in them (n<10). We also examined the item-total correlation, or discrimination index, with a correlation of <0.20 deemed extremely low.[428] The item-rest correlation was also examined and had to be positive.

In order to determine whether there were any mis-fitting participants, we examined the residual fit statistics[442], with the optimal range -1.96 to 1.96. To examine targeting of the measure we examined the Wright map. The Wright map displays the position of the items on the logit scale, as well as the distribution of the participants. If the scale is well targeted then the mean person location should be centred at zero logits.[429, 441] Where the scale is not well targeted caution needs to be applied when interpreting the fit statistics.[420] Local dependency was detected by examining the correlation matrix of the item residuals[420, 429]; low dependency defined as absolute correlations of <0.40.[443]

We also used Rasch analysis to examine whether there was any differential item functioning (DIF) whereby sub-groups respond differently to an item despite equivalence overall.[420, 429, 441] We examined DIF for age, gender, socioeconomic status, being a student, and being a musician. The presence of significant DIF was determined with the Wald test; that is comparing the item estimates in the item*group (e.g. item*gender) model, with the error, where the absolute estimate was greater than twice the error, the item was deemed to potentially have DIF.[444] In addition, the weighted fit mean square and t-value for the items for each sub-group was examined, using the criteria outlined above.[445] If DIF was identified via the Wald test or the weighted fit mean square and t-value then the magnitude of DIF was determined. If the difference between the groups was greater than 0.5 logits, then the magnitude was sufficient to influence the results.[445]

The type of DIF was determined where there was significant DIF of greater than 0.5 logits. Uniform DIF refers to the situation where the differences are consistent across all logits[420, 441, 446], and when this does not occur it is described as being non-uniform DIF. Uniform DIF was addressed by splitting the dataset by the group, and re-analysing separately[420, 441], so that different estimates were obtained for the subgroups. Although removing the uniform DIF item is another option available[420], we opted for a more conservative approach given the small number of items being examined.

Within ConQuest[430] the weighted likelihood estimates (WLE) were determined. The WLE was selected over other transformation methods for it minimises estimation bias.[447] The WLEs were then transformed into W-scores, using the formula W=9.1024 logits + c, where the c is a constant term, selected so that negative values are eliminated.[448] This was conducted in Microsoft Excel.

Results

A total of 547 participants who reported pain in the last 7 days were included in the analysis. Of the participants, 34.5% were male, 58.3% were currently studying at university, and 36.4% of the sample were either university music students or professional musicians. The median age of the sample was 26 years (interquartile range 20-45 years). Ratings of pain at its least (Item 1) ranged from 0-8, pain on average (Item 2) from 0-8, and pain at its worst (Item 3) from 1-10.

The data did not fit the PCM well, with Items 1 (pain at its least) and 2 (pain on average) having t-values that exceeded the optimal range (Item 1: 3.5, and Item 2: -5.7). The estimates for Item 1 were disordered, as were the item deltas and point biserial correlations. The point biserial correlations were also disordered for Items 2 and 3. Similar issues were encountered after collapsing categories 7-8 for Item 1.

The estimates and item deltas were not disordered after further collapsing categories for Item 1, such that ratings of 6-8 were coded as 6; however, the point biserial correlation disordering remained. Importantly, the data of 40 participants (7.3%) did not fit the model, with t-values of 1.98-4.28. The model was re-run without these 40 mis-fitting participants, with similar results obtained.

There was no DIF detected for age, gender, socioeconomic status or whether the participant was a musician or not. There was however significant DIF for whether the participant was a student or not, of 0.528 logits for Item 1. This degree of DIF is of sufficient magnitude to alter results. The DIF was non-uniform (Figure 1).

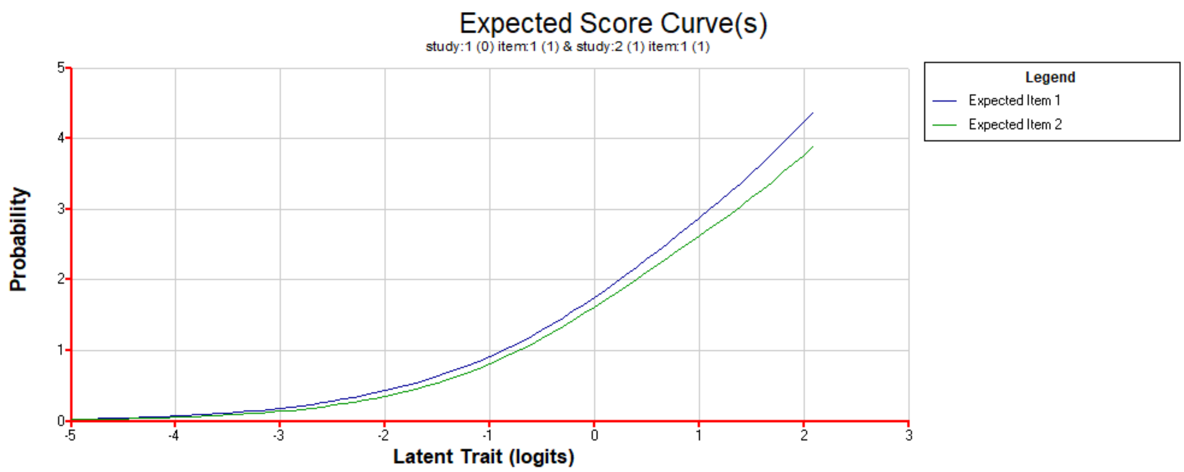


Figure 1: Expected score curve for Item 1 by whether the participant was a student or not.

The analysis was re-run without Item 1 (pain at its least), because of the DIF finding. Category estimates, item thresholds and item deltas were in ascending order. There was disordering of point biserial correlations for both items, as well as predicted values for Item 2 (pain at its worst). The disordering of mean predicted values was rectified by collapsing categories 9-10 for Item 2. Data were mis-fitting for 24 participants (4.4%), with t-values of 2.49-8.89. Findings were similar when these participants were removed.

There was no DIF identified for whether the participant was a student or not, there was however significant DIF for whether the participant was a musician or not (5.3 logits) for both items. The DIF was present whether mis-fitting participants were included or not, and whether the highest two response categories for Item 2 (pain at its worst; 9-10) were collapsed or not.

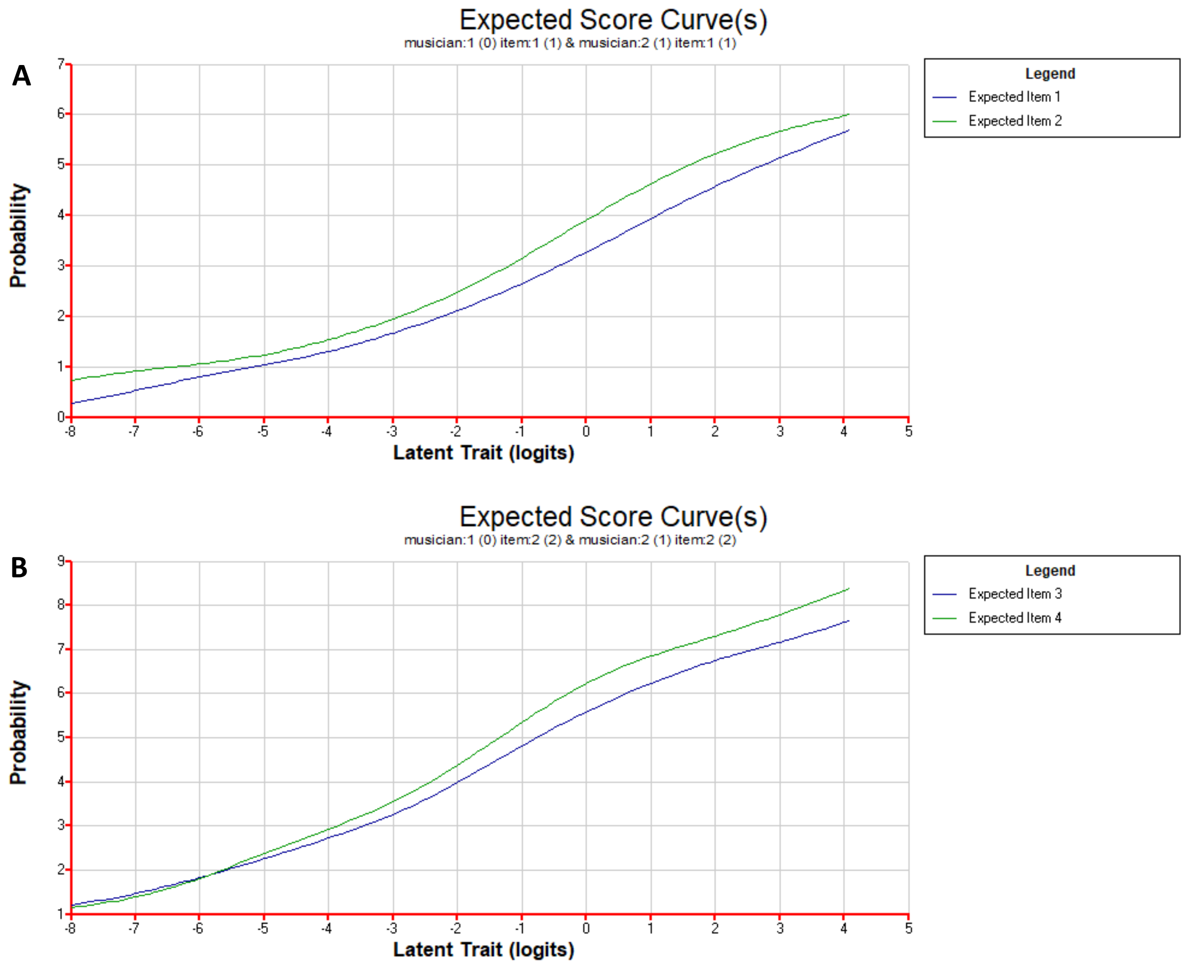


Figure 2: Expected score curve for A. Item 1 (pain on average) and B. Item 2 (pain at its worst) for whether the participant was a musician or not

Musicians only

As part of our research included musicians only, the utility of the measure was examined for musicians only. For musicians, responses for pain at its least ranged from 0-5, for on average response ranged 0-7, and for pain at its worst ratings ranged from 1-10. The data fit the PCM well, with no categories being collapsed. The data of 11% of respondents was mis-fitting; however, the deviation was minimal with t-values ranging from 2.01-3.52. Removing these participants from the analysis did not alter the results.

Differential item functioning was again identified for whether the participant was a student or not, for Item 2 ('pain on average', 0.552 logits). This DIF was non-uniform (Figure 3).

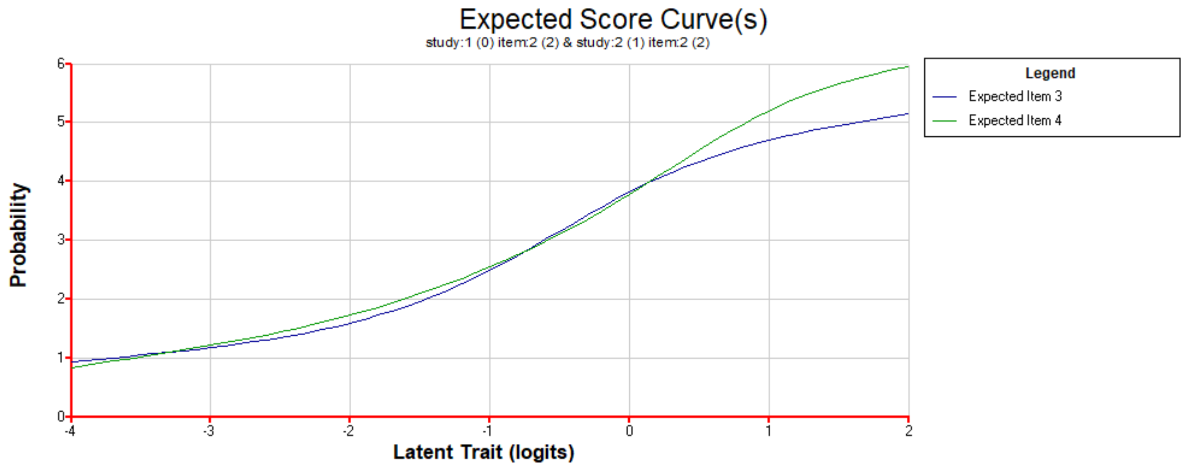


Figure 3: Expected score curve for Item 2 (pain on average) for whether the musician was a student or not

After removing Item 2 there was significant disordering of the item deltas and point biserial correlations for both items, as well as some disordering of the mean predicted values and category estimates (Figure 4). We were unable to resolve the disordering through collapsing response categories (see supplementary material for more information).

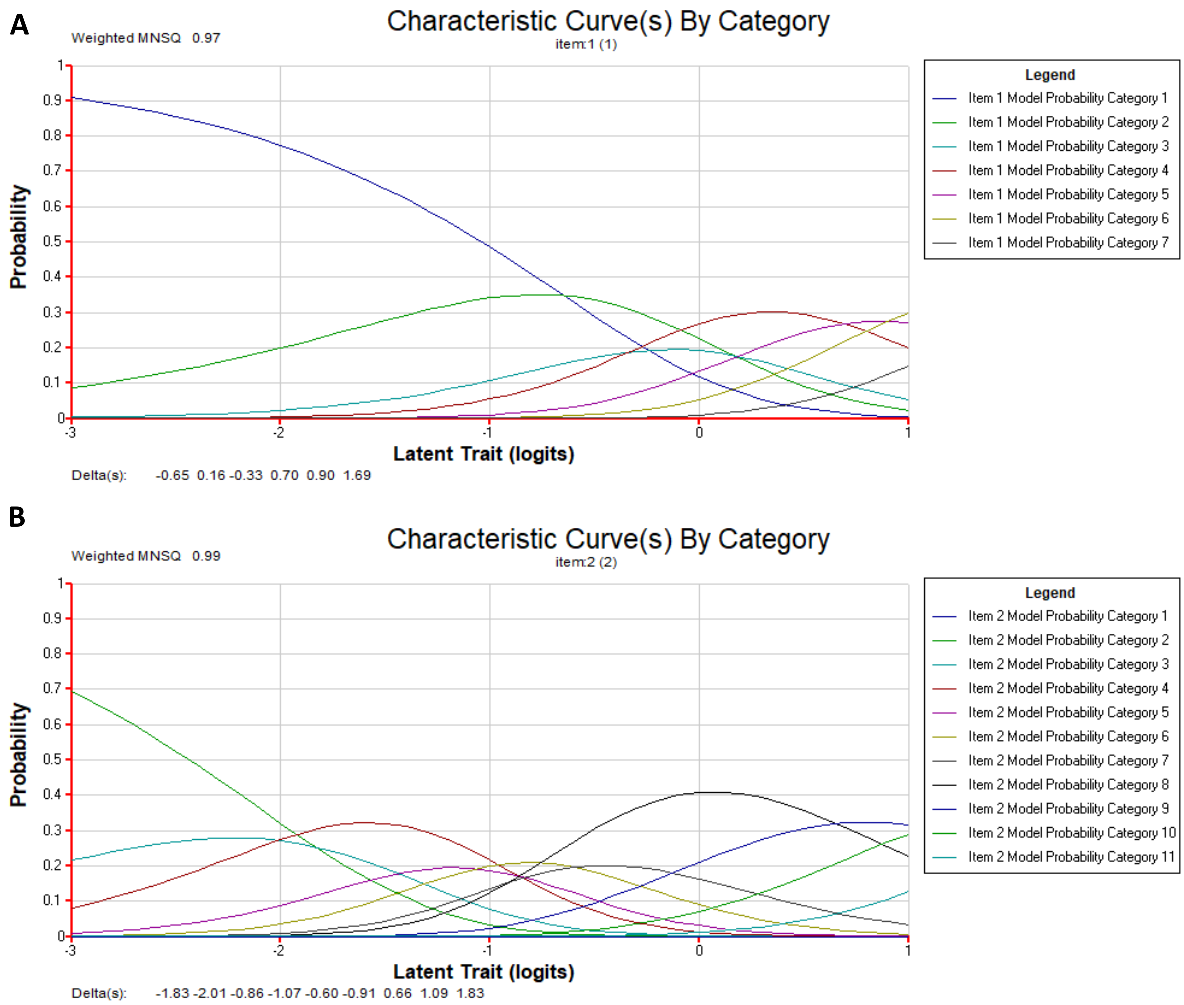


Figure 4: Characteristic curves by score for the analysis with musicians only

Discussion

Despite previous recommendations[404-406] suggesting that ratings of pain intensity at its worst, on average, and at its least be combined, to improve the reliability of pain measurement there have not been any studies of the utility of this approach with 7 day recall periods, tested using Rasch analysis. In the present study, we investigated the utility of this approach for use with professional musicians, university music students, university science students and non-music university staff. For a combined population of professional musicians, university staff, and university music and science students, and for musicians specifically the scale exhibited DIF, and its use cannot be recommended.

The data did not initially fit the PCM, as indicated by disordered category estimates, item deltas, mean predicted values and/or point biserial correlations, particularly for Item 1 (pain at its least). After collapsing the highest categories for Item 1 (6-10) the data fit the PCM, despite some minor disordering of the point biserial correlations. There was however significant non-uniform DIF for Item 1 for whether the participants were students or not, of sufficient magnitude to influence results. Item 1 was therefore removed.

After removing Item 1 (pain at its least), the data still fit the PCM, and there was no DIF for whether the participants were students or not, however there was DIF for whether the participant was a musician or not. Differential item functioning was non-uniform; hence, the only option for rectifying this problem was to delete one of the items. This approach would result in a 1-item scale. It has previously been suggested that when data can only be collected using one scale, that 'pain on average' be rated. This approach has been found to be valid[412], however these data remain ordinal. The implications of ordinal data are that parametric statistics should not be used with ordinal data, and that ordinal data should not be used as an outcome to examine changes over time (e.g. in intervention students).[429]

The use of longer measures of pain intensity may be explored, where the data are used in longitudinal studies. Pain diaries with a larger number of ratings may be appropriate in these instances; however, the added burden this would place on the participants would need to be considered.

Importantly, the findings of this study are generalisable to the populations studied, but are not necessarily generalisable to other populations. Importantly, these scales were developed for, and have largely been tested with clinical populations.[383, 459, 716] Clinical populations would be expected to have a different profile of pain intensity; hence we are not stipulating that these pain measures not be used with any population, but highlight the need to first adequately test their utility. Through using Rasch analysis, we identified issues with these pain measures, that otherwise may not have been identified.

Future studies investigating the utility of combined pain measures, such as the one examined in this study, should also consider other important elements of understanding the scales, such as minimally important clinical differences, and cut-points for mild, moderate, and severe pain. In the present study, even had the data fit the PCM, and no DIF had been detected, we would not have been able to comment on these important elements of pain measurement, when reporting the findings of our survey.

Conclusion

The utility of combining the three pain scales cannot be assumed. We found that, due to differential item functioning, the summing of the three scales was not appropriate for our study population. The findings are not necessarily generalisable to other populations, but they do highlight the need to conduct Rasch analysis on measures such as this pain measure in order to test their utility.

Supplementary material

Table S1: Category collapsing strategies attempted, and the resultant item deltas

Category collapsing strategy	Item deltas
Original data	Item 1: -0.65, 0.16, -0.33, 0.70, 0.90, 1.69 Item 2: -1.83, -2.01, -0.86, -1.07, -0.60, -0.91, 0.66, 1.09, 1.83
Lowest two categories combined for both items	Item 1: 0.55, -0.71, 0.43, 0.71, 1.55 Item 2: -2.00, -1.35, -1.49, -0.96, -1.22, 0.41, 0.89, 1.68
Lowest two categories combined for Item 1, and lowest three categories combined for Item 2	Item 1: -1.38, 0.35, 0.29, 0.60, 1.46 Item 2: -0.77, -1.56, -1.02, -1.27, 0.35, 0.83, 1.61
Lowest two categories combined for Item 1, and lowest four categories combined for Item 2	Item 1: -1.39, 0.39, 0.36, 0.69, 1.57 Item 2: -0.43, -1.09, -1.27, 0.41, 0.74
Lowest three categories combined for Item 1, and lowest four categories combined for Item 2	Item 1: 0.67, -0.01, 0.38, 1.28 Item 2: -0.65, -1.34, -1.53, 0.14, 0.47
Collapsed categories 1-2 for Item 1, and 4-5 for Item 2	Item 1: -1.11, 0.59, 0.50, 0.80, 1.65 Item 2: -2.08, -2.19, -1.71, -0.21, -1.09, 0.55, 1.03, 1.81
Collapsed categories 0-2 for Item 1, and 0-2 and 4-5 for Item 2	Item 1: -0.19, 1.03, 0.84, 1.84 Item 2: -3.07, -3.01, -1.63, -2.23, -0.65, 0.43, 1.09, 2.01

A2.10 Measuring the severity of music-related musculoskeletal disorders: Rasch analysis of a new measure

Abstract

Background: Most musicians experience musculoskeletal symptoms (MSSs), and for many of these musicians their musical activities are impaired as a result. There is currently no measure that investigates the degree of musical impairment, which can be applied to the all body regions, and to non-instrumental musicians. The objective of this study was to develop and test a new scale for measuring the degree of musical impairment from MSSs.

Methods: We therefore proposed a new 3-item measure of 'music-related musculoskeletal disorders' (MRMDs). The definition of MRMDs was modified from Zaza et al.'s definition of playing-related musculoskeletal disorders to include non-instrumental musical activities (e.g. singing). Responses regarding the degree of impairment were made on 11-point numeric rating scales for the impairment at its worst, on average and at its least.

Data were collected from university music students and professional musicians using a questionnaire developed for this project, which included the MRMD measure. Data were subject to Rasch analysis, and differential item functioning (DIF) assessed for age, gender, socioeconomic status and whether the musician was a student or not.

Results: There was a large degree of category disordering identified across all items. While this was addressed by collapsing several categories, DIF was identified for the 'MRMD at its worst' for gender, and was ultimately removed. The resultant scale required further collapsing of categories to address disordering. The final scale had raw scores from 0-6, which were transformed into interval-level w-scores. There were still issues with local dependency and the targeting of the scale to the population.

Discussion: A new item of the severity of MRMDs was proposed and tested using Rasch analysis. As with similar studies, there was disordering of categories that were ultimately collapsed. The ratings for MRMD at its worst were also removed due to DIF. The resultant scale still have some limitations, however unlike the single-item ordinal scales that have been used previously, the data can be analysed using parametric statistics and can be used to examine changes over time. Future work should consider the development of more comprehensive measures of MRMD severity which would be anticipated provide a measure without these limitations. Valid measures of MRMD severity are vital in order to reduce the burden of MSSs for musicians.

Keywords: musculoskeletal, musicians, Rasch analysis, measure, impairment

Background

Work-related musculoskeletal disorders are the most common health condition claimed for by professional musicians, and account for the majority of claim costs.[558] Musculoskeletal symptoms (MSSs) are often experienced by musicians[48-52], and may have a range of consequences including impaired musical ability.[60, 218, 286, 295, 296] While a large number of studies have investigated whether or not musical activity has been impaired by the MSSs[559, 619], the examination of the degree of impairment has been less frequently investigated.[619] Our recent review of data collection tools for musicians' MSSs[619] revealed that studies that have investigated the degree of musical impairment from MSSs have either used single-item scales (e.g. numeric rating scales or visual analogue scales), or the performing arts/sports module of the Disability of the Arm, Shoulder and Hand (DASH) questionnaire.[477, 501] The DASH performing arts module is only applicable to instrumentalists, and to MSSs in the upper limb[477, 501]; hence it has limited applications. Single-item scales of musical impairment also have their limitations, in that the data are ordinal; hence the data should not be analysed with parametric statistics, nor used in longitudinal studies[429] (although both have occurred[719]). A new measure of the degree of musical impairment of MSSs was therefore required in order to improve our understanding of the risk factors, and ultimately interventions, to address these impairments, thus reducing the burden of musicians' MSSs.

The objective of this study was to develop and test a measure of the degree of musical impairment of MSSs for use with university music students and professional musicians.

Methods

We conducted our cross-sectional study, with ethics approval granted from The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and the Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006).

Based on our systematic recent review of data collection tools for MSSs[619] we selected Zaza et al.'s[68] definition of 'playing-related musculoskeletal disorders' as the basis for the definition of 'music-related musculoskeletal disorders' (MRMDs). Such a change was required as we were interested in the MSSs of singers, conductors, and drum majors, in addition to instrumentalists. The definition of a MRMD provided to participants was therefore "pain, weakness, lack of control, numbness, tingling or other symptoms that have interfered with your ability to do your musical activity at the level to which you are accustomed".

To examine the degree of the impairment, we used three numeric rating scales (NRS), for impairment at its worst, on average and at its least, in a similar manner to what has previously been recommended for pain intensity measures.[404-406] As an example, participants were asked, "how much has you music-related musculoskeletal disorder interfered with your musical activity at its WORST in the last 7 days?". The anchors used were taken from the Brief Pain Inventory-Interference Scale[383], and were "does not interfere" and "completely interferes".

The measure of MRMD severity was included in a larger questionnaire. The questionnaire was used to collect data on the demographic characteristics in which we planned to examine differential item functioning. These characteristics were age, gender, socioeconomic status, and whether the participant was currently studying music at university or not. Age and socioeconomic status were dichotomised using a median cut-point, with socioeconomic status being based on the Index of Relative Socioeconomic Advantage and Disadvantage.[376] The questionnaire was pilot tested with five musicians prior to recruitment to examine face validity, the flow/layout of the questionnaire, and the time taken to complete. No issues with the MRMD severity measure were identified.

The recruitment strategy for this project has been described elsewhere.[720] In short, data were collected from professional musicians and university music students from two Australian states. Only musicians who reported MRMD in the last 7 days were asked to respond to the MRMD severity measure. Data were cleaned, by removing the responses of anyone who provided disordered ratings (e.g. MRMD at its least was rated high than MRMD at its worst).

Data were imported into ConQuest[430] for analysis. The data were fit to the Partial credit model (PCM); a polytomous model that allows for differences in the number of response categories per item.[432] While all items permitted responses of 0-10, we were unlikely to have any respondents indicate that their MRMD at its least was 10, and as the scale was only completed by those with MRMD in the last 7 days, there would be no ratings of zero for MRMD at its worst.

The analysis follows the methods used in our Rasch analysis of pain intensity scales.[720] In short, the data were fit to the PCM, and the unidimensionality, category ordering, person fit, local dependency, and scale targeting, as per Table 1. Where deviations from the ideal results indicated in Table 1 were identified, the deletion of items or collapsing of categories was considered.

Table 1: Parameters assessed for Rasch analysis

Parameter	Optimal result
Weighted fit mean square and corresponding t-values (an indicator of model fit & unidimensionlity[428, 437, 438])	Weighted fit mean square: 0.60-1.40[437, 438] Corresponding t-value -1.96 to 1.96[428]
Chi-square test of parameter equality (an indicator of overall fit)	Significant chi-square test
Separation reliability (an indicator of overall error & discrimination power[416])	Higher results more favourable[416]
Item deltas, item thresholds, mean predicted values, point biserial correlations & category estimates	Ascending order[428, 429, 439, 440]
Discrimination index (item-total correlation)	Ideally ≥0.40, but ≥0.20 acceptable[428]
Biserial correlation (item-rest correlation)	Positive
Case residual fit statistics (an indicator of person fit[442])	t-value of -1.96 to 1.96
Wright map (an indicator of the targeting of the scale)	Mean person location of approximately zero logits[429, 441]
Correlation of the residuals (an indicator of local or response dependency)[420, 429]	Correlation of <0.40 indicates low dependency[443]

Differential item functioning (DIF) was also examined for age, gender, socioeconomic status, and whether the musician was a student or not. The Wald test[444] and examining the weighted fit mean square[445] of the items for each sub-group were used to determine whether there was significant DIF. Where the DIF exceeded 0.5 logits[445], the item was deleted[420] (see Stanhope et al.[720] for further detail).

If data fit the PCM without DIF, the raw scores were transformed into weighted likelihood estimates (WLE), as this method minimises estimation bias.[447] Using the formula w=9.1024 logits + c, where the c is a constant term, the WLEs were transformed into w-scores. The constant term was selected so that all w-scores were positive.

Results

The data of 111 musicians was included in the analysis. The median age of participants was 30 years (interquartile range 20-50 years), 60.5% were female, and 49.6% were currently studying music at university.

The Rasch analysis revealed a number of problems with the scale. The category estimates, item deltas and point biserial correlations for all three items were disordered. In response to this disordering, response categories were gradually collapsed, with the model re-run each time to examine changes in the fit of the data to the PCM. Ultimately, for Item 1 (MRMD at its worst) categories 4-5 were collapsed, for Item 2 (MRMD on average) categories 3-5 and 6-10 were collapsed, and for Item 3 (MRMD at its least) categories 2-3, 4-5, and 6-10 were collapsed. Although the point biserial correlations for Items 1 and 2 were still slightly disordered, the mean predicted values, item thresholds, item deltas, and category estimates were in ascending order. The weighted fit mean squares for Items 2 and 3 were -3.7 and 2.6, respectively; however, no further changes were made. The item-rest correlations ranged from 0.59-0.90, and the item-total correlations from 0.76-0.95.

Although, with changes to the scales, the data fit the PCM, DIF was detected for gender in Item 1 (MRMD at its worst). The magnitude of the DIF was 0.654 logits; hence Item 1 was removed.

Without Item 1, the analysis was re-run, and some categories had to, again, be collapsed owing to evidence of category disordering. Ultimately, for Item 1 (MRMD on average) categories 3-5 and 4-10 were collapsed, and for Item 2 (MRMD at its least) categories 2-10 were collapsed. The resultant data fit the PCM, with only slight disordering of the point biserial correlations detected for Item 1. The item-rest correlations were 0.63 for both items, and the item-total correlations were 0.87-0.93. No mis-fitting participants were identified, however there was a high degree of local dependency, with the residuals of Items 1 and 2 strongly correlating (-0.804). The scale was not that well targeted to the population, with the mean person location being greater than zero logits (Figure 1). No DIF was detected for the modified scale, and the raw scores were transformed into W-scores (Table 2).

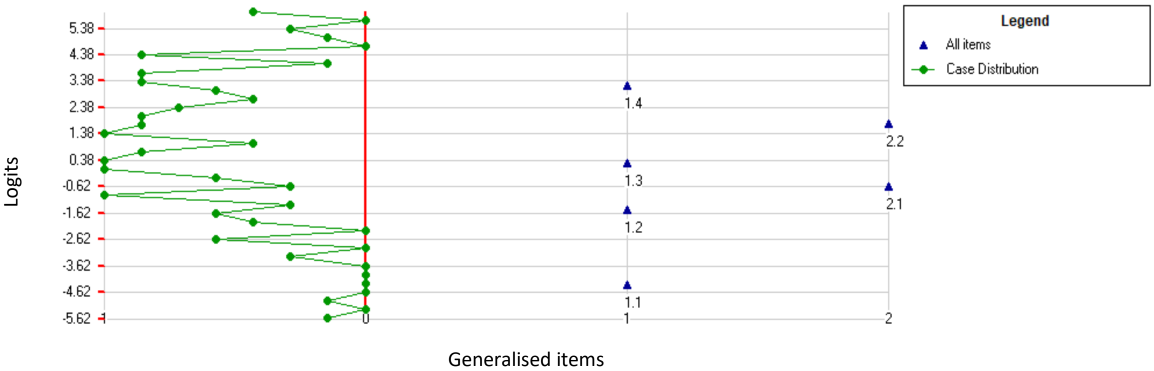


Figure 1: Wright map

Table 2: Transformation table

Raw scores	Weighted likelihood estimates (standard error)	W-scores
0	-5.32 (2.15)	2
1	-2.73 (1.50)	25
2	-1.11 (1.13)	40
3	-0.10 (1.06)	49
4	1.00 (1.13)	60
5	2.42 (1.31)	72
6	4.29 (1.95)	89

Notes: the raw scores are after collapsing categories and removing Item 1.

Discussion

The objective of this study was to develop a scale to measure MRMD severity in university music students and professional musicians. Using an existing definition for playing-related musculoskeletal disorders[68], the concept of combining ratings for their worst, average, and least[404-406], and the anchors of an interference scale[383], the measure of MRMD was developed.

As we found with our examination of pain intensity scales that were summed[720], there were issues with the category ordering. Once these category ordering issues were addressed, DIF was identified for gender for the 'MRMD at its worst' item, which was subsequently removed. With the resultant two-item scale, further categories needed to be collapsed, resulting in a six point summed scale. The scale exhibited a high degree of local dependency and was poorly targeted to the population. Nonetheless, the advantage of this scale over a single-item measure of MRMD severity is that it can be used with parametric statistics and be used in longitudinal studies.[429] This measure is therefore an improvement upon existing methods of data collection for MRMD severity.

The issues with the targeting of the scale and the high degree of local dependency both indicate that more comprehensive measures of MRMD severity be developed. These should be based upon focus groups with musicians to determine the elements of musical activity that may be impaired by MSSs, in a similar manner to the DASH performing arts/ sports module[477, 501] but with broader applications.

A2.11 Rasch analysis in social research: an example using the Musicians' Social Support Scale

Abstract

The utility of questionnaires is integral to ensuring that the inferences derived from the questionnaire data are accurate. Modern psychometric methods, like Rasch analysis, offer a range of advantages over traditional psychometric methods, like Cronbach's alpha, which are under-pinned by Classical Test Theory. In this article, we describe the differences between traditional and modern psychometric methods, and provide an example of Rasch analysis used to assess the utility of the Musicians' Social Support Scale. We collected data from 298 university music students and professional musicians, and applied Rasch analysis to the data. The data fit the Rating scale model, with no evidence of differential item functioning for age, gender, student or professional status. The raw ordinal scales were transformed into interval level w-scores that can be used with parametric statistics, and to assess changes over time.

Keywords*:* social support, psychometrics, Rasch analysis, musicians

Background

The utility of scales used in social research are paramount to ensure that the inferences made using the collected data are accurate[721, 722], and this may have real life implications. Quantitative data in social research may be collected via questionnaires or observational techniques, such as behaviour mapping. Often the scores from individual items or repeated measures are combined (e.g. averaged or summed) in order to provide an overall score. While scales may have reported validity and reliability, often these claims are based on traditional statistics, not modern psychometric methods.

In this paper, we describe traditional and modern psychometric methods, outlining why traditional methods alone are insufficient for examining the utility of social scales. We also provide a worked example of Rasch analysis, a type of modern psychometric method, which we used to examine a new scale, the Musicians' Social Support Scale.

Traditional and modern psychometric methods

Classical Test Theory (CTT) underpins traditional statistics, and includes commonly reported statistics, such as Cronbach's alpha and factorial analysis statistics. Both the CCT[416] and Cronbach's alpha[417-419] have their limitations. There are two main assumptions of the CTT: that the reported raw score is the sum of the true score and a random measurement error[414, 415], and that the errors are randomly distributed, and are independent of one another and the true score.[414] The CTT explores the relationship between the person's measurement and the overall total score.[415]

One of the issues with traditional statistics, underpinned by CTT, is that the scales remain ordinal[414], which means that the scales are inappropriate for use in longitudinal studies (e.g. intervention studies), and non-parametric methods must be used.[429] Another issue with traditional statistics is that they are not generalizable to other samples or other times.[414] Traditional statistics have often inappropriately been used to justify the selection of a scale in a study.

The Rasch measurement model (RMM) addresses these issues, and have a range of other advantages over the CTT. Rasch analysis may be used to supplement traditional statistics.[421] Unlike the CTT, modern psychometric methods investigate the person's measurement in relation to the probability of their response, and has robust underlying theories.[415] RMM is the only modern psychometric method that follows Luce and Tukey's[426] general rules of measurement. The general rules of measurement are interval scaling (invariance of comparisons) and that the total score can be used to predict an item score (sufficiency).[427] The RMM is also the simplest model to check for unidimensionality and parameter invariance, and the underlying theory of item-examinee analysis is well established. The RMM output provides the minimal number of parameter estimates.[422-425]

The RMM can be used to assess the internal construct validity of a measure; by investigating unidimensionality (that only one construct is measured), assessment of category ordering (that categories are operating as intended), item invariance (interval scaling), and differential item functioning (DIF; that there are not differences in the responses to an item between sub-groups, where the overall score is similar).[429, 441]

The testing of scales that involve combining individual items to provide an overall measure should include Rasch analysis.[420, 429] To ensure that items measure the latent trait, Rasch analysis involves fitting the collected data to one of the Rasch measurement models (RMM).[420] The rating scale model (RSM)[422] and the partial credit model (PCM)[425] are the two RMM for polytomous scales, with Rasch's[431] dichotomous model used for dichotomous outcomes. The RSM assumes items are equally discriminating, have the same rating scale structure and the same number of response categories[432], and that the categories are equidistant for each item[429], which is not the case for the PCM.

If the data fits one of the RMMs, the ordinal raw score is transformed into a linear, interval level measure.[420, 429] The interval measure uses log odds units or logits and the transformation is monotonic, in that the ranking of participants is maintained.[428] The advantage of the resultant interval measure is that parametric statistics can be used, and the measure can be validly used to examine change given the equidistant spacing of scores.[429]

Differential item functioning (DIF) is another important element of examining the utility of a measure that Rasch analysis can be used to assess. Differential item functioning refers to when a sub-group of participants respond differently to an item, despite being of a similar level overall.[420, 429, 441] Differential item functioning can be used to examine demographic factors (e.g. age, gender, socioeconomic status), as well as elements of data collection (e.g. the use of paper or online questionnaires). Rasch analysis is therefore a critical element of questionnaire development and testing, and has relevance to data collection in social research.

Here we provide an example of the use of Rasch analysis to test the utility of the Musicians' Social Support Scale.

Our project and the need for a new scale

As part of a larger project, we were interested in the relationship between a range of psychosocial factors and musculoskeletal symptom (MSS) outcomes. The prevalence of MSSs in musicians' is high[50-52], they have a range of negative impacts on their careers and lives in general[60, 192, 287, 289, 298], and musculoskeletal disorders account for the majority of workers' compensation claims for musicians.[558] The association between psychosocial factors, like social support, and MSS outcomes are under-investigated in musicians.[559, 723]

One of the psychosocial factors of interest was social support. Only two studies[232, 724] have previously investigated the association between social support and MSS for musicians. Both studies provide evidence of an association between social support and the presence of pain[232, 724], but they do not look at whether social support alters the consequences of experiencing MSS; a research gap we were hoping to fill.

We were specifically interested in the association between social support from other musicians and MSS outcomes, as musicians with MSS have reported experiencing stigma[62, 197, 255] and social isolation from other musicians when experiencing MSS.[62, 194, 196, 197, 256] As the practice of music is unique, and the meaning music plays in the lives of musicians is unlikely to be adequately understood by non-musicians, it was also important that we were able to examine how musicians support from other musicians may influence MSS outcomes.

No measure of music-specific social support was available. Our research investigated the association between a range of exposures and MSS outcomes; hence, a short measure of social support was appropriate as the basis of our new scale. We selected the support from co-workers subscale from the General Nordic Questionnaire for Psychological and Social Factors at Work (QPS_{Nordic})[378] to adapt to develop our music-specific social support scale. We altered the wording so that it was specific to musicians, and so that it encompassed study as well as work (Figure 1). The response categories used matched the original QPS_{Nordic} social support items.

Circle the alternative that best describes your opinion

	Very seldom or never	Rather seldom	Sometimes	Rather often	Very often or always
If needed, can you get support and help with your studies/ work from other musicians?	1	2	3	4	5
If needed, are other musicians willing to listen to your study/ work related problems?	1	2	3	4	5

Figure 1: The Musicians' Social Support Scale

We aimed to determine the utility of the new Musicians' Social Support Scale for use with university music students and professional musicians, using Rasch analysis.

Methods

The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and the Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006) granted approval for this project.

Study population

Our population of interest were university music students and professional musicians who were aged 18 years or older. We defined professional musicians as those who were employed as musicians in the last 12 months or who were members of the Music Teachers' Association or Musicians' Union.

Sample size

It has been suggested that at least 10 participants are required for each response category in polytomous scales.[409] As we were testing a new scale, we aimed to collect data from as many participants as possible.

Recruitment

Musicians were recruited from two Australian states through the Musicians' Union, two Music Teachers' Associations, three orchestras, two opera companies, five military bands and two universities. Where possible musicians were recruited through face-to-face and email recruitment, however due to organisational policy and/or logistical limitations musicians from some organisations were only recruited via one of these strategies. All potential participants were provided with a brief description of the project, and information sheet and the questionnaire (paper or a link to the online questionnaire on Survey Monkey (www.surveymonkey.com). Paper questionnaires were returned to a return box, via a supplied reply-paid envelope, or directly to the first author. Where permitted by organisational policy, those recruited via face-to-face sessions could also complete the questionnaire online as they were provided with a Quick Response code and link. Similarly, those recruited via email could require that a paper questionnaire be sent to them. As an incentive for participation, where organisational policy permitted it, a prize draw was offered for those who completed the questionnaire within two weeks.

Data collection and management

A questionnaire package was developed for the project that included items regarding a range of demographic, musculoskeletal symptom and psychosocial factors. The Musicians' Support Scale was included within this questionnaire package. The questionnaire package was pilot tested with musicians to examine face validity, comprehensibility, ordering and format of the questionnaire; both on paper and online.

Data collected via Survey Monkey were exported into Microsoft Excel and data from the paper questionnaires were manually entered into the same spreadsheet. The manually entered data were double entered to detect and correct any data entry errors. Within Excel, the data were cleaned and preliminary coding was performed. The spreadsheet from Excel was exported into Stata 14.[411] Within Stata[411] we determined the median age (25 years) which was used to categorise participants into younger (18-25 years) and older (>25 years) age groups. Socioeconomic status based upon the Index of Relative Socioeconomic Advantage and Disadvantage[376], using the participants' residential postcode, then determining the sample median score, with this used as the cut-point for analysis. Participants were also classified as being a current university music student or not.

To facilitate the Rasch analysis the lowest response category had to be zero. As such, the scores reported in Figure 1 were all lowered by one point for coding, such that 'very seldom or never' was coded as zero, 'rather seldom' as one, 'sometimes' as two, 'rather often' as three, and 'very often or always' as four.

Data relevant to this part of the study (identification number, age category, gender, student/ professional status, and data from the Musicians' Social Support Scale) were exported into ConQuest[430] for Rasch analysis. Stata 14[411] was later used to determine the correlation matrix of the residuals.

Data analysis

The utility of the Musicians' Social Support Scale was examined using Rasch analysis. As outlined in the following sections there are optimal statistics for these analyses. Where findings deviate from the optimal ranges, the removal of items and/or collapsing of response categories was considered before re-analysing the data. Rasch analysis is therefore an iterative process.[428] Throughout the analysis $p<0.05$ was considered statistically significant.

Fitting the data to the model

Within Rasch analysis, two polytomous scale models are used; the partial credit model (PCM)[425] and the rating scale model (RSM).[422] We attempted to fit the Musicians' Social Support Scale data to both models, and examined the Akaike information criterion (AIC)[433] to determine which model the data best fit. The model with the lower AIC was selected as this reflects the most parsimonious model[435]; that is the model with the lowest mean square error.[434]

The fit of the data to the model, and whether the measure was unidimensional was determined using item residual fit statistics. Within ConQuest[430] unweighted and weighted fit mean square are reported. Items and categories were flagged as potentially mis-fitting where the weighted fit mean square was not within the range 0.60-1.40[437, 438] or where the associated t-value (from the cube root transformation) was not within the range -1.96-1.96.[428] Before considering omitting any items, the potentially mis-fitting items were examined, along with other statistics outlined in the following sections. A more lenient approach was taken for this study as it was not a 'high stakes' examination regarding the weighted fit mean squares and t-values. We also examined the chi-square test of parameter equality.

If the data fit the model well the category estimates, item deltas and thresholds, point biserial correlations and mean predicted values should all be in ascending order.[428, 429, 439, 440] Collapsing of categories was considered to address disordering, however this was done cautiously given the loss of data that would result.[420, 429, 440, 441] To ascertain whether collapsing categories was an appropriate approach we examined the general response patterns, with those having zero response being appropriate for collapsing, as per Andrich's[439] recommendation that collapsing is only justified where the discrimination at the threshold is zero.

The discrimination indices or item-total correlations were considered extremely low where they were <0.20[428], and the biserial correlation (item-rest correlation) should be positive. To address any issues item deletion was considered.

To identify any mis-fitting cases we explored person fit using the residual fit statistics.[442] Where the residual fit statistic was not within the range -1.96 to 1.96 the participant was deemed to be mis-fitting. Again, as this does not reflect a 'high stakes' examination, and unlike educational testing there is no 'right' or 'wrong' answer, a more lenient approach was adopted. If the residual fit statistics were far outside of the optimal range, and there was a large percentage of mis-fitting participants we re-ran the analysis without these cases to examine whether these cases change the fit of the model.

The targeting of the scale for the population was explored using the Wright map. The Wright map reports the participant distribution along with logit scale, in addition to the item position, so can be used to determine the mean person location, which should be approximately zero logits where the scale is well targeted.[429, 441]

Response or local dependency was examined using the correlation matrix of the residuals[420, 429], where low dependency was defined as correlations <0.40.[443] As the Musicians' Social Support Scale measures perceptions, rather than correct or incorrect answers, a more lenient cut point, 0.60, was used. Higher local dependency may inflate the scale's reliability.[420] Given rating scales were being used to measure perceptions, a more lenient cut point of 0.60 was adopted.

Differential item functioning

We used Rasch analysis to examine whether there was DIF in the Musicians' Social Support Scale for age category, gender, and socioeconomic status, and whether or not they were currently studying music at university. To assess DIF we used the Wald t-test, and weighted mean fit squares for each group. Using the Wald t-test, the absolute estimates for the item*group (e.g. item*gender) which were greater than twice the standard error were deemed as being statistically significant.[444] In addition, statistical significance was determined based on the weighted mean fit square.[445] For this we used the same optimal ranges as for the item fit statistics, i.e. a weighted mean fit square of 0.60-1.40, and t-values of -1.96-1.96. If either approach indicated significant DIF, the magnitude of the DIF was determined. The thresholds of the groups were examined and a difference of greater than 0.5 logits was considered large enough to be a potential problem.[445]

Where DIF was present, the type of DIF was determined using the plots of expected values against the logit, with the groups overlayed. The DIF was classified as uniform where there was a vertical translation between the groups.[420, 441, 446] Uniform DIF was addressed by splitting the data into groups and analysing them separately[420, 441], or by removing the DIF item.[420] In our study removing items was not possible as the original scale only had two items. Non-uniform DIF occurs where expected values between groups were different for different logit levels.[420, 429, 441] Non-uniform DIF could be addressed with item deletion.[441] Where the difference in responses could be explained across groups, no changes were made.

Transformation to W-scores

The raw scores were transformed, within ConQuest[430], into Weighted Likelihood Estimates (WLE). A range of transformation methods are available, however the advantage of the WLE over the other methods is that it reduces estimation bias.[447] To eliminate the need for decimal points and negative values the WLEs were transformed into W-scores[448] in Microsoft Excel. The transformation was performed using the formula W=9.1024 x logits + c, where c was a constant term.[448] The constant term was selected to ensure that the resultant W-scores would be positive.

Results

A total of 298 participants completed the Musicians' Social Support Scale, with both items completed by all. The median age was 25 years (interquartile range 20-46 years), and 159 (53.72%) of the sample were female. 90 (30.20%) participants were students only, 139 (46.64%) were professionals only and 66 (22.15%) were both students and professionals.

We attempted to fit the data to the RSM and the PCM, where the data were found to fit the RSM better with an AIC of 1565.13, compared with the PCM of 1570.83. No issues were identified through examination of the CTT statistics (Table 1), with high item-total correlations (0.91-0.92), and mean predicted values in ascending order. For Item 2, Categories 1 and 2 had the same point biserial correlations, with the corresponding t-values being slight disordered. Given this was minimal, and the mean predicted values were in ascending order no changes were made based on this finding.

Table 1: ***Traditional statistics***

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean± standard deviation)	Item-rest correlation	Item-total correlation
1	0	27 (9.06)	-0.41	-7.67***	-2.735±1.215	0.68	0.92
	1	32 (10.74)	-0.24	-4.21***	-1.257±1.577		
	2	103 (34.56)	-0.18	-3.08**	0.057±1.244		
	3	88 (29.53)	0.18	3.07**	1.727±1.401		
	4	48 (16.11)	0.53	10.69***	4.497±1.878		
2	0	19 (6.38)	-0.35	-6.47***	-3.098±1.318	0.68	0.91
	1	26 (8.72)	-0.27	-4.75***	-1.867±1.151		
	2	91 (30.54)	-0.27	-4.78***	-0.322±1.182		
	3	99 (33.22)	0.13	2.33*	1.396±1.247		
	4	63 (21.14)	0.54	11.11***	4.097±1.886		

Notes: 0 'very seldom or never', 1 'rather seldom', 2 'sometimes', 3 'rather often', 5 'very often or always'
Mean 4.87, standard deviation 2.06, variance 4.26, skewness -0.33, kurtosis -0.37, standard error of the mean 0.12, standard error of measurement 0.90, coefficient alpha 0.81. *p<0.05, **p<0.01, ***p<0.001

The category estimates, item deltas and item thresholds were in ascending order, and the weighted fit mean squares were all within the optimal range, however the t-value for Category 2 was slightly higher than optimal (2.3; Table 2). Some 19 (6.38%) participants had data that did not fit the model, with t-values for the residual fit statistics of 2.13-4.99. The findings were similar after these participants were excluded; hence, they were retained for the rest of the analysis.

The Wright map (Figure 2) indicated that the mean person location was approximately zero logits, indicating that the scale was well targeted. Item 1 was more 'difficult' to endorse than Item 2. There was a high degree of local dependency with the correlation between residuals being -0.85.

Table 2: Rasch analysis statistics

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% confidence interval)	t-value	Mean square (95% confidence interval)	t-value		
Item 1	0.271	0.069	0.97 (0.84-1.16)	-0.3	0.99 (0.83-1.17)	-0.1	-2.09, -1.64, 1.17, 3.65	-2.46, -1.34, 1.15, 3.72
Item 2	-0.271	0.069	1.03 (0.84-1.16)	0.3	1.08 (0.83-1.17)	0.8	-2.63, -2.19, 0.62, 3.10	-3.00, -1.88, 0.61, 3.18
Category 0			1.52 (0.84-1.16)	5.6	1.05 (0.65-1.35)	0.3		
Category 1	-2.356	0.320	1.17 (0.84-1.16)	2.0	1.20 (0.76-1.24)	1.5		
Category 2	-1.916	0.204	1.08 (0.84-1.16)	1.0	1.19 (0.85-1.15)	2.3		
Category 3	0.896	0.150	1.13 (0.84-1.16)	1.5	1.14 (0.85-1.15)	1.7		
Category 4	3.376		2.76 (0.84-1.16)	14.8	1.09 (0.76-1.24)	0.8		

Notes: 0 ‘very seldom or never’, 1 ‘rather seldom’, 2 ‘sometimes’, 3 ‘rather often’, 5 ‘very often or always’
Chi-square test of parameter equality (1) = 15.28

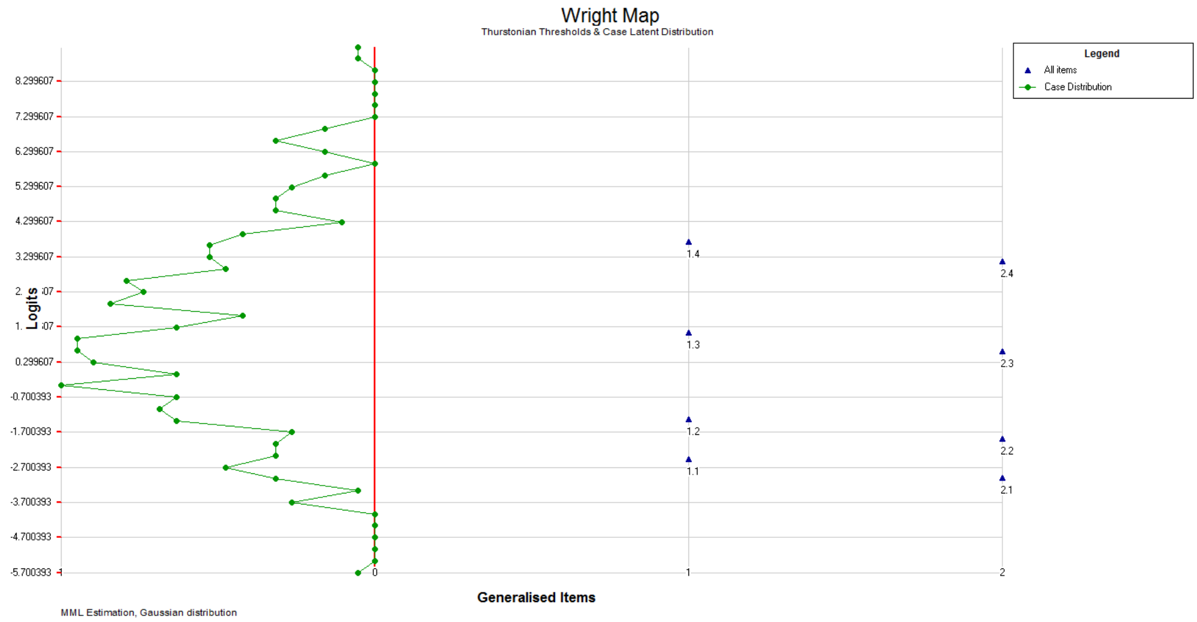


Figure 2*:* **Wright map**

We also examined differential item functioning (DIF), and found that for this scale there was no DIF for gender, age group, and student/ professional status. The Wald t-test indicated that there was statistically significant DIF for socioeconomic status for both items, however the differences in estimates was <0.50 logits (Table 3), hence not of sufficient magnitude to impact upon the results.

Table 3: Differential item functioning statistics

		Item	Estimates	Errors	Weighted fit: Mean square (95% confidence interval)	Weighted fit: t-value	Chi-square test of parameter equality (1)
Gender	Female	1	0.073	0.066	1.00 (0.77-1.23)	0.0	1.21
		2	-0.073	0.066	1.03 (0.77-1.23)	0.3	
	Male	1	-0.073	0.066	1.11 (0.76-1.24)	0.8	
		2	0.073	0.066	0.92 (0.75-1.25)	-0.6	
Age	18-25 years	1	-0.050	0.068	1.02 (0.76-1.24)	0.2	0.54
		2	0.050	0.068	0.96 (0.76-1.24)	-0.3	
	>25 years	1	0.050	0.068	1.13 (0.77-1.23)	1.1	
		2	-0.050	0.068	1.08 (0.77-1.23)	0.7	
Socioeconomic status	Lower	1	-0.054	0.067	0.99 (0.77-1.23)	-0.1	0.63
		2	0.054	0.067	0.99 (0.76-1.24)	-0.1	
	Higher	1	0.054	0.067	1.05 (0.77-1.23)	0.4	
		2	-0.054	0.067	1.00 (0.76-1.24)	0.0	
Student	Yes	1	0.088	0.069	1.15 (0.76-1.24)	1.1	1.61
		2	-0.088	0.069	1.11 (0.76-1.24)	0.9	
	No	1	-0.088	0.069	0.95 (0.77-1.23)	-0.4	
		2	0.088	0.069	0.96 (0.77-1.23)	-0.4	

Although we noted a slight problem with the fit of the Category 2 with a weighted fit t-value of 2.3, and the minimal disordering of the t-values associated with the point biserial correlations in Item 2, we deemed that these issues would not alter the outcomes. The data were therefore transformed to W-scores (Table 4).

Table 4: Transformation table

Raw score	Weighted likelihood estimate (standard error)	W-score
0	-3.87 (1.47)	5
1	-2.80 (0.98)	15
2	-2.15 (0.88)	20
3	-1.51 (0.91)	26
4	-0.56 (1.06)	35
5	0.86 (1.13)	48
6	2.12 (1.15)	59
7	3.38 (1.24)	71
8	4.98 (1.82)	85

Note: The constant used was 40

Discussion

Rasch analysis provides a tool for assessing the utility of measures that are derived from the combination of individual items, with relevance to social research. We used Rasch analysis to examine the utility of a new scale, the Musicians' Social Support Scale, which was based on the social support items from the QPS_{Nordic}.[378]

Traditional statistics did not indicate any problems with the scale, with the exception of the two consecutive point biserial correlations for Item 2 both being -0.27. Rasch analysis provided further insights into the Scale. The data fit the RSM, indicating that the scale was unidimensional, and which allowed for transformation of the raw, ordinal scores into interval level, w-scores (Table 4). The w-scores can be validly used with parametric statistics, improving the power of the analysis, and may also be used to examine changes in social support over time, which would have been invalid using the raw, ordinal scores.

We were also able to examine the targeting of the scale, where the mean person location was approximately zero logits, indicating that the scale was well targeted. Local dependency was detected in the model, with a high correlation between the Item residuals. Higher correlations between residuals are more likely in scales with fewer items; hence, further iterations of the scale should include more items, which would be expected to reduce the local dependency.

Finally, Rasch analysis allowed us to examine DIF with regards to the participants' age, gender, student/ professional status and socioeconomic status, as well as the administration of the scale (i.e. online or paper). We did not detect any DIF based on these characteristics, indicating that the scale is not biased with regards to these characteristics.

Our paper highlights value, and process of Rasch analysis to determine the utility of new or modified scales. Using Rasch analysis we fit the data from the Musicians' Social Support Scale to the Rating scale model, with no DIF detected. The transformed W-scores from the Musicians' Social Support Scale may be used as a valid and reliable, interval measure of social support received by musicians, from other musicians.

Future research in social research using scales that combine items (e.g. average, sum) should conduct Rasch analysis to determine the utility of the measures. Rasch analysis can be used to examine the scales unidimensionality, category ordering, targeting, local dependency, and differential item functioning, as well as being able to transform the ordinal, raw scores into interval, W-scores to allow for the valid use of parametric statistics, and the assessment of change in the measure over time.

A2.13 Testing the utility of measures using Rasch analysis: an example testing a 2-item psychosocial stress measure

Abstract

Background: Stress is a contributor to a wide range of health conditions; hence, valid and reliable measures of stress are required to ensure that accurate inferences from research into the relationship between stress and health outcomes, and the effectiveness of interventions to address stress, can be made.

Littman et al. proposed a 2-item measure of psychosocial stress; however, the utility of this measure has not been examined using modern psychometric methods, such as Rasch analysis. The purpose of the present study was to examine the utility of this measure of psychosocial stress for use with university music students and professional musicians.

Methods: Data were collected from musicians using Littman et al.'s psychosocial stress measure as part of a larger questionnaire. The psychosocial stress data were examined using Rasch analysis, to establish the scale's unidimensionality, category functioning, and invariance, as well as to detect any differential item functioning for age, gender, socioeconomic status and whether the musician was currently studying music at university or not.

Results: A total of 288 musicians were included in the Rasch analysis. The Rasch analysis identified issues with category ordering including disordered estimates, item deltas, point biserial correlations and predicted values at the lower end of the scale. Ultimately, the lowest three response categories were collapsed. The scale exhibited local dependency and the scale was poorly targeted. No differential item functioning was detected.

Discussion: Using Rasch analysis, the utility of Littman et al.'s 2-item measure of psychosocial stress was examined for use with university music students and professional musicians. The analysis identified issues with the function of the categories, which was rectified by collapsing the lowest three response categories. The presence of local dependency and the identification that the scale was poorly targeted for the population indicate that longer stress measures would be more appropriate. Nonetheless, the use of the interval-level W-scores derived from this analysis provide a more accurate measure of psychosocial stress than the raw scores.

Keywords: stress, psychometrics, reliability, Rasch, musicians

Background

Stress is a risk factor for a number of health conditions, including coronary heart disease[734], stroke[735], respiratory infections[736], musculoskeletal conditions[113, 127, 151], and recurrent miscarriage.[737] Valid and reliable measures of stress are therefore required to further investigate the relationships between stress and a range of health outcomes. Furthermore, when investigating the effect of interventions on stress interval-level measures are required.[429]

We were conducting a study into the relationship between a range of modifiable personal factors, including stress and musculoskeletal symptom outcomes (including consequences, e.g. treatment, leave from work/ study) in university music students and professional musicians. Musculoskeletal symptoms are common among musicians[50-52], and may lead to a range of participation restrictions and activity limitations.[60, 63, 64] In addition, musculoskeletal disorders account for the majority of workers' compensation claims among employed musicians.[558] Despite evidence of an association between stress and musculoskeletal symptom outcomes in other populations[113, 127, 151], the association has not been adequately examined in musicians.[559] Littman et al.'s[379] 2-item measure of psychosocial stress was selected for this study, as we sought short measures, so that the questionnaire length was kept to a minimum, reducing the burden on participants.

Littman et al.'s[379] measure of psychosocial stress has two questions, one regarding ability to handle stress and the other the amount of stress experienced at home and work in the last year. Responses are given on a Likert-style scale from one to six.[379] The scale has exhibited test-retest reliability (over three months), and correlates moderately with longer scales (the sum of the two scales generally correlated better with these longer scales than the individual items).[379] Despite these encouraging findings, the utility of the scale has not been examined with modern psychometric methods.

Rasch analysis is a modern psychometric method that can be used to test the utility of a measure, such as Littman et al.'s[379] two-item measure of psychosocial stress. This analysis provides a means of examining internal construct validity, including category ordering, unidimensionality, item invariance (interval scaling), and differential item functioning (DIF; sub-group responses to items are similar where the overall score is similar).[429, 441] Rasch analysis provides a range of advantages over traditional psychometric methods, such as Cronbach's alpha and factor analysis. Unlike these traditional methods, Rasch analysis leads to findings that are generalisable to other samples and over different time points[414], is underpinned by robust theories that can be tested[415], and results in interval-level scores[420, 429] that can be used to examine changes over time, and be used with parametric statistics.[429]

The purpose of this study was to examine the utility of Littman et al.'s[379] two-item measure of psychosocial stress in a sample of university music students and professional musicians, using Rasch analysis.

Methods

University music students and professional musicians were recruited from five military bands, two opera companies, two orchestras, two universities, two music teachers' associations and the Musicians' Union, across two Australian states. Professional musicians were defined as those who were employed as musicians (teaching or performing) in the last 12 months, or who were members of the Musicians' Union or one of the music teachers' associations.

Musicians were asked to complete a questionnaire that included the stress measure, as well as demographic information, other psychosocial measures, and musculoskeletal symptom outcomes. Musicians were recruited via face-to-face sessions (with the paper questionnaire) and/or via email (with a link to the online survey on Survey Monkey), depending on logistical constraints, and organisational policy. Online survey data were exported into Microsoft Excel, where paper survey data were manually added (with double entry to detect errors). Data were cleaned and coded within Excel.

Demographic information relevant to the present study were age, gender, whether they were currently studying music at university, and socioeconomic status (as per the Index of Relative Socioeconomic Advantage and Disadvantage[376]). Age and socioeconomic status were categorised by median cut-point. Scores from the stress measure were coded as 0-5 rather than the original 1-6 to permit Rasch analysis. Relevant coded data were then exported into ConQuest[430] for Rasch analysis.

Rasch analysis

Data from the stress measure were fit to the two polytomous scales available within the suite of Rasch measurement models – Masters'[425] partial credit model (PCM) and Andrich's[422] rating scale model (RSM). The Akaike information criteria (AIC)[433] for the two models were compared, and the model with the lowest AIC selected[434, 435], although if the AICs were within two of one another the RSM was selected as the AIC is not considered different and the RSM is the simplest model. The weighted fit mean square and t-value (from the cube root transformation), for the selected model, were then examined to determine model fit and unidimensionality. The optimal range for the weighted fit mean square was 0.60 to 1.40[437, 438] and a t-value of -1.96 to 1.96.[428] Items with a weighted fit mean square or t-value beyond this range were flagged as being potentially mis-fitting. The chi-square test of parameter equality, a measure of overall fit.

Category ordering was determined by examining the category estimates, point biserial correlations, item deltas and thresholds, and mean predicted values – all of which should be in ascending order.[428, 429, 439, 440] To remedy any disordering categories can be collapsed, however the benefits of this approach should be weighed against the disadvantage of losing data[420, 429, 440, 441], with one researcher[439] recommending that categories only be collapsed when the discrimination at the threshold is zero.

Person-fit was determined using residual fit statistics[442] where the optimal range was -1.96 to 1.96. Participants falling outside of this range were considered to be mis-fitting, however as there were no 'correct' or 'incorrect' responses as there would be with educational assessment, a more lenient approach was adopted, such that these participants were only excluded from the analysis if the values were well beyond the optimal limit, or where a high proportion of participants were identified as mis-fitting.

The item-rest and item-total correlations were examined. The item-rest correlation (biserial correlation) should be positive. The item-total correlation (discrimination index) was considered to be extremely low if it was <0.20.[428] The targeting of the scale was determined by examining the mean person location on the Wright map, where a mean person location of zero logits indicates that the scale is well targeted.[429, 441] Response dependency was examined by determining the correlation between item residuals[420, 429], with low dependency defined as a correlation of less than 0.40.[443]

Two strategies were employed to detect differential item functioning (DIF). We examined DIF with regards to age, gender, socioeconomic status and whether or not the musician was currently studying music at university. The first strategy was the Wald t-test, where an absolute estimate that was greater than twice the standard error was deemed significant DIF.[444] The second strategy was to examine the weighted fit mean square and corresponding t-values, using the same criteria outlined above, for the sub-groups.[445] Where the t-value and/or the weighted fit mean square were beyond the optimal values significant DIF was present.[445] If any items were deemed to have DIF the magnitude of the DIF was considered. Where the DIF was greater than 0.50 logits, it was deemed to be of sufficient magnitude to impact results[445], and action was taken. If the DIF was uniform (a vertical translation between groups)[420, 441, 446] the DIF item could be deleted[420] or the sample split into the groups and analysed separately[420, 441], whereas non-uniform DIF could only be addressed by deleting the DIF item.[441] Given the measure only had two items the deletion of items was not an option in this instance.

Where data fit one of the Rasch models, the raw, ordinal scores were transformed into interval-level w-scores. First, the raw scores were transformed into weighted likelihood estimates (WLE) in ConQuest[430], before being transformed into w-scores to remove the need for decimal places and to remove negative values.[448] The transformation from WLE to w-scores was conducted in Microsoft Excel using the formula w = 9.1024 x WLE (logits) + c, where c is a constant selected to remove all negative values.[448]

Results

A total of 298 musicians who completed the stress scales were included in this analysis. The mean age of the musicians was 25 years (interquartile range 20-46 years), with 53.7% of the sample being female, and 52.4% were currently studying music at university. The findings of the Rasch analysis are reported in the following sections, with detailed output reported in the supplementary material.

The AICs for both the PCM and RSM were 1894; hence, the RSM was selected for it is the simplest model. While the item-rest (0.42) and item-total (0.83-0.86) correlations were good, the point biserial correlations (-0.22, -0.16, -0.20, -0.02, 0.16, 0.31) and predicted values (-1.835, -0.647, -0.655, 0.024, 0.443, 0.964) for Item 2 were disordered. Similarly, the estimates were disordered (-2.203, -0.316, -0.331, 0.723, 2.126), as were the item deltas for both items (Item 1: -1.77, 0.12, 0.11, 1.16, 2.56, Item 2: -2.64, -0.75, -0.77, 0.29, 1.69). The disordering of categories is visually represented in Figure 1.

In response to the disordered categories, the lowest two response categories were collapsed. The AICs for the PCM (1726) and RSM (1727) were similar; hence, the RSM was selected. Again, the item-rest (0.40) and item-total (0.83-0.84) correlations were good, and the collapsing of categories resulted in all point biserial correlations and mean predicted values were in ascending order, there was still disordering evident for category estimates (-0.712, -0.946, 0.125, 1.533) for Item 2 , and for Item deltas for both items (Item 1: -0.28, -0.51, 0.56, 1.79, Item 2: -1.15, -1.38, -0.31, 1.10). Figure 2 shows the disordering of categories.

The lowest two categories were again collapsed, such that the lowest three original categories were coded as zero. The AIC was lower for the PCM (1352) compared with the RCM (1359); hence, the PCM was used. The point biserial correlations and predicted values were in ascending order, and the item-rest (0.43) and item-total (0.83-0.84) correlations were still good (Table 3). The estimates, and item deltas and thresholds were also in ascending order, and all weighted fit mean statistics and t-values were within the optimal range. The improvement in the ordering of categories is evident in Figure 3.

The data of five participants (2.01%) were identified as mis-fitting, with t-values of 2.42-2.96. Given the small percentage and being only slightly beyond the optimal range, no action was taken. Local dependency was detected with the residuals of each item being significantly and strongly correlated (-0.76). The mean person location was below zero logits, indicating that the scale was poorly targeted, and that the items were too 'easy' to endorse. Item 1 was easier to endorse than Item 2 (Figure 4). The collapsing of the response categories shifted the mean person location from above zero logits to approximately zero logits and finally to below zero logits.

There was no DIF detected for gender or socioeconomic status. While there was DIF detected for age and student status using the Wald test, the magnitude of the DIF was less than 0.50 logits, therefore no action was required.

After collapsing the lowest three categories, the raw total scores ranged from zero to six. These raw scores were transformed into w-scores as reported in Table 1.

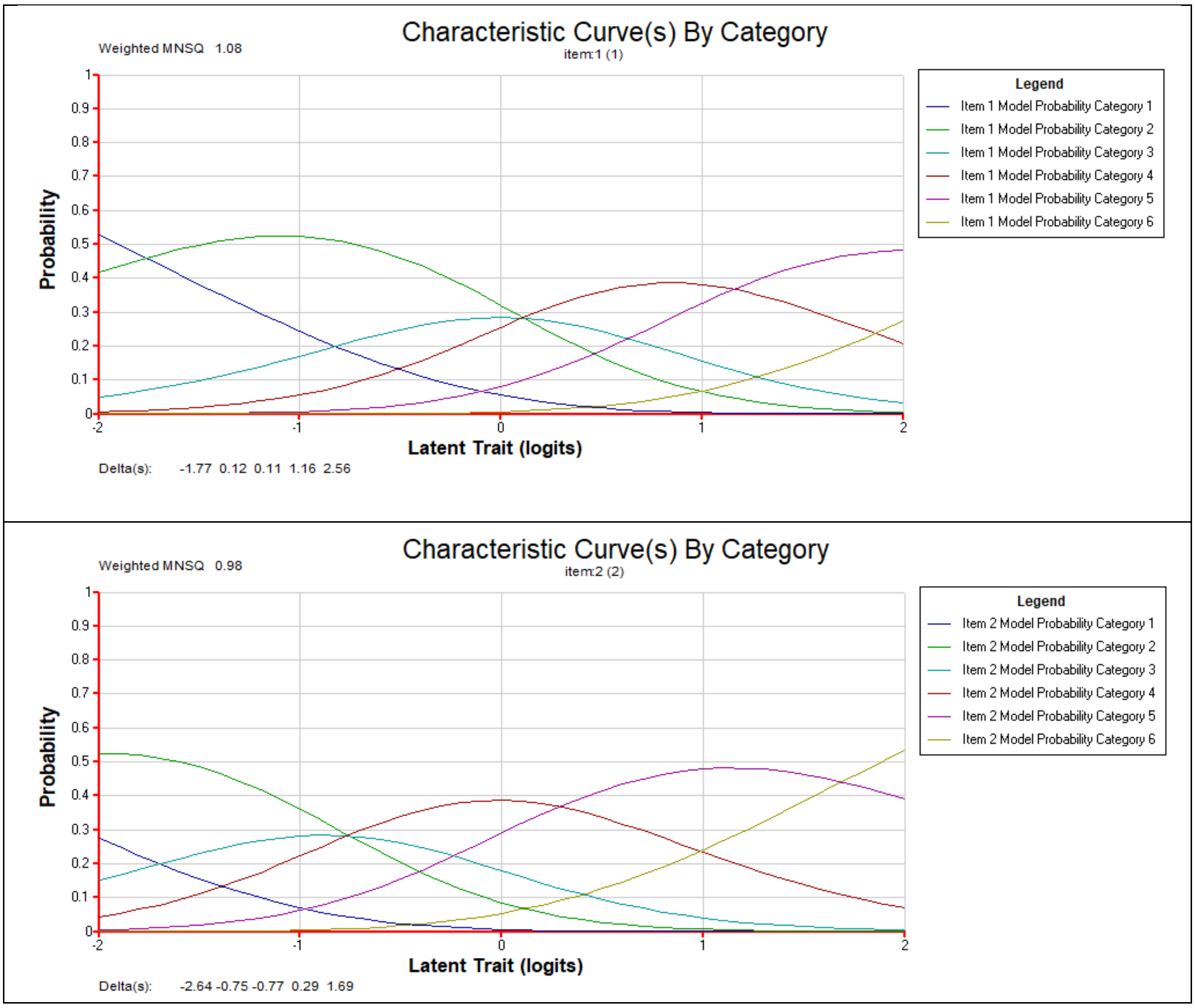


Figure 1: Characteristic curves by category for Items 1 and 2 with all six response categories

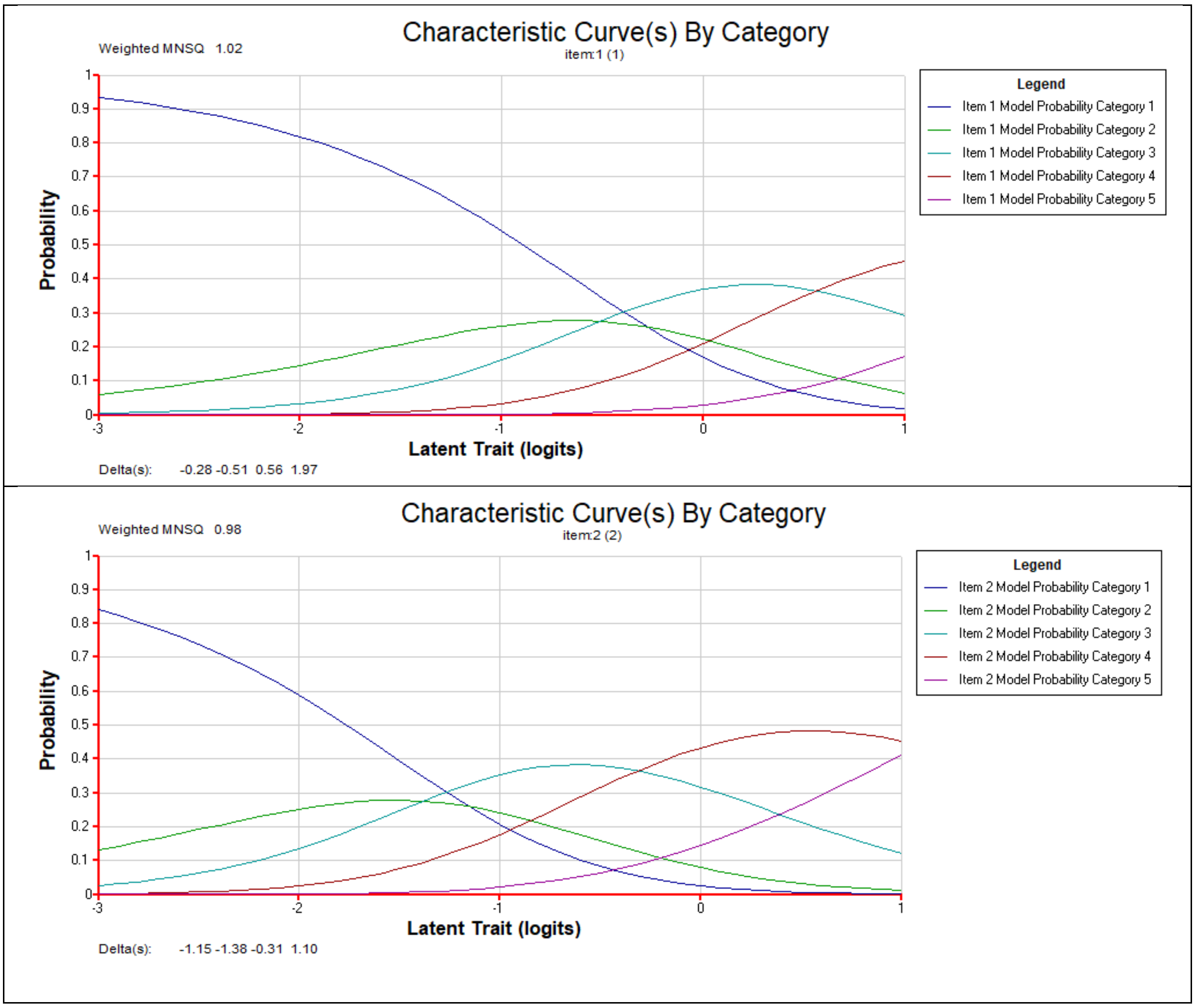


Figure 2: Characteristic curves by category for Items 1 and 2 after collapsing the lowest two categories

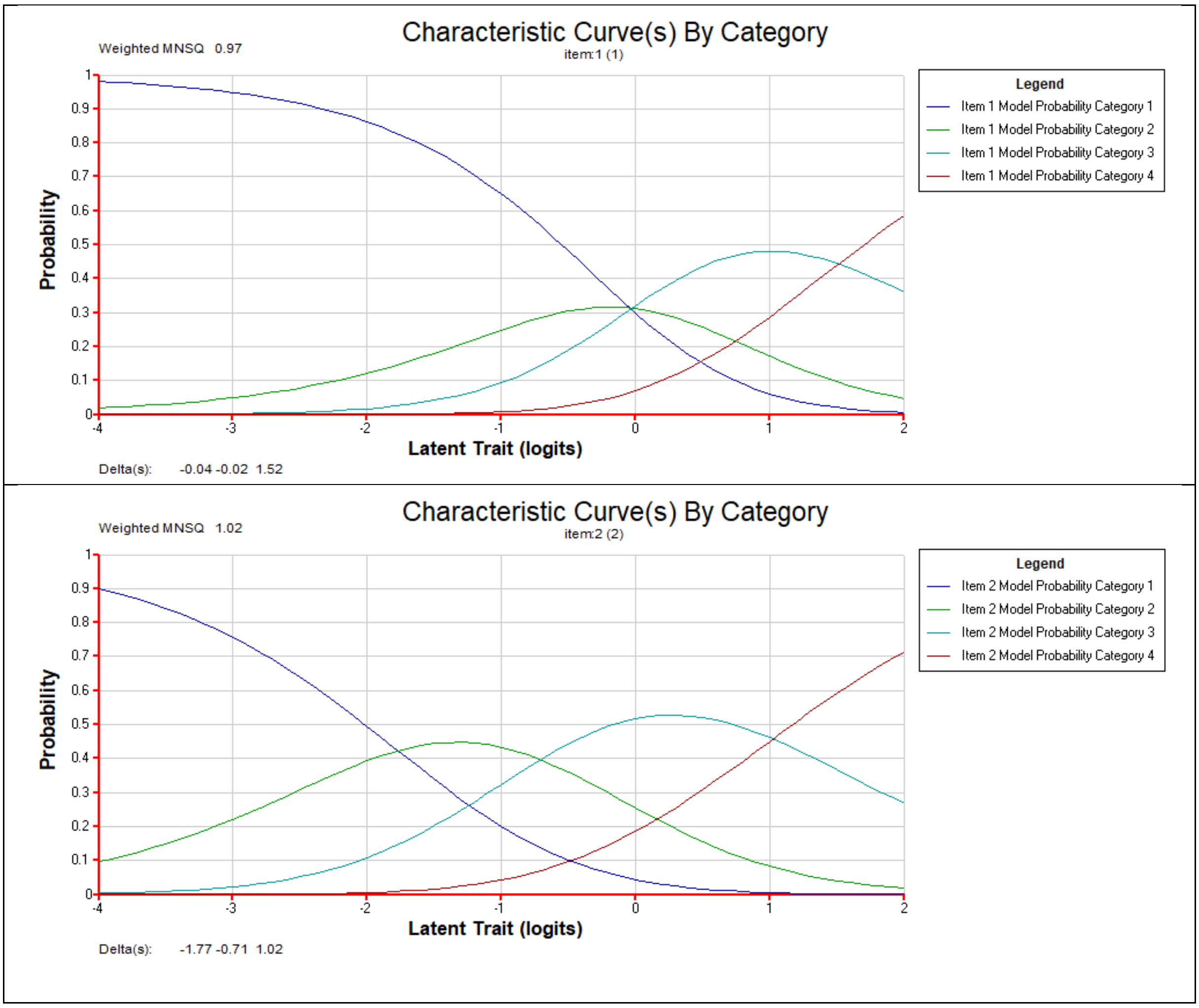


Figure 3: Characteristic curves by category for Items 1 and 2 after collapsing the lowest three categories

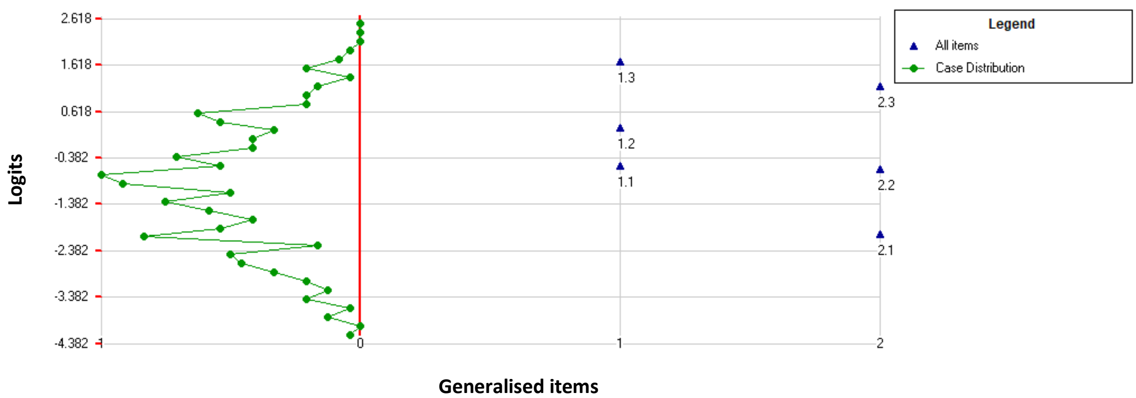


Figure 4: Wright map after collapsing the lowest three categories

Table 1: Transformation of scores from raw scores to W-scores

Raw score	Weighted likelihood estimate (standard error)	W-score
0	-2.73 (1.63)	5
1	-1.39 (1.03)	17
2	-0.60 (0.87)	25
3	0.00 (0.83)	30
4	0.59 (0.87)	35
5	1.36 (1.03)	42
6	2.79 (1.68)	55

Note: the constant was 30

Discussion

The utility of Littman et al.'s[379] two-item measure of psychosocial stress was examined for the first time – in this case with university music students and professional musicians. The Rasch analysis revealed issues with the functioning of the categories, with the lowest three response categories ultimately collapsed, resulting in a total raw score of 0-6, which was transformed into w-scores of 5-55. Had the scale's utility only been measured using traditional statistics the issues with category functioning would not have been detected, and the scale would have remained ordinal, highlighting the importance of using Rasch analysis when testing scale utility.

There were two issues that remained with the scale. The first was local dependency between the two items, which is to be expected with such a short measure, indicating that longer scales should be considered in the future. The second issue was with the targeting of the scale. In the original scale (response categories 0-5) the mean person location was slightly greater than zero logits, which shifted to approximately zero logits when the lowest two response categories were collapsed, and finally lower than zero logits after collapsing the three response categories (Figure 4). The modifications to the scale therefore altered the targeting of the scale, however category functioning was considered more important; hence the scale with the three lowest response categories was retained. Scales with more items may be better targeted to this population.

The results of this analysis are generalisable to other samples of university music students and professional musicians, at other points in time, unlike analyses of scale utility using traditional statistics. The findings are however not necessarily generalisable to other populations. We would not anticipate that other working/studying populations would experience psychosocial stress differently to musicians; hence, the findings may be generalisable.

Littman et al.'s[379] two-item measure of psychosocial stress can be used with university music students and professional musicians providing the lowest three response categories are collapsed, and the transformed W-scores are used. While some issues remained with the scale, the resultant W-scores after collapsing categories, provide a more accurate measure of psychosocial stress than the original scoring. These findings highlight the important role of Rasch analysis in the assessment of scale utility.

Supplementary material

All response categories

Table S1: Traditional statistics with six response categories

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	31 (10.44)	-0.25	-4.48***	-1.058±0.694	0.42	0.86
	1	83 (27.95)	-0.14	-2.41*	-0.501±0.650		
	2	69 (23.23)	-0.07	-1.24	-0.114±0.620		
	3	58 (19.53)	0.09	1.47	0.489±0.621		
	4	42 (14.14)	0.23	4.15***	0.784±0.716		
	5	14 (4.71)	0.26	4.54***	1.595±0.754		
2	0	6 (2.02)	-0.22	-3.95***	-1.835±0.334	0.42	0.83
	1	43 (14.48)	-0.16	-2.76**	-0.647±0.658		
	2	40 (13.47)	-0.20	-3.45**	-0.655±0.658		
	3	96 (32.32)	-0.02	-0.33	0.024±0.690		
	4	83 (27.95)	0.16	2.78**	0.443±0.791		
	5	29 (9.76)	0.31	5.58***	0.964±0.964		

Notes: Mean ± standard deviation: 5.11±2.22, variance: 4.91, skewness: 0.07, kurtosis: -0.43, standard error of mean 0.13, standard error of measurement 1.43, coefficient alpha 0.58. *p<0.050, **p<0.010, ***p<0.001.

Table S2: Rasch analysis statistics with six response categories

	Estimates	Errors	Unweighted fit: Mean square (95% confidence interval)	Unweighted fit: t-value	Weighted fit: Mean square (95% confidence interval)	Weighted fit: t-value	Item deltas	Item threshold
Item 1	0.437	0.055	1.08 (0.84-1.16)	0.9	1.07 (0.85-1.15)	0.9	-1.77	-1.91
							0.12	-0.29
							0.11	0.35
							1.16	1.27
							2.56	2.76
Item 2	-0.437	0.055	0.95 (0.84-1.16)	-0.6	0.94 (0.85-1.15)	-0.7	-2.64	-2.78
							-0.75	-1.16
							-0.77	-0.53
							0.29	0.39
							1.69	1.89
Category 0			1.72 (0.84-1.16)	7.3	1.18 (0.70-1.30)	1.2		
Category 1	-2.203	0.229	1.07 (0.84-1.16)	0.8	1.06 (0.84-1.16)	0.7		
Category 2	-0.316	0.159	0.98 (0.84-1.16)	-0.2	0.99 (0.83-117)	-0.1		
Category 3	-0.331	0.135	1.06 (0.84-1.16)	0.7	1.07 (0.86-1.14)	0.9		
Category 4	0.723	0.149	0.94 (0.84-1.16)	-0.7	0.98 (0.84-1.16)	-0.2		
Category 5	2.126		0.91 (0.84-1.16)	-1.2	1.20 (0.72-1.28)	1.4		

Note: Chi-square test of parameter equality (1) = 62.95

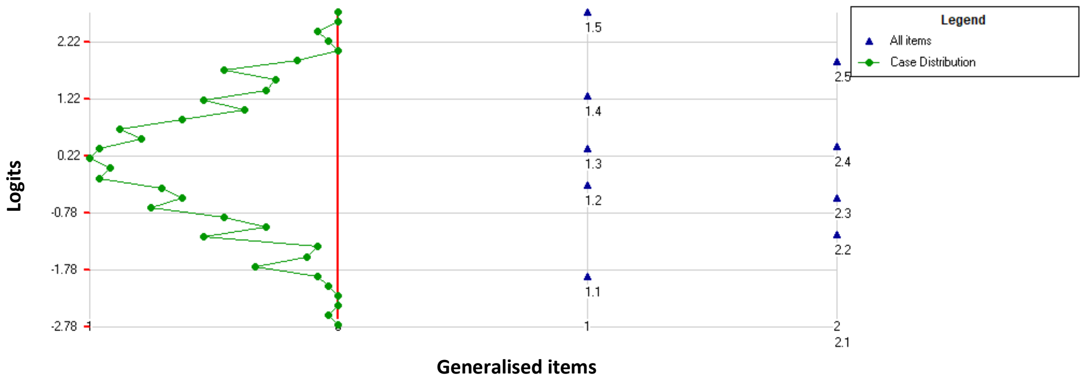


Figure S1: Wright map with all six categories

After collapsing the lowest two response categories

Table S3: Traditional statistics after collapsing the lowest two categories

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	114 (38.38)	-0.28	-4.92***	-1.040±0.642	0.40	0.84
	1	69 (23.23)	-0.08	-1.44	-0.619±0.736		
	2	58 (19.53)	0.08	1.38	-0.215±0.623		
	3	42 (14.14)	0.24	4.17***	0.293±0.699		
	4	14 (4.71)	0.26	4.64***	0.897±0.516		
2	0	49 (16.50)	-0.22	-3.83***	-1.404±0.600	0.40	0.83
	1	40 (13.47)	-0.20	-3.43**	-1.019±0.637		
	2	96 (32.32)	-0.04	-0.67	-0.485±0.596		
	3	83 (27.95)	0.16	2.81**	-0.100±0.751		
	4	29 (9.76)	0.32	5.70***	0.585±0.588		

Notes: Mean ± standard deviation: 3.23±2.05, variance: 4.21, skewness: 0.31, kurtosis: -0.60, standard error of mean 0.12, standard error of measurement 1.33, coefficient alpha 0.58. *p<0.050, **p<0.010, ***p<0.001

Table S4: Rasch analysis statistics after collapsing the lowest two categories

	Estimates	Errors	Unweighted fit: Mean square (95% confidence interval)	Unweighted fit: t-value	Weighted fit: Mean square (95% confidence interval)	Weighted fit: t-value	Item deltas	Item threshold
Item 1	0.437	0.057	1.02 (0.84-1.16)	0.3	1.04 (0.85-1.15)	0.5	-0.28	-0.89
							-0.51	-0.24
							0.56	0.67
							1.79	2.17
Item 2	-0.437	0.057	0.95 (0.84-1.16)	-0.6	0.95 (0.85-1.15)	-0.7	-1.15	-1.76
							-1.38	-1.11
							-0.31	-0.20
							1.10	1.29
Category 0			0.98 (0.84-1.16)	-0.3	0.99 (0.84-1.16)	-0.1		
Category 1	-0.712	0.177	0.97 (0.84-1.16)	-0.3	0.99 (0.83-1.17)	-0.1		
Category 2	-0.946	0.141	1.04 (0.84-1.16)	0.6	1.07 (0.86-1.14)	0.9		
Category 3	0.125	0.134	1.00 (0.84-1.16)	0.0	0.97 (0.84-1.16)	-0.3		
Category 4	1.533		0.83 (0.84-1.16)	-2.2	1.05 (0.72-1.28)	0.3		

Notes: Chi-square test of parameter equality (1) = 58.84

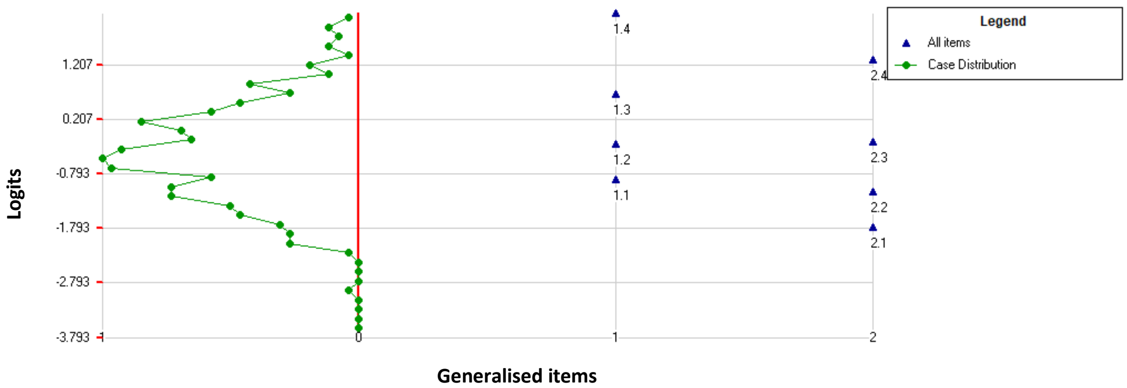


Figure S2: Wright map after collapsing the lowest two response categories

After collapsing the lowest three response categories

Table S5: Traditional statistics after collapsing the lowest three categories

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	183 (61.62)	-0.35	-6.43***	-1.619±1.066	0.43	0.83
	1	58 (19.53)	0.05	0.88	-0.918±0.835		
	2	42 (14.14)	0.26	4.54***	-0.056±0.840		
	3	14 (4.71)	0.29	5.16***	0.397±0.734		
2	0	89 (29.97)	-0.30	-5.50***	-2.065±1.047	0.43	0.86
	1	96 (32.32)	-0.08	-1.31	-1.218±0.910		
	2	83 (27.95)	0.17	3.01**	-0.581±0.927		
	3	29 (9.76)	0.33	6.00***	0.141±0.730		

Notes: Mean ± standard deviation: 1.79±1.58, variance: 2.49, skewness: 0.76, kurtosis: -0.12, standard error of mean 0.09, standard error of measurement 1.00, coefficient alpha 0.60. *p<0.05, **p<0.01, ***p<0.001

Table S6: Rasch analysis statistics after collapsing the lowest three categories

	Item	Category	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
					Mean square (95% confidence interval)	**t-value**	**Mean square (95% confidence interval)**	**t-value**		
Item	1		0.485	0.085	0.97 (0.84-1.16)	-0.4	1.01 (0.82-1.18)	0.1		
	2		-0.485	0.085	1.00 (0.84-1.16)	0.0	0.99 (0.85-1.15)	-0.1		
Item*Step	1	0			1.07 (0.84-1.16)	0.8	1.05 (0.86-1.14)	0.7	-0.04	-0.55
		1	-0.525	0.224	0.97 (0.84-1.16)	-0.3	1.00 (0.83-1.17)	-0.0	-0.02	0.27
		2	-0.509	0.225	0.88 (0.84-1.16)	-1.4	0.98 (0.81-1.19)	-0.2	1.52	1.71
		3	1.034		0.64 (0.84-1.16)	-5.1	0.99 (0.59-1.41)	0.0		
	2	0			0.92 (0.84-1.16)	-0.9	1.00 (0.86-1.14)	0.1	-1.77	-2.02
		1	-1.285	0.210	0.99 (0.84-1.16)	-0.1	1.00 (0.91-1.09)	0.0	-0.71	-0.61
		2	-0.225	0.169	1.09 (0.84-1.16)	1.0	1.00 (0.89-1.11)	0.1	1.02	1.17
		3	1.509		0.88 (0.84-1.16)	-1.5	0.99 (0.74-1.26)	-0.1		

Note: Chi-square test of parameter equality (1) = 32.66

Table S7: Differential Item Functioning statistics

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.007	0.084	1.04 (0.76-1.24)	0.4	0.01
		2	0.007	0.084	1.03 (0.80-1.20)	0.3	
	Male	1	0.007	0.084	0.98 (0.71-1.29)	-0.1	
		2	-0.007	0.084	0.96 (0.78-1.22)	-0.3	
Age	18-44	1	-0.185	0.089	0.93 (0.76-1.24)	-0.6	4.35
	years	2	0.185	0.089	0.97 (0.79-1.21)	-0.3	
	>44	1	0.185	0.089	1.11 (0.70-1.30)	0.7	
	years	2	-0.185	0.089	1.07 (0.78-1.22)	0.6	
Socioeconomic status	Lower	1	-0.042	0.076	0.98 (0.76-1.24)	-0.2	0.30
		2	0.042	0.076	0.95 (0.79-1.21)	-0.5	
	Higher	1	0.042	0.076	1.05 (0.72-1.28)	0.3	
		2	-0.042	0.076	0.97 (0.78-1.22)	-0.3	
Student	Yes	1	-0.199	0.089	0.90 (0.76-1.24)	-0.8	5.02
		2	0.199	0.089	0.91 (0.80-1.20)	-0.9	
	No	1	0.199	0.089	1.17 (0.69-1.31)	1.0	
		2	-0.199	0.089	1.09 (0.77-1.23)	0.7	

A2.14 Rasch analysis as a method of testing the utility of psychological measures: an example using the Patient Health Questionnaire-4

Abstract

Background: The Patient Health Questionnaire-4 (PHQ-4) is a measure of psychological distress, an important health outcome. The utility of the PHQ-4 has been examined using classical test analyses, but not using Rasch analysis, which allows sample- and test-independent measures to be reported. Here we describe how Rasch analysis can be used to test the utility of a measure, in this case the PHQ-4. We aimed to determine the utility of the PHQ-4 for use with professional musicians and university music students.

Methods: Data were collected using standard questionnaire methods from 298 professional and university student musicians. The PHQ-4 data were subjected to Rasch analysis.

Results: Challenges in fitting the data to a Rasch measurement model were encountered, including disordered point biserial correlations, and differential item functioning for gender. These problems were addressed by collapsing the highest two response categories.

Limitations: Our findings are only directly applicable to musicians; however, this is an improvement on traditional statistics, which are sample specific.

Conclusion: Using Rasch Analysis we identified that the point biserial correlations were disordered and that differential item functioning was present for gender in the PHQ-4 for use with musicians. These issues were overcome by collapsing the highest two response categories. Raw, ordinal scores were transformed into interval scores. We highlight the importance of undertaking Rasch analysis for use with any measure where items are combined, in order to test the measure's utility.

Keywords: Rasch analysis; patient health questionnaire; musician; validity; reliability; psychometrics

Background

Psychological distress, which may comprise of anxiety and depression symptoms[441, 738], is common, and may impact heavily on the lives of not only the person with the condition, but also those around them. Major depressive disorder is the fifth leading cause of years lived with disability worldwide, while anxiety is ranked ninth.[1] Understanding the prevalence, incidence and impact of psychological distress is a priority, as well as the association between distress and other health outcomes.

As psychological symptoms, like those of distress, cannot be measured directly, researchers and clinicians rely upon scales to measure such symptoms. Whether these are used as clinical screening tools or measures of change, or in research to estimate the prevalence or incidence of a condition, or in trials of treatment, the utility of the measures is paramount to ensure the inferences made from the data are valid. Traditionally, such scales have been tested using statistics underpinned by the Classical Test Theory (CTT), including factorial analysis and Cronbach's alpha.

The CTT is based on the assumption that the sum of the true score and a random measurement error is equal to the reported raw score[414, 415], and that the errors are independent of one another, are randomly distributed and are not correlated with the true score.[414] Both the CTT[416] and Cronbach's alpha[417-419] have their challenges. The limitations of the CTT include that the findings are specific to the sample at the time of data collection[414]; hence the findings are not generalizable, such that findings of existing studies cannot be used to justify the use of the scale in future studies, although this is often done. Many measures use ordinal item scales produce ordinal overall scores. Summing ordinal items assumes that the response categories are equidistant, which is rarely the case. This problem is not addressed through CTT methods.[414]

Rasch analysis

Modern psychometric methods, like Rasch analysis, have a range of advantages over the CTT, and may be used to supplement CTT.[421] Rasch analysis is underpinned by theories which are robust, and unlike the CTT, can be tested.[415] The only psychometric method that follows the general rules of measurement proposed by Luce and Tukey[426] is the Rasch measurement model (RMM).[427] The general rules of measurement to which we refer are interval scaling (invariance of comparisons) and that the score for an item can be predicted using the overall score (sufficiency).[427] RMM theory of item-examinee analysis is well developed, and simplest model that provide parameter invariance and check for unidimensionality (i.e. that the items all measure the same construct). Output of the RMM analysis provides minimal number of parameter estimates that can be interpreted easily (on the interval scale with estimate of precision).[422-425]

Rasch measurement model provides a means of assessing internal construct validity, including unidimentionality (that only one construct is measured), category ordering (that categories operate as expected), invariance (interval scaling), and differential item functioning (that item responses do not differ between sub-groups with similar overall scores).[429, 441] The RMM also addresses the CTT limitation of ordinal measures as the ordinal raw scores are transformed into linear interval level measures.[420, 429] The resultant scores are reported in terms of log odds unit or logits, and the ranking of participants is maintained through the transformation.[428] As the transformed scores provide an interval scale, parametric statistics can be used, and the scores can be used to assess change.[429]

A number of researchers argue that Rasch analysis should be used whenever items, with either dichotomous or polytomous responses, are to be combined (e.g. summed or averaged) to produce an overall measure.[420, 429] The process of Rasch analysis involves fitting data to one of the RMM.[420] If the items measure the latent trait, the data will fit the RMM.[420] There are three main RMMs available; these are Rasch's[431] dichotomous model, Andrich's [422] rating scale model (RSM), and Masters's[425] partial credit model (PCM). The RSM and PCM are polytomous models, the primary difference between the two being that equidistant categories for each item is assumed for the RSM, but not the PCM.[429] In addition, the RSM assumes that all items have the same number of response categories, are equally discriminating and share the same rating scale structure, which is not the case for the PCM.[432]

Measuring distress in musicians

Recent evidence suggests that psychological distress is higher in professional musicians than the general working population.[191] Psychological distress has also been associated with musculoskeletal symptoms in musicians[45, 190, 307, 739-741], with a high prevalence of musculoskeletal symptoms reported among musicians.[50-52]

To further our research into the association between psychological distress and musculoskeletal symptoms we sought a short tool for measuring psychological distress and the PHQ-4 was selected. In order to examine the association between PHQ-4 data and musculoskeletal symptom outcomes we first needed to examine the utility of the PHQ-4. If the utility of this measure is confirmed, the PHQ-4 may also provide a short screening tool for PHQ-4 in occupational health and clinical settings.

Patient Health Questionnaire-4

The Patient Health Questionnaire-4 (PHQ-4) is an ultra-brief screening tool for psychological distress, which combines the Generalized Anxiety Disorder-2 Scale and Patient Health Questionnaire-2.[370, 371] The PHQ-4 has four items, with ratings of zero to three assigned to each, producing an overall summed score of 0-12, such that higher scores indicate a higher degree of distress.[370, 371] It has been suggested that scores of six or greater for the PHQ-4 are considered a 'yellow flag' and nine or greater a 'red flag'[370], while a score of four of more has been suggested as positive screening for post-surgical patients.[375]

Previous research has supported the use of the PHQ-4, with evidence suggesting adequate construct validity[370-373], factorial validity[370-374], sensitivity and specificity[375], internal consistency[370-375], and test-retest reliability.[372] Based on the evidence and tests, the use of the PHQ-4 has been promoted[370-375, 742], despite the utility of the PHQ-4 only having been examined using traditional statistics. The utility of the PHQ-4 for samples beyond those in the abovementioned studies cannot be assumed, and without further testing of the PHQ-4 with Rasch analysis, the PHQ-4 cannot be validly reported as interval level data (e.g. mean and standard deviation), cannot be analysed with parametric statistics, and cannot be used in longitudinal studies (e.g. trials). The utility of the PHQ-4 therefore requires further examination, using Rasch analysis.

Aim

The aim of the current study was to determine the utility of the PHQ-4 when used with university music students and professional musicians, using the RMM.

Methods

The analysis in this paper forms part of a larger cross-sectional study, investigating musculoskeletal symptoms and their association with psychosocial and organisational factors in university music students and professional musicians. The project had approval from The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and Australian Defence Organisation Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006).

Sampling and data collection

We recruited professional musicians and university music students from two universities, five military bands, three orchestras, two opera companies, one musicians' union and two music teachers' associations, from two Australian states. We defined professional musicians as those employed as musicians (i.e. not just self-employed), or who were members of the Musicians' Union and/or Music Teachers' Association. To be eligible to participate, musicians also had to be aged 18 years or older. For this analysis, we only included those who completed at least one of the PHQ-4 items.

It has been suggested that there should be at least 10 participants per response category for Rasch analysis of polytomous scales[409], however as we had no existing data available to us, we were unable to estimate the required sample size, instead attempting to recruit as many participants as possible.

Musicians were recruited at a face-to-face session and/or via email. Where possible, both strategies were employed, however this was not always possible due to logistical limitations or organisational policies. The project was briefly explained to the musicians, and an information sheet provided. Paper questionnaires were distributed at the face-to-face sessions, and participants were provided with a link and Quick Response code for the online version of the questionnaire (Survey Monkey). The email contained a link to the questionnaire, and participants could request a paper copy of the questionnaire be sent to them. Paper questionnaires were distributed with a reply-paid envelope, and return boxes were kept on-site for 2-3 weeks. Where organisational policy permitted, participants could opt to be included in a prize draw for returning completed questionnaires.

Data were collected using a questionnaire package that included the PHQ-4. Other items relevant to the present study included the age, gender, residential postcode and whether or not the participant was currently a university music student.

Data management

Data collected via Survey Monkey were exported into Microsoft Excel for data cleaning and preliminary coding. Data from the paper questionnaires were entered manually into the same Excel spreadsheet, and this was double entered to minimise any errors in data entry. The PHQ-4 responses were coded as 0 for 'not at all', 1 for 'several days', 2 for 'more than half the days' and 3 for 'nearly every day'.[370, 371] The participant's identification number, gender, age category (median cut-point), socioeconomic status (median cut-point), whether or not they are a university music student, and PHQ-4 item data were exported into ConQuest[430] for the Rasch analysis.

Data analysis

To determine the utility of the PHQ-4 for use with university music students and professional musicians, we used RMM. Rasch analysis provides information to the dimensionality of the constructs and their measurement properties, with alternations made to the scale to remedy identified problems; thus reflecting an iterative process.[428] Throughout the analysis $p<0.05$ indicated statistical significance.

We attempted to fit the data to the partial credit model (PCM)[425] and the rating scale model (RSM).[422] The RSM assumes equidistance categories for each item[429], that items share the same rating scale structure, all items are equally discriminating, and have the same number of response categories[432]; which is not true of the PCM. To select which model the data fit the best, we used the Akaike information criterion (AIC)[433], a fit statistic where the lower AIC indicates that the mean squared error is reduced[434], representing the most parsimonious model.[435, 436]

To determine how well the data fit the selected model, item residual fit statistics were used; namely the weighted fit mean square, where the optimal range of 0.60-1.40[437, 438] and the t-value derived from the cube root transformation of -1.96 to 1.96.[428] Where items fit statistics were outside of these ranges, the items were flagged as potentially mis-fitting and not within the dimension (unidimensionality) of the trait being measured. As our study was not a 'high stakes' test, a more lenient approach was adopted, with regards to the weighted fit mean square and t-values, and items were examined before any changes were made to the scale. We also examined the separation reliability as a measure of overall error and discrimination power[416], and the chi-square test of parameter equality as a measure of overall fit.

To ensure that categories were operating as intended, we examined the item deltas and thresholds, point biserial correlations, mean predicted values and category estimates, as these should be in ascending order.[428, 429, 439, 440] If disordering was detected, then we considered collapsing the categories[420, 429, 440, 441], particularly where there were small numbers of respondents in a category. In order to determine which categories were appropriate to collapse, the general response patterns were examined, with those having zero response collapsed. As highlighted by Andrich[439], collapsing categories is only justified if the discrimination at the threshold between two categories is zero.

Item deletion was considered for extremely low total correlations (discrimination index <0.20)[428], and negative item-rest correlations (biserial correlations). We also examined person fit, using residual fit statistics[442] with optimal values being -1.96 to 1.96. Participants were deemed to be mis-fitting if their residual fit statistics were outside of this range, and their omission from the analysis was considered.

Targeting of the scale was examined using the Wright map, which displays the participant distribution along the logit scale, and the item positions. Ideally, the mean person location would be approximately zero logits.[429, 441] Where this is not the case, fit-statistics should be interpreted cautiously.[420]

Local or response dependency, where items are related, was examined using a correlation matrix of the residuals[420, 429], with an absolute correlation of <0.40 being considered low.[443] Given the nature of this measure, we used a more lenient cut-point of 0.60.

Differential item functioning (DIF), or measurement variance, was examined concerning age, gender, socioeconomic status and whether or not the participant was currently a university music student. Two approaches were adopted to detect significant DIF. The weighted mean fit squares for items for each sub-group were examined[445], using the aforementioned ranges. The other approach was using the Wald test, where significant DIF was present if the estimate for the item*group (e.g. item*age) was twice the standard error.[444] Where DIF was detected using either method the magnitude of the DIF was examined, with a DIF of 0.5 logits[445] indicating that the DIF was large enough to impact results. If significant DIF of sufficient magnitude was detected the type of DIF was determined. Uniform DIF refers to the situation whereby the differences are uniform across all logits[420, 441, 446], with DIF where this is not the case being labelled non-uniform DIF.[420, 429, 441] To remedy both types of DIF item deletion may be considered[420, 441], while uniform DIF may also be addressed by analysing the sub-groups separately.[420, 441] No action was required where the differences could be explained as real differences, rather than biases, in which case no changes were required.

Once the data fitted one of the Rasch measurement models, the raw scores were transformed in ConQuest[430] into Weighted Likelihood Estimates (WLE). The WLE was selected over other methods, as it minimises estimation bias.[447] To remove the need for decimal places and to eliminate negative scores the WLEs were transformed into W-scores, using the formula W=9.1024 x logits + c, where c is a constant term selected to ensure the negative values were omitted.[448]

Results

A total of 298 musicians completed at least one item from the PHQ-4 (Items 1-2 n=297, Item 3 n=295, Item 4 n=296). 53.7% of the sample were female, and the median age was 25 years (interquartile range 20-46 years). Some 47.1% of participants were current university music students.

We fit the data to both the PCM and RSM, where upon the AIC for the PCM (2251.74) was lower than the RSM (2259.62); hence, the PCM was used.[436] Considering the CTT output, the point biserial correlations were disordered for Items 3 and 4, for the highest two response categories; however the mean predicted values were in ascending order. No other issues identified (Table 1). The data fit the PCM well with all category estimates being in ascending order, and while Item 3 was outside of the optimal range for t-values (2.2), the weighted mean fit square was acceptable (1.24). The item deltas and thresholds were all in ascending order (Table 2).

Table 1: Traditional statistics

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean± standard deviation)	Item-rest correlation	Item-total correlation
1	0	112 (37.71)	-0.45	-8.72*	-3.790±1.877	0.67	0.82
	1	117 (39.39)	-0.06	-0.97	-1.597±1.293		
	2	36 (12.12)	0.22	3.88*	-0.405±1.046		
	3	32 (10.77)	0.56	11.74*	1.214±1.057		
2	0	164 (55.22)	-0.63	-14.12*	-3.358±1.782	0.77	0.88
	1	72 (24.24)	0.08	1.39	-1.109±0.924		
	2	34 (11.45)	0.39	7.18*	0.233±0.838		
	3	27 (9.09)	0.55	11.33*	1.348±1.030		
3	0	174 (58.98)	-0.56	-11.68*	-3.114±1.949	0.62	0.78
	1	73 (24.75)	0.19	3.40*	-0.951±1.185		
	2	34 (11.53)	0.40	7.44*	0.356±1.202		
	3	14 (4.75)	0.31	5.57*	1.223±1.369		
4	0	170 (57.43)	-0.63	-14.09*	-3.256±1.814	0.69	0.83
	1	83 (28.04)	0.26	4.58*	-0.756±1.210		
	2	27 (9.12)	0.39	7.24*	0.538±1.077		
	3	16 (5.41)	0.38	7.05*	1.162±1.223		

Notes: 0 'not at all', 1 'several days', 2 'more than half the days', 3 'nearly every day'. *p<0.05. Mean ± standard deviation 2.96±3.06, variance 9.36, skewness 0.99, kurtosis 0.10, standard error of mean 0.18, standard error of measurement 1.18, coefficient alpha 0.85.

Thirteen (4.36%) participants had t-values for the residual fit statistics of greater than 1.96 (range 2.03-4.31), with similar results obtained when these 13 participants were excluded from the analysis. The Wright Map revealed that the mean person location was less than zero logits, indicating that the scale was poorly targeted and that Items 3 and 4, the depression items, were more 'difficult' than Items 1 and 2, the anxiety items (Supplementary Material). There was significant DIF detected for Item 3 for gender using the Wald test, which was greater than 0.5 logits; hence, action had to be taken (Table 3). As the DIF was non-uniform (Figure 1), item deletion was considered and follows from Hagquist and Andrich's[743, 744] argument that invariance of item parameters across groups is not retained.

Given the low number of respondents for the highest two response categories, particularly for Items 3 and 4, and the disordering of the point biserial correlations for these items, we attempted to fit the data to one of the RMM after collapsing the highest two response categories ("more than half the days" and "nearly every day").[439] The data fit the PCM (AIC 1959.87) better than the RSM (AIC 1969.28). The point biserial correlations were all in ascending order, as were the predicted values, and the item rest-correlations and item-total correlations were adequate (Table 4). The data fit the PCM well with category estimates, item deltas and thresholds of increasing order, and all weighted fit mean squares and t-values within acceptable limits (Table 5).

Nine mis-fitting participants (3.02%) with t-values of 2.38-3.16 were identified; however, these t-values were still relatively low, and with few cases. Excluding these nine participants did not change our findings. There was some evidence of local dependency with the correlations between Items 1 and 3, 1 and 4, and 2 and 3 being greater than 0.40 (-0.42 to -0.56), however given the nature of the measure these were deemed acceptable. The mean person location was less than zero logits, indicating that the scale is poorly targeted, however it was closer to zero logits, than it was prior to collapsing the response categories (Supplementary Material).

Table 2: Rasch analysis statistics

	Item	Category	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
					Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item	1		-0.619	0.097	1.02 (0.84-1.16)	0.3	1.04 (0.83-1.17)	0.5		
	2		-0.110	0.095	0.78 (0.84-1.16)	-2.9	0.86 (0.81-1.19)	-1.6		
	3		0.394	0.109	1.08 (0.84-1.16)	1.0	1.24 (0.81-1.19)	2.2		
	4		0.335	0.106	0.89 (0.84-1.16)	-1.4	1.05 (0.80-1.20)	0.5		
Item*Step	1	0			1.26 (0.84-1.16)	2.9	1.06 (0.85-1.15)	0.8		
		1	-1.986	0.186	0.95 (0.84-1.16)	-0.6	1.00 (0.91-1.09)	0.0	-2.60	-2.66
		2	0.871	0.207	5.55 (0.84-1.16)	28.3	1.02 (0.79-1.21)	0.2	0.25	-0.11
		3	1.115		0.46 (0.84-1.16)	-8.4	0.95 (0.73-1.27)	-0.3	0.50	0.92
	2	0			0.77 (0.84-1.16)	-3.1	0.94 (0.84-1.16)	-0.7		
		1	-1.145	0.187	0.84 (0.84-1.16)	-2.0	0.96 (0.88-1.12)	-0.7	-1.25	-1.45
		2	0.277	0.223	0.53 (0.84-1.16)	-7.0	0.94 (0.79-1.21)	-0.5	0.17	0.02
		3	0.868		0.48 (0.84-1.16)	-7.9	0.95 (0.70-1.30)	-0.3	0.76	1.11
	3	0			1.14 (0.84-1.16)	1.7	1.02 (0.84-1.16)	0.3		
		1	-1.429	0.204	0.97 (0.84-1.16)	-0.4	0.99 (0.88-1.12)	-0.2	-1.03	-1.22
		2	0.047	0.234	1.36 (0.84-1.16)	4.0	1.06 (0.79-1.21)	0.5	0.44	0.42
		3	1.381		2.86 (0.84-1.16)	15.3	1.29 (0.56-1.44)	1.2	1.78	1.98
	4	0			0.77 (0.84-1.16)	-3.0	0.91 (0.84-1.16)	-1.1		
		1	-1.542	0.199	0.94 (0.84-1.16)	-0.7	0.99 (0.89-1.11)	-0.2	-1.21	-1.33
		2	0.471	0.244	0.55 (0.84-1.16)	-6.6	1.00 (0.75-1.25)	0.0	0.81	0.59
		3	1.072		0.84 (0.84-1.16)	-2.1	1.25 (0.58-1.42)	1.2	1.41	1.75

Notes: 0 'not at all', 1 'several days', 2 'more than half the days', 3 'nearly every day'. Separation reliability = 0.961, chi-square test of parameter equality (3) = 54.86, $p < 0.001$

Table 3: Differential item functioning statistics

		Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	
Gender	Female	1	-0.207	0.096	1.11 (0.77-1.23)	1.0	Separation reliability = 0.870
		2	-0.189	0.097	0.84 (0.76-1.24)	-1.4	Chi-square test of parameter
		3	0.290	0.111	1.03 (0.74-1.26)	0.3	equality (3) = 15.20, p = 0.002
		4	0.106	0.106	0.97 (0.74-1.26)	-0.2	
	Male	1	0.207	0.096	1.02 (0.73-1.27)	0.2	
		2	0.189	0.097	0.84 (0.69-1.31)	-1.0	
		3	-0.290	0.111	1.26 (0.70-1.30)	1.6	
		4	-0.106	0.106	1.02 (0.71-1.29)	0.2	
Age	18-25	1	-0.144	0.105	1.03 (0.77-1.23)	0.3	Separation reliability = 0.151
	years	2	-0.133	0.108	0.90 (0.76-1.24)	-0.8	Chi-square test of parameter
		3	0.069	0.118	1.13 (0.75-1.25)	1.0	equality (3) = 3.74, p = 0.291
		4	0.209	0.109	0.98 (0.75-1.25)	-0.1	
	>25	1	0.144	0.105	1.11 (0.75-1.25)	0.8	
	years	2	0.133	0.108	0.87 (0.69-1.31)	-0.9	
		3	-0.069	0.118	1.25 (0.68-1.32)	1.4	
		4	-0.209	0.109	0.94 (0.68-1.32)	-0.4	
Socioeconomic status	Lower	1	-0.008	0.096	1.08 (0.76-1.24)	0.6	Separation reliability = 0.000
		2	-0.033	0.098	0.89 (0.73-127)	-0.8	Chi-square test of parameter
		3	-0.080	0.112	1.14 (0.74-1.26)	1.0	equality (3) = 0.63, p = 0.889
		4	0.121	0.105	0.99 (0.73-1.27)	-0.1	
	Higher	1	0.008	0.096	1.05 (0.76-1.24)	0.4	
		2	0.033	0.098	0.87 (0.74-1.26)	-1.0	
		3	0.080	0.112	1.25 (0.72-1.28)	1.6	
		4	-0.121	0.105	0.96 (0.72-1.28)	-0.2	
Student	Yes	1	0.064	0.109	1.16 (0.72-1.28)	1.1	Separation reliability = 0.000
		2	-0.024	0.110	0.74 (0.67-1.33)	-1.7	Chi-square test of parameter
		3	-0.056	0.132	1.15 (0.68-1.32)	0.9	equality (3) = 0.57, p = 0.904
		4	0.017	0.133	0.99 (0.68-1.32)	0.0	
	No	1	-0.064	0.109	1.02 (0.78-1.22)	0.2	
		2	0.024	0.110	0.90 (0.76-1.24)	-0.8	
		3	0.056	0.132	1.14 (0.76-1.24)	1.1	
		4	-0.017	0.133	1.10 (0.76-1.24)	0.8	

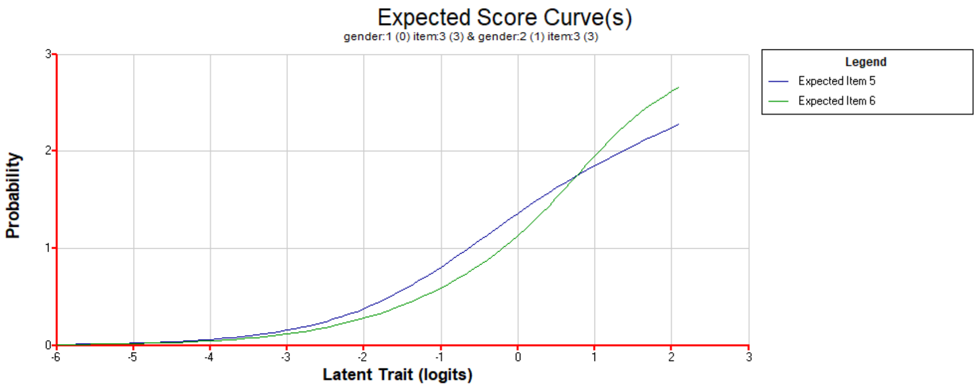


Figure 1: Expected scores for Item 3 by gender

Table 4: Traditional statistics with collapsed categories

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean± standard deviation)	Item-rest correlation	Item-total correlation
1	0	112 (37.71)	-0.48	-9.38*	-3.292±1.870	0.62	0.79
	1	117 (39.39)	-0.02	-0.33	-1.073±1.404		
	2	68 (22.90)	0.58	12.08*	1.334±1.544		
2	0	164 (55.22)	-0.65	-14.70*	-2.849±1.760	0.73	0.86
	1	72 (24.24)	0.15	2.55*	-0.472±1.254		
	2	61 (20.54)	0.64	14.49*	1.550±1.453		
3	0	174 (58.98)	-0.60	-12.71*	-2.636±1.876	0.63	0.80
	1	73 (24.75)	0.25	4.38*	-0.232±1.344		
	2	48 (16.27)	0.50	10.00*	1.579±1.705		
4	0	170 (57.43)	-0.67	-15.36*	-2.790±1.799	0.72	0.85
	1	83 (28.04)	0.29	5.25*	-0.069±1.222		
	2	43 (14.53)	0.56	11.68*	1.756±1.597		

Notes: 0 'not at all', 1 'several days', 2 'more than half the days' or 'nearly every day'. Mean ± standard deviation 2.66±2.53, variance 6.40, skewness 0.65, kurtosis -0.77, standard error or mean 0.15, standard error of measurement 0.99, coefficient alpha 0.85. *p<0.05

We identified no evidence of DIF for the age, socioeconomic status and whether they were currently a university music student, however for Item 4 there was a significant difference between genders according to the Wald test (Supplementary Material). The magnitude of the DIF for Item 4 for gender was 0.496, and therefore not of sufficient magnitude to alter results, hence no action was required[743, 744], indicating that there was no item bias.

By collapsing the highest two response categories, the challenges in fitting the data to one of the Rasch measurement models were overcome. The transformation table for raw scores to w-scores is reported in the Supplementary Material.

Discussion

Our study is the first to examine the utility of PHQ-4 using Rasch analysis, and highlights the importance of Rasch analysis for any measure that combines items. For use with university music students and professional musicians, we were able to identify problems with the PHQ-4 and rectify these, enabling the transformation of raw, ordinal scores into interval scores, which allow for valid examination of repeated measures, and permit the use of parametric statistics. The utility of the PHQ-4 has previously been examined using statistics underpinned by the CTT[370-375], including for use with the general population.[370] We would not expect that musicians would experience different symptoms of distress, compared with those of the general population; hence, if we were to accept the CTT statistics as accurate indicators of the utility of a scale, the PHQ-4 would be anticipated to be valid and reliable. Using Rasch analysis, a modern psychometric method, we identified issues with the PHQ-4 for use with musicians.

Table 5: Rasch analysis statistics after collapsing categories

	Item	Category	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
					Mean square (95% confidence interval)	t-value	Mean square (95% confidence interval)	t-value		
Item	1		-0.719	0.110	1.06 (0.84-1.16)	0.7	1.08 (0.84-1.16)	1.0		
	2		-0.016	0.103	0.74 (0.84-1.16)	-3.4	0.91 (0.82-1.18)	-1.0		
	3		0.340	0.108	1.07 (0.84-1.16)	0.8	1.11 (0.81-1.19)	1.1		
	4		0.394	0.110	0.76 (0.84-1.16)	-3.2	0.92 (0.82-1.18)	-0.8		
Item*Step	1	0			1.72 (0.84-1.16)	7.3	1.07 (0.84-1.16)	0.8		
		1	-1.351	0.157	1.00 (0.84-1.16)	0.0	1.02 (0.91-1.09)	0.5	-2.07	-2.13
		2	1.351		0.80 (0.84-1.16)	-2.5	1.04 (0.81-1.19)	0.5	0.63	0.69
	2	0			0.75 (0.84-1.16)	-3.3	0.95 (0.83-1.17)	-0.6		
		1	-0.629	0.164	0.82 (0.84-1.16)	-2.3	0.97 (0.87-1.13)	-0.4	-0.65	-0.85
		2	0.629		0.50 (0.84-1.16)	-7.5	0.92 (0.78-1.22)	-0.8	0.61	0.82
	3	0			1.17 (0.84-1.16)	2.0	1.03 (0.83-1.17)	0.4		
		1	-0.752	0.169	0.94 (0.84-1.16)	-0.8	0.99 (0.87-1.13)	-0.1	-0.41	-0.58
		2	0.752		1.42 (0.84-1.16)	4.5	1.11 (0.75-1.25)	0.9	1.09	1.26
	4	0			0.77 (0.84-1.16)	-3.0	0.90 (0.84-1.16)	-1.2		
		1	-0.981	0.168	0.78 (0.84-1.16)	-2.9	0.94 (0.88-1.12)	-1.1	-0.59	-0.70
		2	0.981		0.62 (0.84-1.16)	-5.4	0.98 (0.75-1.25)	-0.2	1.37	1.49

Notes: 0 'not at all', 1 'several days', 2 'more than half the days' or 'nearly every day'. Separation reliability = 0.961, chi-square test of parameter equality (3) = 53.01, p<0.001.

In attempting to fit the original data to one of the Rasch measurement models, we encountered a number of difficulties. We detected slight disordering of the point biserial correlations for Items 3 and 4, for categories 2 and 3. The response numbers for these categories were also relatively low, although still higher than Linacre's[409] suggested limit of 10 per response category. This, in itself, was insufficient justification to make changes to the scale. Item 3 had a t-value for the weighted fit mean square of 2.2, which is slightly outside of the optimal range -1.96 to 1.96, however the t-value is influenced by sample size, hence it has been argued that the weighted fit mean square itself is a better measure of item fit[745], and in this case the weighted fit mean square was within the optimal range. Importantly, significant non-uniform DIF was detected for Item 3 for gender. The number of respondents for the two highest response categories was nine for males, and the highest response category only had five females, the small sample size may have influenced this findings. Rather than delete Item 3 to remedy this problem, we elected to collapse the two highest response categories; a strategy which resolved in a scale that fit the Rasch measurement model well. As highlighted by Andrich[439] there is a trade-off between fit and invariance, and reliability and validity that needs to be taken into account when items showing DIF are to be resolved. While recent advancement in the methodology of DIF is paramount, the complexity of making correct inferences for measurement is still a challenge.

After collapsing the highest two categories, the mean person location of the PHQ-4 was closer to zero than it was prior to collapsing the categories, however it was still less than zero logits. A mean person location of less than zero indicates that the measure is 'too difficult' for the population. This problem may be due to the nature of the scale and the population, given the majority of the general population (particularly those who are studying or working), would not be anticipated to be experiencing high levels of psychological distress. The PHQ-4 is therefore likely to be 'too difficult' for the general population; however, for clinical populations, we would anticipate that the mean person location of the PHQ-4 would be closer to zero logits. Nonetheless, collapsing the highest two response categories resulted in a better targeted scale than the original PHQ-4.

The findings of our Rasch analysis are sample independent, indicating that the findings are applicable to other samples of university music students and professional musicians, and are applicable over time. This is in contrast with statistics under-pinned by the CTT, such as Cronbach's alpha which are only applicable to the particular sample at that point in time [414], and therefore have little value in justifying the use of the scale beyond that study sample. Our findings are not necessarily applicable to the general population, although we would not anticipate that musicians' experience of psychological distress would differ significantly from that of the general population. Examination of the PHQ-4's utility in other populations, both the general population and clinical populations, using Rasch analysis, is indicated. In doing so, not only would the optimum psychometric methods be used, but the data could also be transformed into interval level data (e.g. W-scores) for use in analysis.

Conclusion

Our study is the first to use the RMM to investigate that utility of the PHQ-4 in any population, and highlighted the importance of undertaking Rasch analysis. Our study supports Alagumalai[721] and DeVellis's[722] caution regarding the inappropriate use of measurement tools, where haphazard measurement approaches may lead to inaccuracies in the data and resultant inferences made. Moreover, item-dependent test statistics and reliabilities associated with Cronbach Alpha pose challenges to the objectivity of measurement and for generalising item/person measures.

Furthermore, the study highlights the importance of specific objectivity or invariance is a pertinent requirement of undertaking test of utility for any instrument, test or questionnaire. One must adhere to the Rasch analysis processes, by assessing the fit of the data to the RMM and examining equivalence through DIF analyses, reporting the scales unidimensionality, and generating measures for individuals for inferential analyses.[746]

Challenges were identified in fitting the data to one of the RMM, which were overcome by collapsing the highest two response categories, thus improving the utility of the PHQ-4 for use with university music students and professional musicians. We acknowledge the resultant potential loss of information through using this approach; however, it improved the utility of the scale, which will lead to more valid inferences made from the data. The resultant scale was unidimensional, and had no differential item functioning. Transformation of the raw scores to w-scores allows these scales to be used as interval measures, providing a range of advantages for statistical analysis. The RMM should be used to examine the PHQ-4, and indeed all measures where items are combined, in other populations.

Supplementary Material

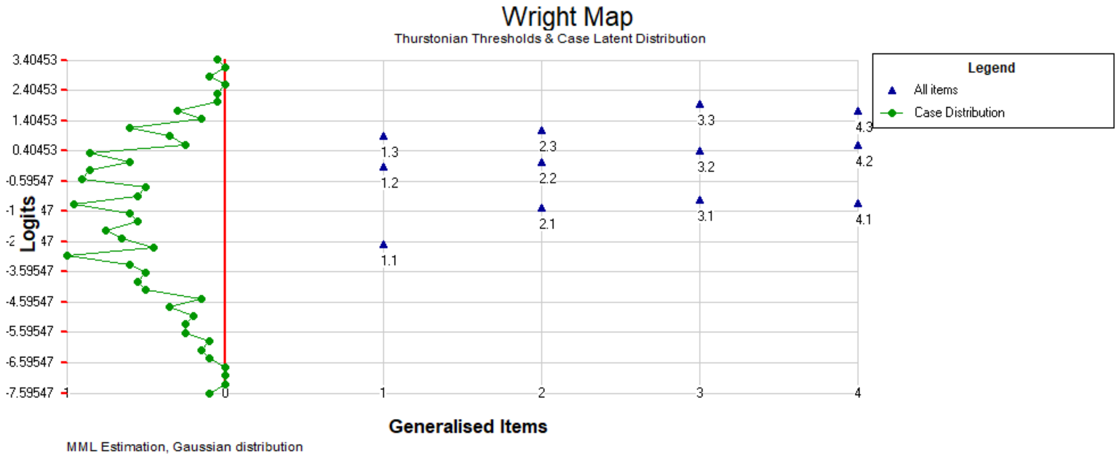


Figure S1: Wright map for the original PHQ-4

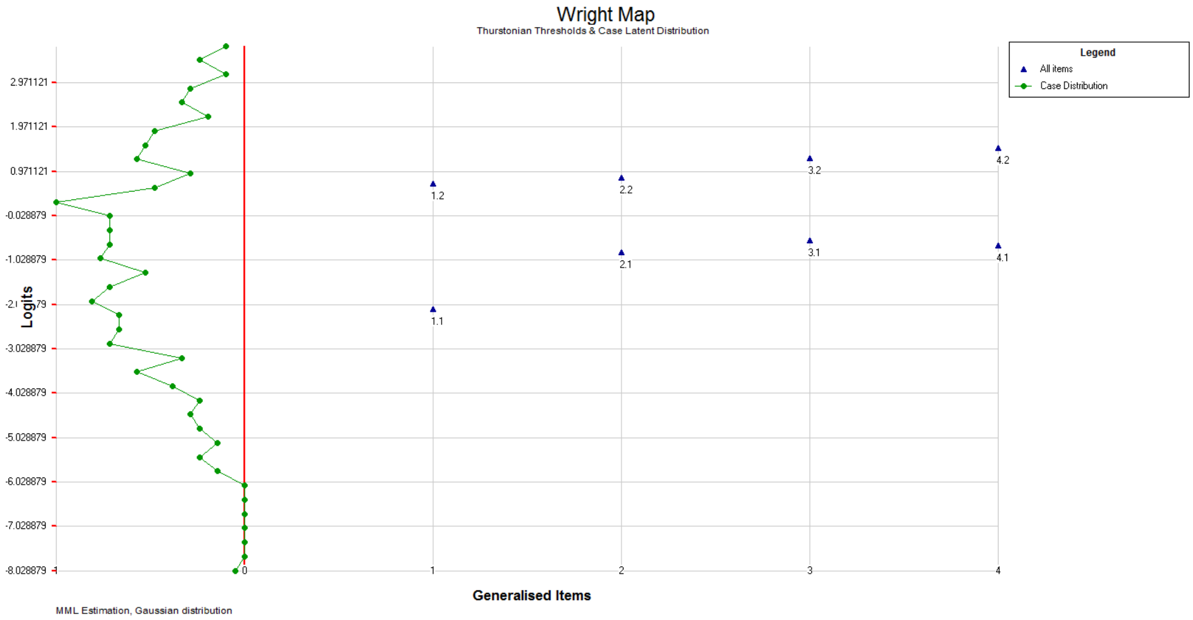


Figure S2: Wright map after collapsing Categories 2 and 3

Table S1: Differential item functioning after collapsing Categories 2 and 3

		Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	
Gender	Female	1	-0.216	0.108	1.12 (0.78-1.22)	1.0	Separation reliability 0.742
		2	-0.194	0.106	0.92 (0.76-1.24)	-0.7	Chi-square test of parameter
		3	0.162	0.109	0.99 (0.75-1.25)	-0.1	equality (3) = 9.52, p = 0.023
		4	0.248	0.110	0.91 (0.76-1.24)	-0.7	
	Male	1	0.216	0.108	1.05 (0.76-1.24)	0.4	
		2	0.194	0.106	0.98 (0.72-1.28)	-0.1	
		3	-0.162	0.109	1.23 (0.73-1.27)	1.6	
		4	-0.248	0.110	0.83 (0.73-1.27)	-1.3	
Age	18-25	1	-0.037	0.109	1.00 (0.77-1.23)	0.0	Separation reliability 0.000
	years	2	-0.108	0.109	0.94 (0.76-1.24)	-0.5	Chi-square test of parameter
		3	0.018	0.113	1.08 (0.77-1.23)	0.6	equality (3) = 1.12, p = 0.773
		4	0.128	0.113	0.96 (0.77-1.23)	-0.3	
	>25	1	0.037	0.109	1.11 (0.77-1.23)	0.9	
	years	2	0.108	0.109	0.92 (0.72-1.28)	-0.6	
		3	-0.018	0.113	1.21 (0.71-1.29)	1.4	
		4	-0.128	0.113	0.86 (0.72-1.28)	-1.0	
Socioeconomic	Lower	1	-0.027	0.136	0.97 (0.66-1.34)	-0.2	Separation reliability 0.000
status		2	-0.100	0.141	0.70 (0.64-1.36)	-1.8	Chi-square test of parameter
		3	-0.089	0.163	1.27 (0.66-1.34)	1.5	equality (3) = 0.84, p = 0.840
		4	0.216	0.151	1.15 (0.64-1.36)	0.8	
	Higher	1	0.027	0.136	1.08 (0.66-1.34)	0.5	
		2	0.100	0.141	0.89 (0.65-1.35)	-0.6	
		3	0.089	0.163	1.19 (0.57-1.43)	0.8	
		4	-0.216	0.151	1.23 (0.57-1.43)	0.9	
Student	Yes	1	-0.035	0.157	1.14 (0.55-1.45)	0.6	Separation reliability 0.000
		2	-0.002	0.161	0.71 (0.50-1.50)	-1.2	Chi-square test of parameter
		3	-0.012	0.195	1.06 (0.48-1.52)	0.3	equality (3) = 0.05, p = 0.997
		4	0.049	0.196	1.16 (0.41-1.59)	0.6	
	No	1	0.035	0.157	1.01 (0.73-1.27)	0.1	
		2	0.002	0.161	0.87 (0.72-1.28)	-0.9	
		3	0.012	0.195	1.16 (0.68-1.32)	1.0	
		4	-0.049	0.196	1.23 (0.66-1.34)	1.3	

Table S2: Score transformation table

Raw score	Weighted likelihood estimate (standard error)	W-score
0	-3.38 (1.70)	19
1	-1.91 (1.05)	33
2	-1.09 (0.86)	40
3	-0.48 (0.78)	46
4	0.06 (0.76)	51
5	0.57 (0.77)	55
6	1.14 (0.83)	60
7	1.85 (0.99)	67
8	3.14 (1.59)	79

Note: the constant used was 50

A2.15 The application of Rasch analysis to occupational health and safety measures: Elements of safety climate in professional musicians

Abstract

Background: Occupational health and safety research often involves the measurement of constructs, often through the use of questionnaires. The utility of these questionnaires should first be examined to ensure that inferences following analysis are accurate, and can best inform recommendations to improve the health of workers. In this study we examine the utility of three safety climate scales: Communication, Priority and Involvement from Whysall's modification of Cox and Cheyne's Safety Climate Assessment for use with employed musicians.

Methods: Employed musicians were asked to complete a questionnaire, which included the scales of interest. Data from these three scales were analysed using Rasch analysis. Analysis included an examination of differential item functioning.

Results: Data from the three scales fit the Rating scale model, without any items being deleted, nor response categories collapsed. No differential item functioning was detected. All three scales exhibited local dependency, while there was little diversity in the 'difficulty' of the items.

Conclusion: The Communication, Priority and Involvement scales all fit the Rating scale model, and the W-scores derived from this analysis should be used in statistical analyses. To improve the measurement of these three constructs, longer measures should be developed to overcome issues with local dependency and the lack of diversity in the 'difficulty' of the items. Nonetheless, the W-scores should be used as they offer several advantages over the raw scores, given their interval properties, including that parametric statistics can be used, and changes over time regarding these three constructs can be examined.

Key words: musicians, safety climate, occupational health, Rasch analysis, psychometrics

Background

Research into occupational health and safety (OHS) often uses measures of constructs as either exposures or outcomes. These measures may include self-report or interview questionnaires, or tools used by health professionals to measure exposure. Measures need to have demonstrated validity and reliability in order to ensure that the inferences made from the research are accurate, and provide the best available evidence from which recommendations can be drawn to minimise OHS issues, and improve the health of workers.

Examining the utility of measures

Traditional statistics, such as Cronbach's alpha, are often used to test the utility of measures. These statistics are based on the Classical Test Theory (CTT), with both the CTT[416] and Cronbach's alpha[417-419] having their limitations. The CTT assumes that 1. The reported raw scores is the sum of the true score and a random measurement error; and 2. That the errors are randomly distributed, not correlated with the true score, and that the errors are independent of one another.[414] As the errors are unknown, the CTT cannot be tested. Another limitation of the CTT is that it does not address the issue of summing ordinal item scales, where it is assumed that the response categories are equidistant, and that the findings are not necessarily generalisable beyond the sample tested, at that one point in time.[414] Rasch analysis provides a solution to the limitations of the CTT, and in practice the two methods supplement one another.[421]

Rasch analysis, based on the Rasch measurement model (RMM) is the only psychometric method to examine invariance of comparisons (interval scaling), and sufficiency (that the overall score can predict an item score)[427] – Luce and Tukey's[426] general rules of measurement. The RMM is underpinned by robust theories that can be tested.[415] Rasch analysis is used to examine internal construct validity of a measure; specifically unidimensionality (the measurement of only one construct), invariance (interval scaling), and category ordering, as well as differential item functioning.[429, 441]

Rasch analysis can also be used to transform the ordinal raw scores into linear, interval-level measures[420, 429], which can be used with parametric statistics, and to measure change over time.[429] The transformed scores through Rasch analysis are expressed as log odds or logits.[428]

Measuring organisational safety climate

We were interested in measuring elements of organisational safety climate as part of a larger study into the risk factors for musculoskeletal symptoms, and their consequences, in employed musicians (performers and teachers). Musculoskeletal symptoms are experienced by the majority of professional musicians[52], and musculoskeletal disorders account for the majority of musicians' workers' compensation claims, result in the most time off work, and the majority of the costs of claims.[558] Despite the high burden, the risk factors of musculoskeletal symptoms in musicians remain unclear[199], with insufficient evidence to support any particular public health intervention to address the issue.[719] Few studies have investigated organisational factors in musicians, and none examined elements of safety climate.[559, 723] Elements of safety climate, such as communication of OHS, involvement in OHS, and the workplace's prioritisation of OHS may provide new avenues for intervening with employed musicians, and thus reduce the burden of musculoskeletal conditions for employed musicians.

To examine communication of OHS, involvement in OHS, and the workplaces' prioritisation of OHS, we used Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment. The modifications were made to improve applicability of the assessment tool to musculoskeletal conditions.[382, 393] While this measure has been used in a number of studies[382, 391-393] to the best of our knowledge there is no evidence of the utility of the measures within this tool.

The purpose of this study was to determine the utility of the three measures included in our study (communication of OHS, involvement in OHS, and the workplaces' prioritisation of OHS) from Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment. This paper also serves as an explanation of Rasch analysis.

Methods

Musicians from two Australian states were recruited from three orchestras, two opera companies, five military bands, two music teachers' associations, and the Musicians' Union, with only musicians who were aged 18 years and older, and who were currently employed as musicians included within the present study. Musicians were recruited via email and/or face-to-face sessions, depending upon logistical constrains and organisational policy. The questionnaire was available on paper or via Survey Monkey (except where organisational policy did not permit the use of Survey Monkey). Participants were encouraged to return the questionnaire within 2-3 weeks, with a prize draw offered as an incentive (where permitted by organisational policy).

The questionnaire included the Communication, Priority and Involvement scales from Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment. Each scale consisted of two items, with responses given on 5-point Likert scales. Musicians were asked to respond with regards to the main musical employer only.

Data were exported from Survey Monkey to Microsoft Excel, while data from paper questionnaires were manually entered into the same spreadsheet, and were double entered to detect any errors. Within Excel, data were cleaned and coded. Although the original scoring of the Safety Climate Assessment were 1-5, responses were recoded as 0-4 to permit the Rasch analysis. Other data relevant to the present study were age, gender, main organisation type (teaching or performing), and socioeconomic status (Index of Relative Socioeconomic Advantage and Disadvantage[376]). Relevant data were exported into ConQuest[430] for analysis. The median age (in years) and mean Index of Relative Socioeconomic Advantage and Disadvantage[376] were established and used as cut-points for these variables.

Rasch analysis

There are two models for polytomous scales within Rasch analysis – the rating scale model (RSM)[422] and the partial credit model (PCM).[425] The two models differ in that the RSM assumes that items have the same number of response categories, share the same rating scale structure, that all items are equally discriminating[432], and that response categories are equidistant for each item[429], while the PCM does not. Data from the three safety climate scales were fit to both the RSM and PCM, with the Akaike information criterion (AIC)[433] used to select the most parsimonious model that the data fit[435, 436]; that is the model with the lower AIC.[434] Where the two AICs were within two of each other, the RSM was selected, as it is a more parsimonious model.

After selecting the most appropriate model (i.e. the RSM or the PCM) the weighted fit mean square, and the corresponding t-value (derived from the cube root transformation) were examined, where the optimal range was 0.60-1.40 for the weighted fit mean square[437, 438], and -1.96 to 1.96 for the t-value.[428] Items where the fit statistics were beyond these ranges were not necessarily omitted, but were flagged as being potentially mis-fitting. The chi-square test of parameter was examined as a measure of overall fit. The separation reliability, a measure of discrimination power and overall error[416], was also examined with a higher reliability being ideal. Low item-total correlations (discrimination index <0.20)[428] and negative item-rest correlations were potential reasons for item deletion.

Category functioning was determined by examining the estimates, mean predicted values, point biserial correlations, item deltas and item thresholds[428, 429, 439, 440], all of which should be in ascending order. Where this was not the case, collapsing of the categories was considered[420, 429, 440, 441], however it has been suggested that categories should only be collapsed when the discrimination at the threshold between two categories is zero.[439]

Residual fit statistics were also used to examine person fit[442], with t-values of -1.96 to 1.96 being considered optimal. Where t-values were well beyond this range, or where a large proportion of participants had mis-fitting data, these participants were removed from the analysis, which was re-run to determine whether results remained consistent.

Response, or local dependency, refers to the situation where items are related.[420, 429] Local dependency was examined by examining the correlation matrix of the residuals for each item[420, 429] with a low level of local dependency defined as an absolute correlation of less than 0.40.[443]

The Wright map plots item positions and participant distribution along the logit scale. This map is used to determine how well the measure is targeted to the population, with a measure with a mean person location of approximately zero logits being considered well targeted.[429, 441]

Differential item function (DIF) was also examined using Rasch analysis, with regards to age, gender, socioeconomic status, and whether the musicians' main musical employed focused on performance or education. Differential item functioning refers to measurement variance, where item responses should not differ between sub-groups where the overall score is similar.[429, 441] Two strategies were used to determine whether significant DIF was present. The first strategy was the Wald test, where DIF was deemed significant where the estimate (for the item*group, e.g. item*age) was over twice the standard error.[444] The second strategy involved examining the weighted mean fit squares for the items for each sub-group, using the same optimal ranges as outlined above. Where significant DIF was detected using either method, the magnitude of the DIF was then examined. Differential item functioning was only considered to be of sufficient magnitude to impact upon results, when it exceeded 0.5 logits.[445] Differential item functioning could be rectified by deleting the item, or where DIF was considered uniform (differences between the groups are uniform across all logits[420, 441, 446]), another option was to analyse the sub-groups separately.

If data fit one of the Rasch models, and no significant DIF of >0.5 logits was detected, the raw scores were transformed into weighted likelihood estimates (WLE) in ConQuest.[430] Weighted likelihood estimates minimise estimation bias, compared with other methods[447], and were therefore selected for this study. The WLE were then transformed into W-scores to eliminate negative scores and remove the need for decimal places, using the formula W = 9.1024 x WLE logits + c, where c was selected to ensure that all scores were positive.[448]

The project had approval from The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and Australian Defence Organisation Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006).

Results

The median age of the 111 participants in this study was 44 years (interquartile range 31-54 years). Almost half (47.8%) of the participants were female, while the majority (71.2%) indicated that their main musical employer was a performance organisation.

Communication scale

The Communication scale data fit the PCM and RSM equally well (AICs of 461 for both) - the RSM was used, as it is a more parsimonious model. The traditional statistics revealed that the point biserial correlations and mean predicted values were all in ascending order, and the item-rest and item-total correlations were all 0.90 or greater. The category estimates, item deltas and item thresholds were in ascending order, and the weighted fit mean square and t-values were within the optimal ranges, indicating the data fit the RSM. See the supplementary material for all output.

There were two mis-fitting participants (1.80%) with t-values 5.07-5.22, however given the small proportion of mis-fitting participants we did not remove these participants from the analysis. The Wright map (Figure 1) indicates that the mean person location was approximately zero logits, and both items were of a similar level of 'difficulty'. There was some evidence of local dependency with a statistically significant correlation between the items of -0.51, however this was deemed acceptable given the nature of the scale. There was no evidence of DIF for age, gender, socioeconomic status or the type of employer (performing or teaching. The raw scores were transformed into w-scores (Table 1).

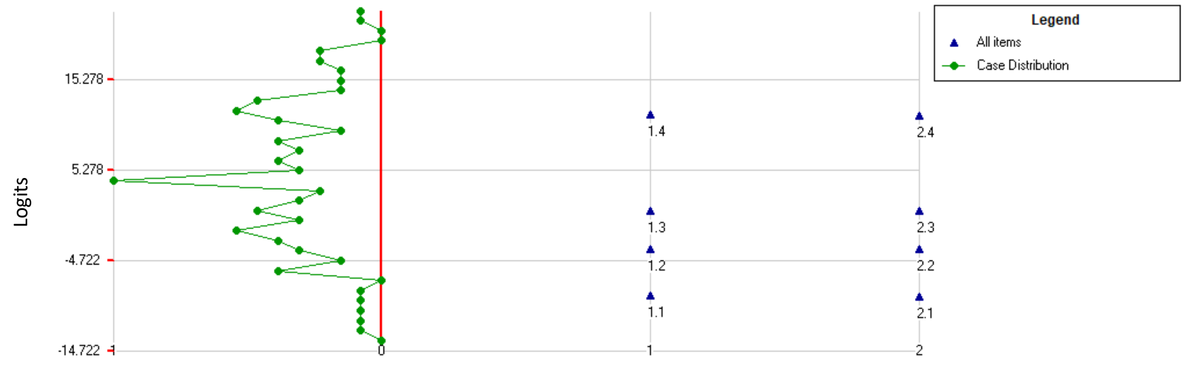


Figure 1: Wright map for the Communication scale

Table 1: Transformation of raw scores to W-scores

Raw score	Communication scale		Involvement scale		Priority scale	
	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score
0	-10.29 (1.89)	6	-6.01 (1.87)	5	-8.190 (1.878)	5
1	-8.68 (1.40)	21	-4.31 (1.27)	21	-6.556 (1.346)	20
2	-5.42 (1.86)	51	-3.00 (1.16)	33	-4.788 (1.398)	36
3	-3.44 (1.36)	69	-1.73 (1.15)	44	-3.023 (1.310)	52
4	-1.34 (1.60)	88	-0.40 (1.18)	56	-0.970 (1.562)	71
5	0.77 (1.38)	107	0.98 (1.25)	69	1.111 (1.376)	90
6	2.39 (1.88)	122	2.97 (1.50)	87	2.782 (1.890)	105
7	11.35 (1.41)	203	5.05 (1.41)	106	8.468 (1.421)	157
8	12.96 (1.90)	217	6.82 (1.95)	122	10.105 (1.909)	172

Note: the constant for the communication scale was 100, the constant for the involvement scale was 60, and the constant for the priority scale was 80.

Involvement scale

The data from the Involvement Scale better fit the RSM (AIC 580) than the PCM (AIC 583), hence the RSM was used. The point biserial correlations and mean predicted values were in ascending order and the item-rest and item-total correlations were adequate. Regarding the Rasch analysis, the category estimates and item deltas and item thresholds were in ascending order, and while the Category 1 t-value for the weighted fit was 2.3, the weighted fit mean square was within the optimal range; hence no changes were required.

The Wright map (Figure 2) indicates that the mean person location was approximately zero logits; hence, the scale appears to be well targeted, while Item 2 was more 'difficult' to endorse than Item 1. Four mis-fitting cases (3.60%) were identified with t-values of 3.89-5.54. As the proportion of participants who were mis-fitting was relatively low, no changes were made. There was a high degree of local dependency, with a statistically significant correlation between the residuals (-0.87).

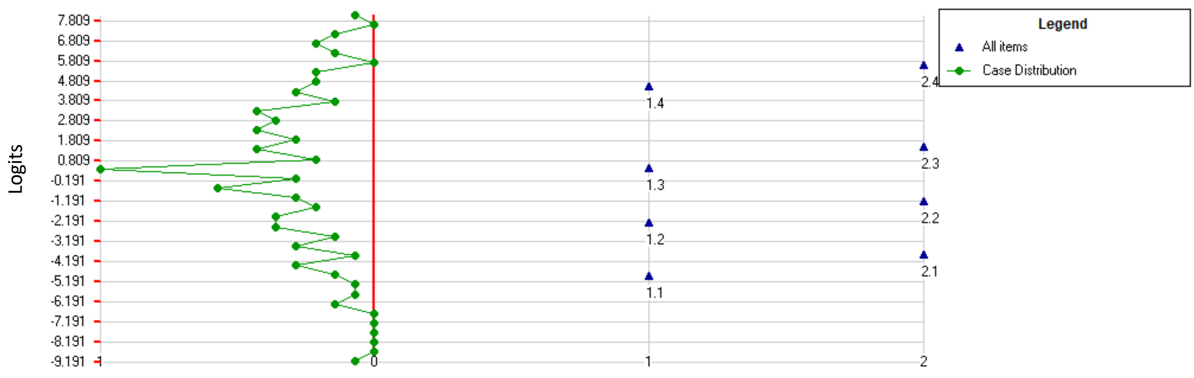


Figure 2: Wright map for the Involvement scale

We examined DIF for gender, age, socioeconomic status and organisation type. While the weighted fit mean scale for the higher socioeconomic status for Item 1 was beyond the optimal range (1.41), the magnitude of the DIF was small (0.060), hence no changes were required. There was no DIF for gender, age and organisation type. The raw scores from the Involvement scale were transformed into w-scores (Table 1).

Prioritisation scale

The data for the Prioritisation scale better fit the RSM (AIC 490) than the PCM (AIC 494). The predicted mean values were in ascending order, however the point biserial correlations for Item 1 were disordered (-0.57, -0.23, -0.35, 0.21, 0.57), which appears to relate to the small number of respondents in the lower categories. The item-rest and item-total correlations were also adequate. The weighted fit mean square, and their t-values were within the optimal ranges, while the category estimates, and item thresholds and deltas were in ascending order.

There was evidence of local dependency, with a significant correlation of -0.683 between the residuals of the two items. Only one participant had data that did not fit (t-value 5.32). The Wright map (Figure 3) indicates that there was little difference in the 'difficulty' of the two items. Further, it revealed that the mean person location was greater than zero logits, bringing into question the targeting of the scale. There was no evidence of DIF for the Prioritisation scale. The transformation of raw Prioritisation scale scores to W-scores is reported in Table 1.

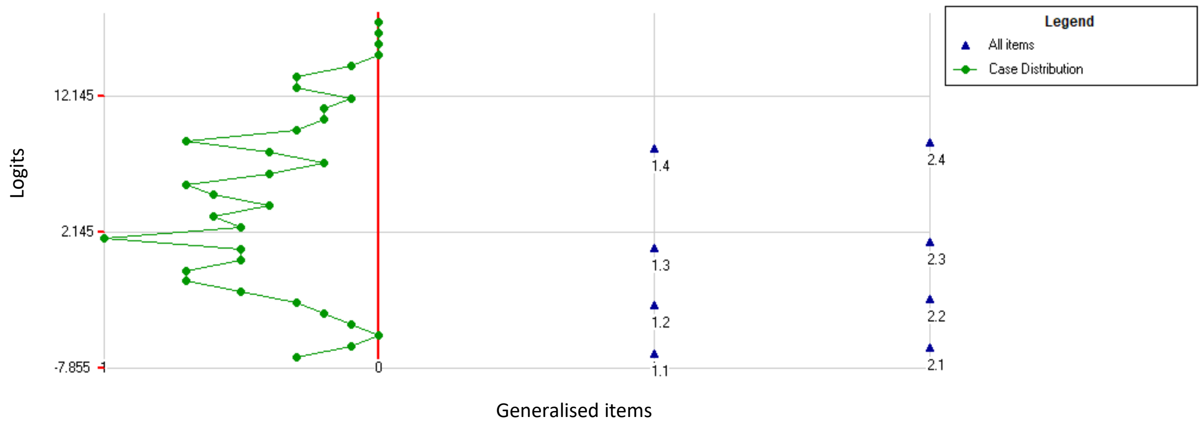


Figure 3: Wright map for the Prioritisation scale

Discussion

The utility of three of the scales (Communication, Involvement and Prioritisation) of Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment were examined, for the first time in the present study – in this case with employed musicians. All three scale fit the Rasch model without modifications being made (i.e. collapsing categories or deleting items), and are therefore considered unidimensional scales, without DIF for age, gender, organisational type, or socioeconomic status, and the resultant w-scores can be used in studies comparing these elements of safety climate over time, and permit the use of parametric statistics.

The Rasch analysis did however identify some issues with the measures that would not have been detected had traditional statistics alone been used. Local dependency was detected for all three scales, as would be anticipated for measures with so few items; hence, longer measures of these scales should be developed for future research.

Although the Involvement scale was considered well targeted, there were some issues for the Communication and Prioritisation scales, with the mean person location for the Communication scale being greater than zero logits, and the Prioritisation scale being less than zero logits. These findings indicate that it was too 'difficult' to endorse the communication items, and too 'easy' to endorse the prioritisation items, and may be used to guide the development of new, longer measures of these constructs for future research.

The individual items for the Communication and Priority scales were of a similar level of 'difficulty' to one another, as indicated in the Wright map, and by high item-rest and item-total correlations. These findings indicate that there was little added value in including the second scale item; further supporting the recommendation for longer measures to be developed.

After longer measures of communication, priority and involvement as part of safety climate at work are developed, their utility should be examined using Rasch analysis. Ideally, a larger sample size would be obtained in such a study, with Linacre[409] suggesting that studies using Rasch analysis with polytomous scales have at least 10 participants in each response category.

While the findings of this study are generalisable to other musicians, they are not necessarily generalisable to other occupational groups. Nonetheless, longer measures are typically more reliable, and allow greater scope for modification to overcome issues that may be identified in Rasch analysis with other occupational groups. The expansion of measures within of Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment to include more items should therefore be considered in future research.

Data from the Communication, Priority and Involvement scales of Whysall's[382, 393] modification of Cox and Cheyne's[381] Safety Climate Assessment were found to fit the RSM, indicating that they are unidimensional measures, that did not exhibit DIF. The scales can however be further improved through the inclusion of more items, with greater diversity in 'difficulty' to address issues with local dependency, and high item-total and item-rest correlation. Despite these identified issues, the W-scores derived from this analysis should be used in regression analyses, rather than the raw scores, as parametric statistics can be used, and these W-scores can be used to examine changes over time, owing to the interval scaling.

Supplementary material

Communication scale

Table S1: Traditional statistics for the Communication scale

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	7 (6.31)	-0.65	-8.84***	-14.020±5.655	0.90	0.98
	1	12 (10.81)	-0.37	-4.19***	-5.504±1.803		
	2	21 (18.92)	-0.18	-1.91	-0.721±2.183		
	3	47 (42.34)	0.21	2.28*	5.435±3.137		
	4	24 (21.62)	0.58	7.38****	14.93±4.475		
2	0	7 (6.31)	-0.61	-7.94***	-14.020±5.655	0.90	0.97
	1	9 (8.11)	-0.34	-3.78***	-5.917±2.123		
	2	21 (18.92)	-0.29	-3.14**	-1.885±1.480		
	3	55 (49.55)	0.29	3.11**	5.811±3.266		
	4	19 (17.12)	0.56	7.01***	16.100±4.298		

Notes: Mean ± standard deviation: 5.25±2.13, variance: 4.55, skewness: -0.85, kurtosis: 0.28, standard error of mean 0.20, standard error of measurement 0.50, coefficient alpha 0.95. *p<0.050, **p<0.010, ***p<0.001

Table S2: Rasch analysis for the Communication scale

			Unweighted fit		Weighted fit			
	Estimates	Errors	Mean square (95% confidence interval)	t-value	Mean square (95% confidence interval)	t-value	Item deltas	Item threshold
Item 1							-8.65	-8.65
							-3.41	-3.42
	0.039	0.197	0.89 (0.74-1.26)	-0.8	1.03 (0.69-1.31)	0.1	0.82	0.84
							11.39	11.39
Item 2	-0.039	0.197	0.73 (0.74-1.26)	-2.2	0.95 (0.69-1.31)	-0.3	-8.73	-8.73
							-3.49	-3.50
							0.74	0.76
							11.32	11.32
Category 0			0.08 (0.74-1.26)	-12.8	1.13 (0.00-2.18)	0.3		
Category 1	-8.688	1.646	0.84 (0.74-1.26)	-1.2	1.32 (0.47-1.53)	1.1		
Category 2	-3.450	0.727	0.75 (0.74-1.26)	-2.0	1.20 (0.64-1.36)	1.1		
Category 3	0.783	0.562	2.86 (0.74-1.26)	9.4	0.98 (0.64-1.36)	-0.1		
Category 4	11.354		0.25 (0.74-1.26)	-8.2	0.95 (0.38-1.62)	-0.1		

Notes: Chi-square test of parameter equality (1) = 0.04

Table S3: Differential item functioning for the Communication scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.207	0.223	1.03 (0.54-1.46)	0.2	0.86
		2	0.207	0.223	1.06 (0.54-1.46)	0.3	
	Male	1	0.207	0.223	1.01 (0.48-1.52)	0.0	
		2	-0.207	0.223	1.00 (0.45-1.55)	0.0	
Age	18-44 years	1	0.454	0.263	1.08 (0.52-1.48)	0.3	2.99
		2	-0.454	0.263	0.90 (0.46-1.54)	-0.4	
	>44 years	1	-0.454	0.263	1.05 (0.49-1.51)	0.2	
		2	0.454	0.263	1.14 (0.47-1.53)	0.5	
Socioeconomic status	Lower	1	0.176	0.217	1.02 (0.54-1.46)	0.1	0.65
		2	-0.176	0.217	1.05 (0.54-1.46)	0.2	
	Higher	1	-0.176	0.217	0.85 (0.51-1.49)	-0.6	
		2	0.176	0.217	0.82 (0.49-1.51)	-0.7	
Type	Education	1	-0.401	0.281	10.2 (0.38-1.62)	0.1	2.03
		2	0.401	0.281	1.15 (0.40-1.60)	0.5	
	Performance	1	0.401	0.281	1.09 (0.59-1.41)	0.3	
		2	-0.401	0.281	0.90 (0.45-1.55)	-0.4	

Involvement scale

Table S4: Traditional statistics for the Involvement scale

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	9 (8.11)	-0.43	-4.91***	-4.463±1.941	0.76	0.93
	1	14 (12.61)	-0.35	-3.90***	-2.271±1.013		
	2	36 (32.43)	-0.15	-1.57	-0.633±1.588		
	3	37 (33.33)	0.25	2.66**	2.145±1.678		
	4	15 (13.51)	0.54	6.77***	4.655±1.723		
2	0	12 (10.81)	-0.44	-5.12***	-3.884±2.135	0.76	0.94
	1	28 (25.23)	-0.35	-3.94***	-1.667±1.438		
	2	30 (27.03)	-0.03	-0.28	0.255±1.407		
	3	30 (27.03)	0.34	3.77***	2.714±1.437		
	4	11 (9.91)	0.50	6.11***	5.334±1.332		

Notes: Mean ± standard deviation: 4.32±2.14, variance: 4.56, skewness: -0.13, kurtosis: -0.56, standard error of mean: 0.20, standard error of measurement: 0.80, coefficient alpha: 0.86. *p<0.05, **p<0.01, ***p<0.001

Table S5: Rasch analysis statistics for the Involvement scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item threshold
			Mean square (95% confidence interval)	t-value	Mean square (95% confidence interval)	t-value		
Item 1	-0.498	0.137	0.92 (0.74-1.26)	-0.6	0.99 (0.73-1.27)	0.0	-4.44	-4.52
							-2.11	-2.10
							0.42	0.47
							4.14	4.16
Item 2	0.498	0.137	1.03 (0.74-1.26)	0.3	1.06 (0.73-1.27)	0.4	-3.44	-3.53
							-1.12	-1.10
							1.42	1.47
							5.13	5.16
Category 0			1.28 (0.74-1.26)	2.0	1.30 (0.49-1.51)	1.1		
Category 1	-3.938	0.598	2.29 (0.74-1.26)	7.1	1.40 (0.69-1.31)	2.3		
Category 2	-1.617	0.345	1.12 (0.74-1.26)	0.9	1.26 (0.75-1.25)	1.8		
Category 3	0.920	0.274	1.49 (0.74-1.26)	3.2	1.16 (0.73-1.27)	1.1		
Category 4	4.635		1.02 (0.74-1.26)	0.2	1.02 (0.53-1.47)	0.1		

Note: Chi-square test of parameter equality (1) = 13.24

Table S6: Differential item functioning statistics for the Involvement scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.139	0.123	1.00 (0.60-1.40)	0.0	1.29
		2	0.139	0.123	0.92 (0.61-1.39)	-0.4	
	Male	1	0.139	0.123	0.98 (0.61-1.39)	-0.1	
		3	-0.139	0.123	0.94 (0.63-1.37)	-0.3	
Age	18-44	1	0.150	0.124	0.88 (0.62-1.38)	-0.6	1.46
	years	2	-0.150	0.124	0.89 (0.63-1.37)	-0.6	
	>44	1	-0.150	0.124	0.99 (0.59-1.41)	0.0	
	years	2	0.150	0.124	0.97 (0.60-1.40)	-0.1	
Socioeconomic status	Lower	1	0.030	0.127	0.85 (0.61-1.39)	-0.8	0.05
		2	-0.030	0.127	0.81 (0.62-1.38)	-1.0	
	Higher	1	-0.030	0.127	1.41 (0.60-1.40)	1.8	
		2	0.030	0.127	1.14 (0.61-1.39)	0.7	
Organisation type	Teaching	1	-0.164	0.142	1.19 (0.48-1.52)	0.7	1.34
		2	0.164	0.142	1.36 (0.50-1.50)	1.3	
	Performing	1	0.164	0.142	0.89 (0.67-1.33)	-0.6	
		2	-0.164	0.142	0.88 (0.67-1.33)	-0.7	

Prioritisation scale

Table S7: Traditional statistics for the Prioritisation scale

Item	Category	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	6 (5.45)	-0.57	-7.22***	-9.030±1.841	0.84	0.96
	1	8 (7.27)	-0.23	-2.50*	-3.342±2.510		
	2	23 (20.91)	-0.35	-3.86***	-1.201±1.742		
	3	51 (46.36)	0.21	2.25*	4.375±2.648		
	4	22 (20.00)	0.57	7.14***	10.17±2.951		
2	0	5 (4.55)	-0.56	-7.04***	-9.165±2.024	0.84	0.96
	1	10 (9.09)	-0.36	-3.98***	-4.086±2.134		
	2	28 (25.45)	-0.24	-2.59*	-0.535±2.030		
	3	47 (42.73)	0.25	2.63*	5.030±2.552		
	4	20 (18.18)	0.53	6.45***	10.200±3.188		

Notes: mean ± standard deviation 5.28±1.99, variance 3.97, skewness -0.78, kurtosis 0.43, standard error of mean 0.19, standard error of measurement 0.76, coefficient alpha 0.85. *p<0.05, **p<0.01, ***p<0.001

Table S8: Rasch analysis for the Prioritisation scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item threshold
			Mean square (95% confidence interval)	t-value	Mean square (95% confidence interval)	t-value		
Item 1	-0.218	0.170	0.85 (0.74-1.26)	-1.1	1.00 (0.72-1.28)	0.0	-6.79	-6.82
							-3.24	-3.23
							0.90	0.92
							8.25	8.25
Item 2	0.218	0.170	1.01 (0.74-1.26)	0.1	1.04 (0.72-1.28)	0.3	-6.35	-6.38
							-2.80	-2.79
							1.34	1.35
							8.69	8.69
Category 0			0.10 (0.74-1.26)	-12.0	1.04 (0.04-1.96)	0.1		
Category 1	-6.572	1.823	0.40 (0.74-1.26)	-5.9	0.96 (0.53-1.47)	-0.1		
Category 2	-3.019	0.574	0.75 (0.74-1.26)	-2.0	1.04 (0.67-1.33)	0.3		
Category 3	1.122	0.462	1.11 (0.74-1.26)	0.8	1.02 (0.69-1.31)	0.1		
Category 4	8.469		0.33 (0.74-1.26)	-6.9	0.94 (0.53-1.47)	-0.2		

Note: Chi-square test of parameter equality (1) = 1.65

Table S9: Differential item functioning statistics for the Prioritisation scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.064	0.179	0.89 (0.57-1.43)	-0.5	0.13
		2	0.064	0.179	1.03 (0.59-1.41)	0.1	
	Male	1	0.064	0.179	1.18 (0.54-1.46)	0.7	
		2	-0.064	0.179	1.10 (0.56-1.44)	0.5	
Age	18-44 years	1	-0.13	0.171	0.96 (0.56-1.44)	-0.2	0.58
		2	0.13	0.171	0.94 (0.59-1.41)	-0.2	
	>44 years	1	0.13	0.171	1.09 (0.55-1.45)	0.4	
		2	-0.13	0.171	0.94 (0.57-1.43)	-0.2	
Socioeconomic status	Lower	1	-0.160	0.172	1.00 (0.56-1.44)	0.0	0.86
		2	0.160	0.172	1.21 (0.58-142)	1.0	
	Higher	1	0.160	0.172	1.26 (0.55-1.45)	1.0	
		2	-0.160	0.172	0.97 (0.57-1.43)	-0.1	
Type	Teaching	1	-0.064	0.187	0.94 (0.41-1.59)	-0.2	0.12
		2	0.064	0.187	0.95 (0.45-1.55)	-0.1	
	Performing	1	0.064	0.187	1.03 (0.63-1.37)	0.2	
		2	-0.064	0.187	1.05 (0.66-1.34)	0.3	

A2.16 Using Rasch analysis to examine the utility of the short version of the Effort-Reward Imbalance Questionnaire

Abstract

Background: The effort and reward scales from the short version of the Effort-Reward Imbalance (ERI) Questionnaire are measures of occupational stress; important risk factors for a range of occupational health conditions. The short version of the ERI Questionnaire has not previously been examined using modern psychometric methods.

The aim of this study was to investigate the utility of the Effort and Reward Scales, as well as the three Reward Sub-scales, from the short version of the ERI Questionnaire, for use with employed, professional musicians.

Methods: Standard survey methods were used to gather the ERI data. These data were subjected to Rasch analysis, with the scales examined separately. We also examined differential item functioning for these scales with regards to age, gender, socioeconomic status and the type of employer (education or performance).

Results: The data for the Effort Scale, and the Job Security and the Esteem Sub-Scales fit the Rasch model well, with no evidence of differential item functioning detected. Challenges were encountered in fitting the Reward Scale and Promotion Scale. These challenges were overcome by removing mis-fitting items.

Discussion: Improvements were made to the scales of the short version of the ERI questionnaire. The raw scores for each of the scales were transformed into interval-level w-scores for future analysis. This study highlights the importance of Rasch analysis in determining the utility of measures using the occupational health.

Keywords: Rasch analysis, psychometrics, occupational stress, effort-reward imbalance, musicians

Background

Occupational stress

Occupational stress is associated with a range of adverse health outcomes for workers, including coronary heart disease[747], high blood pressure[748], metabolic syndrome[749], type 2 diabetes[750], musculoskeletal symptoms[483], and depression.[751] Occupational stress also predicts long-term sick leave from work.[752] The two prevailing models of occupational stress are the Effort-Reward Imbalance (ERI) model[354] and Job Demand-Control model[355], and these are considered complementary models.[358] The utility of the measures used for occupational stress is important in ensuring the inferences made from occupational stress studies are accurate.

Effort Reward Imbalance model

The ERI model is based on concept of social reciprocity as a norm regarding effort and reward.[358] The ERI model considers three factors: effort, reward and overcommitment. Effort and reward are considered organisational factors, and overcommitment a personal factor.[357, 358] The model proposes that:

- ERI is a more important factor in determining the risk of adverse health outcomes than the individual components (i.e. effort and reward);
- overcommitment is associated with poorer health outcomes; and
- those with both an ERI and overcommitment are at the highest risk of experiencing adverse health outcomes.[357]

While the focus of ERI was initially on how ERI led to adverse cardiovascular outcomes[354, 482], it has since been used to investigate a wide range of health outcomes[482], including musculoskeletal symptoms (MSSs).[359]

Data regarding ERI are often collected using the ERI questionnaire[358], or a short version thereof.[380] The ERI questionnaires have three subscales for 'effort', 'reward' and 'overcommitment'.[358, 380] The original questionnaire has five or six effort items, with the physical load item removed for use with white collar workers[358], whereas the short questionnaire has three items.[380] Reward is measured using 11 items in the original questionnaire[358] and seven items in the short questionnaire.[380] Reward has been divided further into three sub-scales: esteem (including financial rewards), job security and promotion opportunities.[358, 380]

Musculoskeletal symptoms and occupational stress

As part of a larger study, we were interested in exploring the association between occupational stress and MSS outcomes in employed, professional musicians. Musculoskeletal symptoms are common among musicians[50-52], and may have a considerable negative impact upon their lives[60, 192, 287, 289, 298], and the majority of musicians' workers' compensation claims are for musculoskeletal disorders.[376]

Our project was based upon ERI, rather than the Job Demand-Control model (JD-C), as there is evidence of ERI being associated with MSS outcomes across different populations, whereas the JD-C model was only associated with MSS outcomes for blue collar workers.[356] A recent study of nurses also found that ERI was a stronger predictor of MSS outcomes than the JD-C model, also finding that there was little gain in using both models.[483] The ERI model was considered more appropriate for our project than the JD-C model. We examined the Effort and Reward subscales, as for MSS, including the Overcommitment subscale has no added benefit.[483] Despite evidence of the association between MSSs and ERI in other groups[356, 483], this association has not been investigated in musicians.[559, 723]

Utility of the Effort Reward Imbalance Questionnaires

Both the original and short versions of the ERI questionnaires have been reported to be valid and reliable[358, 380, 388-390, 753-758], however these statements were made based upon traditional psychometric methods under the Classical Test Theory (CTT), such as Cronbach's alpha and factor analysis, rather than using modern psychometric methods, such as Rasch analysis.

There are limitations with both the CTT[416] and Cronbach's alpha.[417-419] Findings from traditional statistics are not generalisable to other samples[414], and the CTT that underpins the traditional methods cannot be tested.[415] In addition, the overall score remains ordinal.[414] The implications of these limitations are that existing evidence on the utility of the scale should not be used to justify the choice of scale for future studies that parametric statistics should not be used to analyse the data, and the scales should not be used to examine changes over time. Without first undertaking analysis of the ERI questionnaires using modern psychometric methods, the ERI questionnaires should not be used to examine changes over time, nor with parametric statistics.

Rasch analysis

Modern psychometric methods, like Rasch analysis, address the limitations of traditional psychometric methods, and are considered complementary to the traditional methods.[421] The Rasch measurement model (RMM) is the optimal modern psychometric method as the theory of item-examinee analysis, which underpins it, is well established and it provides the most parsimonious model to examine unidimensionality and parameter invariance. The RMM also provides the minimal number of parameter estimates[422-425], and is the only method which addresses the Luce and Tukey's[426] general rules of measurement; that an item score can be predicted form the total score (sufficiency) and invariance of comparisons (interval scaling).[427]

The RMM can be used to examine the measure's internal construct validity, including the unidimensionality of a scale (that it is measuring one latent trait), category ordering (that the categories as functioning as intended), item testing of invariance (interval scaling), and differential item functioning (that sub-groups respond to items in the same way where the overall score is similar).[429, 441] Rasch analysis involves fitting the data to one of the RMMs.[420] The two models available for polytomous scales are the rating scales model (RSM) developed by Andrich[422] and the partial credit model (PCM) that was developed by Masters.[425] The primary differences between these two models are that the RSM assumes that the categories are equidistant across categories[429], the items are equally discriminating, have the same number of categories and share the same rating scale structure.[432]

If the data fit one of the RMM, the ordinal, raw scores can be transformed into interval level measures.[420, 429] The transformation is monotonic, in that the ranking of participants is maintained, and the units of measurement are log odds or logits.[428] Interval level measures have a number of advantages over ordinal level measures, as parametric statistics can be used, and changes over time can be validly examined.[429]

Study objective

The objective of this study was to investigate the utility of the Effort and Reward Scales, and the three Reward Sub-scales (perceived esteem, job security and promotion opportunities) from the short version of the ERI questionnaire[380, 388] for use with employed professional musicians.

Methods

Approval was granted from The University of Adelaide Human Research Ethics Committee (protocol number: H-2015-279) and the Joint Health Command Low-Risk Ethical Review Panel (protocol number: LREP 16-006).

Sample and recruitment

The present study included employed musicians (performers, and instrumental or vocal teachers) who were aged 18 years or older. Musicians were recruited from the main musical employers in two Australian states: three orchestras, two universities, two opera companies and five military bands. In addition, we recruited university music students, and musicians who were members of the Musicians' Union and/ or Music Teachers' Association as part of our larger study. Any of the musicians who were employed as musicians were also included in the present study.

It has been suggested that for polytomous scales, like those in the short version of the ERI Questionnaire, at least 10 participants are required in each response category.[409] As there were no existing data regarding the questionnaire we were unable to estimate the sample size *a priori*, so aimed to collect data from as many participants as possible.

Recruitment was conducted via email and/or a face-to-face session. Where possible, logistically and in order to follow organisational policy, both strategies were employed. At the face-to-face sessions, a brief description of the project was provided, and information sheets, paper questionnaires and reply-paid envelopes were distributed. The email used for recruitment included a brief written explanation of the project, and an information sheet, as well as link to the online questionnaire (on Survey Monkey, www.surveymonkey.com). Where permitted by organisational policy, the link to the online questionnaire, as well as a Quick Response code were provided on the paper information sheet, while those recruited via email could request that a paper copy of the questionnaire be sent to them. Paper questionnaires could be returned directly to the first author, via a collection box onsite, or via the supplied reply-paid envelopes. To encourage participation, those who completed the questionnaire could elect to participate in a prize draw, where organisational policy allowed.

Questionnaire package

A questionnaire package was developed for our project, and included demographic, musculoskeletal, psychosocial and organisational items. The short version of the ERI Questionnaire was included and other items relevant to the present study included age, gender, residential postcode, and the main type of employer (performance or teaching).

The short version of the ERI Questionnaire consists of three effort items (Effort 1-3), and seven reward items (Reward 1-7). Reward Items 1 and 5 measure 'esteem', 2, 6 and 7 measure 'promotion', and 3 and 4 'job security'. The items have been published elsewhere.[380] Originally a 5-point Likert scale was used for the questionnaire, however a 4-point scale has been recommended[380], which is in keeping with questionnaire design recommendations where 'neutral' response categories should be avoided, as these responses do not always reflect neutral responses.[729-731]

In the present study, participants responded to each item using a 4-point Likert scale with headings 'strongly agree', 'agree', 'disagree' and 'strongly disagree'.[380] To facilitate the Rasch analysis the lowest score was zero; hence 'strongly disagree' was coded as 0, 'disagree' as 1, 'agree' as 2, and 'strongly agree' as 3. Reward Items 2-4 were negatively worded items; hence, the scoring for these items was reversed.

Data management

Data collected online were exported into Microsoft Excel for initial cleaning and coding. The data from the paper questionnaires were manually entered into the same spreadsheet twice in order to detect any data entry errors, with only one entry retained for analysis. For the present study, we excluded participants who had not been employed as musicians in the last 12 months. The effort and reward items were coded as outlined above. For age, we used a median cut-point to classify participants as being younger or older. Socioeconomic status was coded as higher or lower using the sample median cut-point from the Index of Relative Socioeconomic Advantage and Disadvantage[376], based on the participants' residential postcode. The main employer was coded as a performance or education organisation.

Participant identification number, age category, gender, socioeconomic status category, main employer type, and scores for the effort and reward items were exported into ConQuest[430] for Rasch analysis.

Data analysis

Data were fit to both the RSM and the PCM, and the Akaike Information Criteria (AIC)[433], a model fit statistic[434] was used to select the best model. A lower AIC indicates a lower mean squared error[434], which is the most parsimonious model.[435] As differences in AIC of <2 are considered minimal, hence where the difference in AICs for the PCM and RCM were <2 the RCM was selected, as it is the simplest model.

The model fit was then examined using the parameters outlined in Table 1. Results falling outside of the optimal ranges did not necessarily mean that modifications were required, particularly given that perceptions were being measured rather than correct/incorrect answers (e.g. examination), hence the evidence was considered as a whole in order to determine whether modifications were required. Modifications were item deletion or collapsing of response categories.

Table 1: Parameters assessed for Rasch analysis

Parameter	Optimal result
Weighted fit mean square and corresponding t-values (an indicator of model fit & unidimensionlity[428, 437, 438])	Weighted fit mean square: 0.60-1.40[437, 438] Corresponding t-value -1.96 to 1.96[428]
Chi-square test of parameter equality (an indicator of overall fit)	Significant chi-square test
Separation reliability (an indicator of overall error & discrimination power[416])	Higher results more favourable[416]
Item deltas, item thresholds, mean predicted values, point biserial correlations & category estimates	Ascending order[428, 429, 439, 440]
Discrimination index (item-total correlation)	Ideally ≥0.40, but ≥0.20 acceptable[428]
Biserial correlation (item-rest correlation)	Positive
Case residual fit statistics (an indicator of person fit[442])	t-value of -1.96 to 1.96
Wright map (an indicator of the targeting of the scale)	Mean person location of approximately zero logits[429, 441]
Correlation of the residuals (an indicator of local or response dependency)[420, 429]	Correlation of <0.40 indicates low dependency[443]

Rasch analysis was also used to examine differential item functioning (DIF) for age category, gender, socioeconomic status, and the main type of musical employer (education or performance). The Wald t-test and weighted mean fit square for the groups were used to examine DIF. For each item within each group we examined the weighted mean fit square and the associated t-value[445], using the optimal ranges outlined above. The Wald t-test involved examining the estimates for the item*group (e.g. item*gender), where the DIF was considered significant if the absolute estimate was greater than twice the error.[444] The chi-square test was also examined with $p<0.05$ indicating that there were overall differences between the groups.

If DIF was identified, the magnitude of DIF was examined, as a small DIF would not be expected to alter results. Where the difference in thresholds was greater than 0.5 logits, the DIF was of sufficient magnitude to alter findings, and was therefore addressed.[445] The approach taken to address DIF was dependent on the type of DIF. Uniform DIF, where there is a vertical translation such that the differences are uniform across logits[420, 441, 446], the dataset may be split by sub- group and analysed separately[420, 441], or the DIF item was removed.[420] Non-uniform DIF refers to DIF where the expected values are different across the logit values[420, 429, 441] and may be addressed by deleting the item.[441] Before making any changes, the items were examined to ascertain whether these differences across groups could be explained, in which case no changes were made.

After fitting the data to the model, the raw ordinal scales were transformed into w-scores. Within ConQuest[430], the raw scores were transformed into weighted likelihood estimates (WLE). Weighted likelihood estimates minimise bias, compared with other transformation methods, hence it was selected for this study.[447] The WLEs were exported into Microsoft Excel where they were transformed into w-scores, using the formula $w=9.1024 \times \text{logits} + c$, where c was a constant term.[448] The advantage of w-scores is that they eliminate the need for decimal points and negative values[448]; hence the constant term is selected such that all W-scores are positive.

Results

A total of 111 participants responded to the ERI part of the questionnaire. Data were missing for one participant each for the Reward Items 2, 3, 6 and 7. Females accounted for 47.8% of respondents, and the median age was 44 years (interquartile range 31-54 years). The majority (71.2%) of participants indicated that their main musical employer was a performance organisation, rather than education. The results for the Effort scale are first reported, followed by the Reward scale, and finally the three Reward Sub-scales: perceived job security, esteem, and promotion opportunities.

Effort subscale

For the Effort scale, the data fit the RSM better than the PCM, with AICs of 710 and 716, respectively; hence, the RSM was used. Examining the traditional statistics, all point biserial correlations, mean predicted values and item deltas and thresholds were in ascending order, with the item-rest correlations being 0.64-0.77 and the item-total correlations 0.83-0.90. All weighted fit mean squares, and t-values were within the optimal ranges and the category estimates were in ascending order. Nine participants (8.11%) had data that did not fit the RSM (t-values 2.00-3.91). The results were similar when these participants' data were omitted. There was evidence of local dependency with the residuals for Items 1 and 2 (-0.42), and 2 and 3 (-0.64) being significantly correlated. The scale was well targeted with the mean person location approximating zero logits (Figure 1).

We did not detect any DIF for age, socioeconomic status or organisation type; however there was some evidence of significant DIF for Item 2 for gender (the weighted fit mean square was 1.56, and the t-value was 2.4), however no action was required as the magnitude of the difference was only 0.444 logits.

Reward scale

For the Reward scale, the RSM was a better fit for the data with an AIC of 1735, compared with 1742 for the PCM; hence, the RSM was used. Based on the traditional statistics, the mean predicted values were in ascending order for all items. We detected a potential problem with Item 4, as the point biserial correlations were not in ascending order (-0.17, 0.05, 0.12, 0.03). Item 4 also had the lowest item-total correlation of 0.40, and the lowest item-rest correlation of 0.14.

The Rasch analysis also revealed a potential problem with Item 4 with a weighted fit mean square of 1.64, and t-value of 4.1. The category weighted fit mean squares and t-values were beyond the optimal range, while there were no issues identified with the other items.

Removal of Item 4

The poor weighted fit mean square and t-value, the disordered point biserial correlations, and poor item-rest and item-total correlation for Item 4 supported the omission of this item. Without Item 4, the data were a better fit for the RSM (AIC 1421) compared with the PCM (AIC 1433); hence, the RSM was used. This strategy resulted in slight disordering of the point biserial correlations for Items 1, 4 and 5 (originally Items 1, 5 and 6) which appeared to relate to the small number of participants endorsing the response categories, particularly for the lower response categories. The Rasch analysis indicated that all items fit the RSM. The Wright map indicated the measure was well targeted, with Item 2 being the most difficult item to endorse. There was some local dependency detected between Items 3 and 6 (originally Items 3 and 7), with a correlation of the residuals of 0.451.

Differential item functioning was examined for the Reward scale (without Item 4), with a significant DIF of >0.50 logits, was detected for Items 2 and 6. Differential item functioning for Item 2 related to age and organisation type, and for Item 6 DIF was related to socioeconomic status; all were uniform DIF.

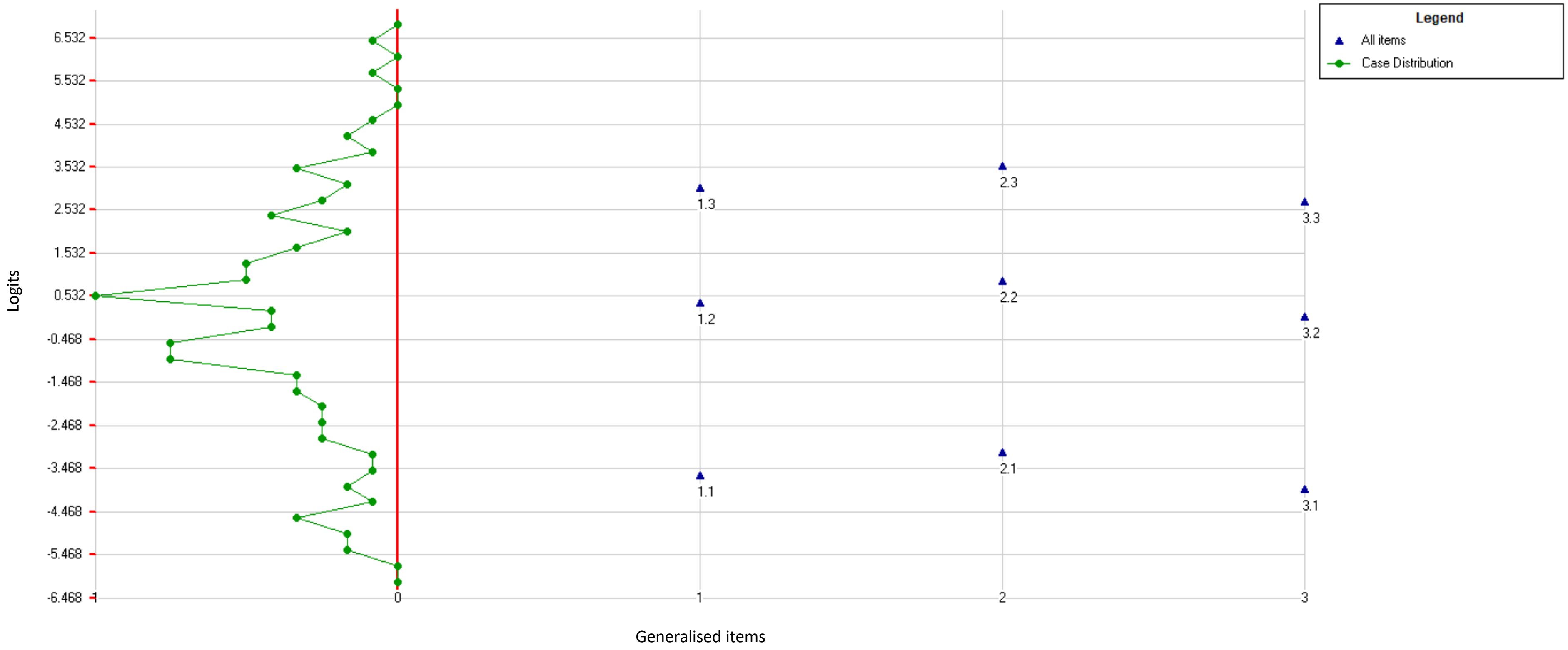


Figure 1: Wright map for the Effort Scale
Notes: The Wright Map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

Removal of Item 2
In an attempt to rectify the identified DIF, Item 2 was removed, such that the scale included Items 1, 3, 5, 6, and 7 of the original scale, as Item 2 had DIF detected for two groups. The RSM was selected over the PCM, owing to the smaller AIC (1176 c.f. 1188). While there was some slight disorder of the point biserial correlations of Items 5 and 7 (original item numbers), all item deltas and thresholds, and average predicted values were in ascending order; hence no further action was taken. Otherwise, the data fit RSM well, as indicated by the weighted fit mean square and corresponding t-values.

The Wright map (Figure 2) indicated that the scale was well targeted, with Item 4 (original Item 6) being the most difficult to endorse, and Item 1 being the easiest. There was a low level of local dependency identified between Items 3 and 5, and Items 3 and 7 (original item numbers), with the residuals being correlated (0.431 and 0.489, respectively). The data of nine participants (8.10%) had t-values of greater than two (2.16-5.55). Removing these nine participants from the analysis, resulted in similar findings. There was no significant DIF of >0.5 logits detected for any of the four sub-group analyses.

Job Security Sub-Scale
For the Job Security Sub-Scale (which included Items 3 and 4 of the Reward Scale) there was little difference in the AICs between the RSM (542) and PCM (540); hence, the RSM was used, as it was a more parsimonious model. Both items fit the RSM well, with appropriate item-rest correlations (0.20) and item-total correlations (0.73-0.81). There was slight disordering of the point biserial correlation for Item 2 (original Reward Item 4; -0.07, -0.22, 0.12, 0.12), however no changes were made as the predicted values, and the item deltas, item thresholds, and item estimates were all in ascending order. The scale exhibited a high degree of local dependency (residual correlation -0.904). The mean person location approximated zero logits (Figure 3), indicating that the scale was well targeted. Data from three participants (2.7%) mis-fit the model (t-values 3.14-3.50). No action was taken given the small percentage, and relatively low t-values. No DIF was detected (Supplementary Material 4).

Esteem Sub-Scale
The Esteem Sub-Scale (Items 1 and 5 of the Reward Scale) data better fit the RSM than the PCM (AIC 433 c.f. 436). The weighted fit mean square and t-values were all within the optimal ranges. There was some disordering of the point biserial correlations for both items (Item 1: -0.42, -0.46, 0.20, 0.37, Item 2: -0.34, -0.47, 0.27, 0.39), however the predicted values, estimates, item deltas and item thresholds were all in ascending order. The item-rest correlations (0.65) and item-total correlations (0.91) were both acceptable. There were three mis-fitting cases (2.7%), and a high degree of local dependency (-0.823). The Wright map indicated that the scale was well targeted (Figure 4). There was no DIF detected.

Promotion Sub-Scale
The data from the Promotion Sub-Scale (Items 2, 6 and 7 of the Reward Scale) fit the RSM better than the PCM (AIC 764 c.f. 769). The data fit the RSM well, although there was some disordering of the point biserial correlation for Item 2 (Item 6 of the Reward Scale; -0.28, -0.31, 0.38, 0.19). The predicted values, estimates, item deltas and item thresholds were however all in ascending order. Significant DIF was detected in Item 1 (Reward Item 2) for age, which was of 0.52 logits. Item 1 (Reward Item 2) was therefore removed from the Promotion Sub-Scale.

After removing Item 1 (Item 2 of the Reward Scale), the data still fit the RSM better than the PCM (AIC 512 c.f. 516). The data of eight participants (7.2%) mis-fit the model, and a high degree of local dependency was detected (-0.924). The scale was, however, well targeted (Figure 5) and no DIF was detected.

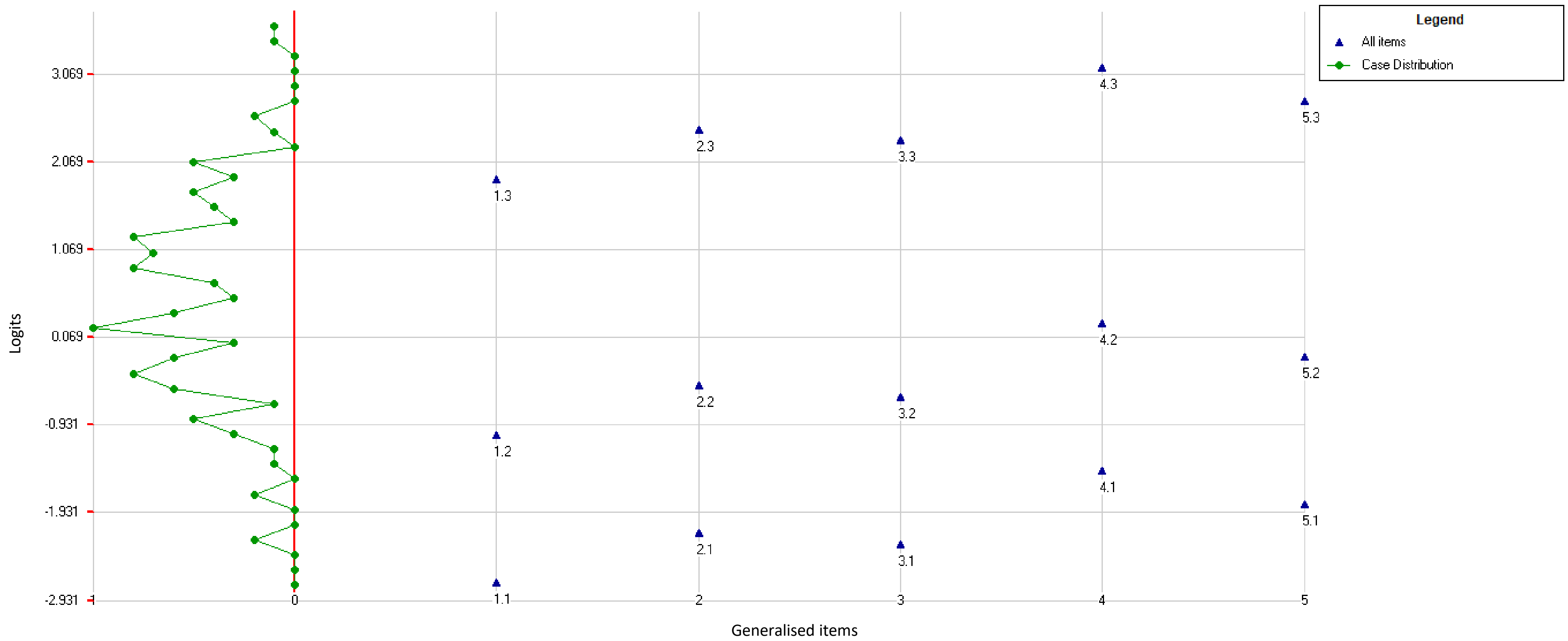


Figure 2: Wright map for the Reward Scale (without Items 2 and 4)
Notes: The Wright Map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

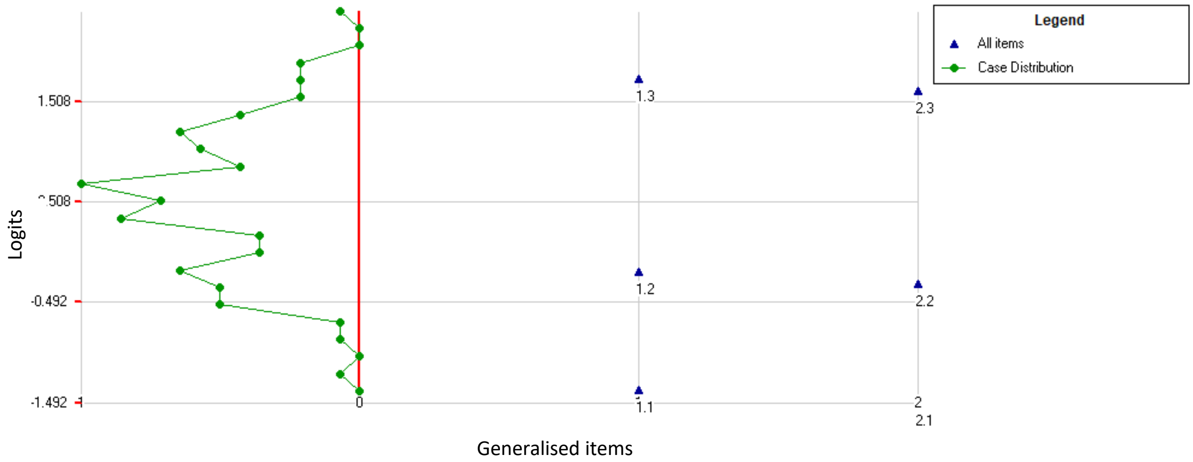


Figure 3: Wright map for the Job Security subscale
Notes: The Wright Map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

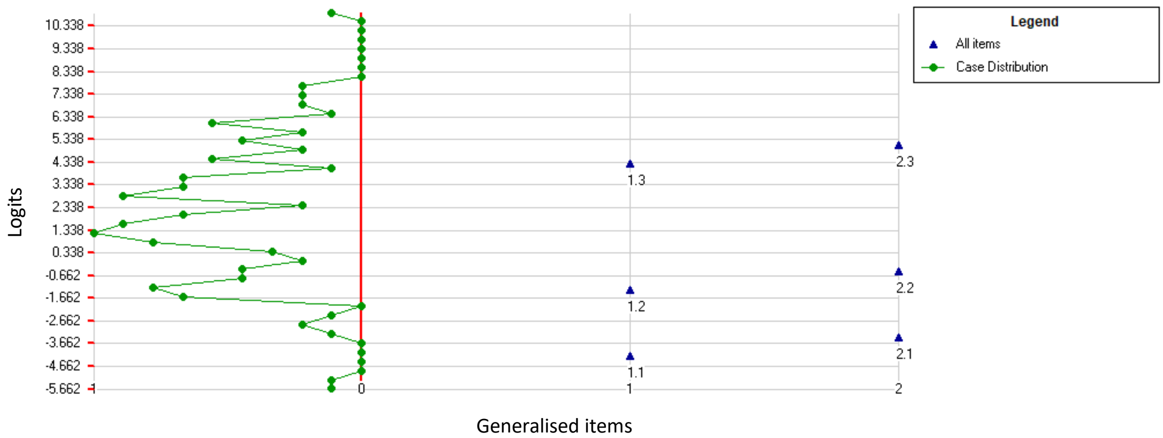


Figure 4: Wright map for the Esteem subscale
Notes: The Wright Map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

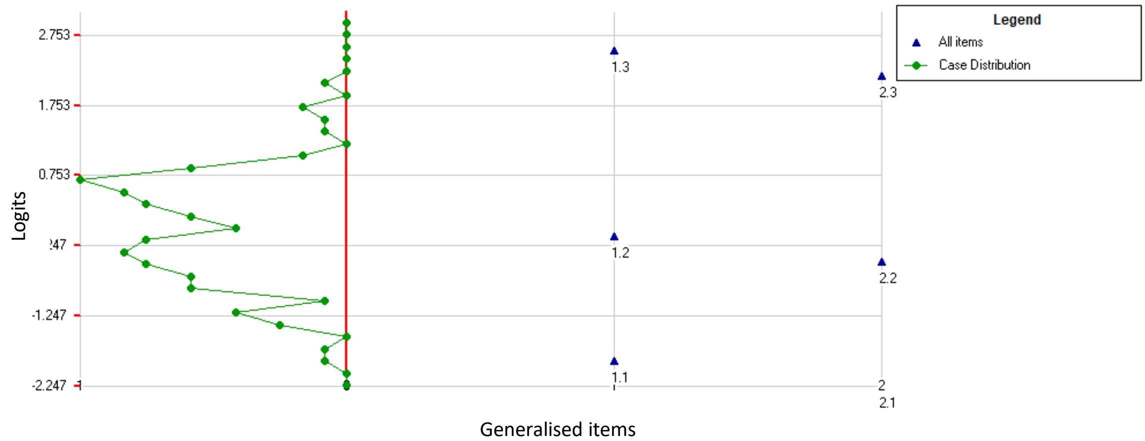


Figure 5: Wright map for the Promotion Opportunities subscale
Notes: The Wright Map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

Transformation of raw scores to w-scores

The raw data from each of the scales were transformed into w-scores (Table 2). The raw scores in Table 2 refer to the scores following modifications to the scale (i.e. Items 2 and 4 removed from the Reward Scale, and Item 1 (original Item 2) removed from the Promotion Sub-Scale.

Discussion

Our study was the first to use Rasch analysis to examine the utility of the short version of the ERI Questionnaire.[380, 388] For use with employed professional musicians, the data for Effort scale from the short version of the ERI Questionnaire fit the RSM well, however, there was some evidence of local dependency between Items 1 and 2, and Items 2 and 3 as the residuals for these items were significantly correlated. Local dependency is more likely where the scale has fewer items; hence the Effort scale from the original ERI Questionnaire[358] may be more appropriate, and should be examined in future studies. We did not detect any DIF for the scale with regards to age, gender, socioeconomic status, and the type of employer.

For the Reward Scale, Items 2 and 4 were ultimately removed in order to improve this scale. Item 4 was flagged as mis-fitting and also had disordered point biserial correlations, as well as relatively low item-total and item-rest correlations, while Item 2 exhibited significant DIF for age and organisation type (after removing Item 4), and was subsequently removed. These modifications to the scale resulted in a measure that fit the Rasch model, was well-targeted, and did not exhibit significant DIF of sufficient magnitude (i.e. >0.50 logits).

The three sub-scales of Reward were also examined: Promotion Opportunities, Esteem and job security. For the Promotion Opportunities sub-scale, Item 2 (Item 6 of the original Reward scale) had to be removed. Otherwise, the three scales fit the RSM well, with no DIF detected. Each of the scales exhibited degree of local dependency, as would be anticipated with short measures like these.

Although our findings are only of direct applicability to employed professional musicians, they highlight the importance of using modern psychometric methods to examine the utility of scales that combine (sum, average) scores from items. While the existing evidence indicated that the short version of the ERI questionnaire had good validity and reliability[380, 388, 390], we identified issues in the Reward Scale that had not previously been detected. It is possible that using the raw scores from the seven items and four response categories, may have altered the results of our broader study, and the recommendations based on our findings. The transformation of the ordinal, raw scores from both scales to interval level W-scores, provides the advantage of using parametric statistics, and of being able to use these scales to examine changes over time (e.g. in trials), which cannot be validly performed with ordinal scores.

Conclusion

Our study highlights the need for modern psychometric methods to be applied to any scales where the item scores are combined, such as the short version of the ERI Questionnaire. For use with employed professional musicians, the Effort Scale fit the RSM and there was no DIF detected, whereas Items 2 and 4 from the Reward Scale had to be omitted, in order to fit the RSM and to address DIF. The changes made to the Reward Scale ensures that it has the utility required to make valid inferences from the data. The transformation from the raw, ordinal scales for both scales, to interval-level, W-scores allows the measures to be used to examine changes in these outcomes over time, for example in trials, as well as the use of parametric statistics, which have greater power than the non-parametric scales required for ordinal scales. Research into ERI of employed professional musicians, should use the W-scores rather than the raw scores.

Table 2: Transformation of raw scores to W-scores for the Effort Scale, Reward Scale, and the three Reward Sub-Scales

Raw score	Effort		Reward		Job Security		Promotion Opportunities		Esteem	
	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score	Weighted likelihood estimate (standard error)	W-score
0	-5.54 (1.76)	5	-4.34 (1.53)	5	-2.56 (1.49)	2	-3.42 (1.69)	1	-5.39 (1.87)	4
1	-4.07 (1.18)	18	-3.13 (0.93)	17	-1.45 (0.97)	12	-2.03 (1.10)	16	-3.73 (1.29)	17
2	-3.01 (1.13)	28	-2.50 (0.76)	22	-0.80 (0.86)	18	-1.14 (0.99)	29	-2.34 (1.22)	25
3	-1.50 (1.23)	36	-2.02 (0.68)	27	-0.19 (0.86)	23	-0.28 (1.02)	41	-0.95 (1.28)	32
4	-0.05 (1.05)	55	-1.62 (0.64)	30	0.54 (0.95)	30	0.90 (1.14)	59	0.95 (1.86)	43
5	0.88 (0.97)	63	-1.25 (0.63)	34	1.57 (1.13)	39	2.28 (1.26)	93	4.68 (1.43)	56
6	1.77 (0.96)	71	-0.88 (0.63)	37	3.09 (1.75)	53	3.88 (1.83)	108	6.39 (1.94)	70
7	2.65 (0.99)	79	-0.50 (0.64)	40						
8	3.59 (1.12)	88	-0.09 (0.67)	44						
9	5.03 (1.71)	101	0.40 (0.72)	49						
10			0.97 (0.76)	54						
11			1.59 (0.79)	59						
12			2.22 (0.81)	65						
13			2.86 (0.87)	71						
14			3.63 (1.02)	78						
15			4.95 (1.62)	90						

Supplementary Material 1

Effort scale

Table S1: Traditional statistics for the Effort scale

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	13 (11.71)	-0.60	-7.87***	-5.019±1.783	0.77	0.90
	1	52 (46.85)	-0.18	-1.91	-1.032±1.465		
	2	31 (27.93)	0.20	2.13*	0.724±1.337		
	3	15 (13.51)	0.57	7.19***	3.617±1.845		
2	0	19 (17.12)	-0.45	-5.28***	-3.447±2.968	0.64	0.83
	1	51 (45.95)	-0.13	-1.35	-0.964±1.368		
	2	30 (27.03)	0.19	2.00*	0.964±1.600		
	3	11 (9.91)	0.50	6.06***	4.007±1.908		
3	0	14 (12.61)	-0.51	-6.13***	-4.605±2.010	0.71	0.88
	1	43 (38.74)	-0.23	-2.46*	-1.392±1.485		
	2	36 (32.43)	0.17	1.79	0.684±1.217		
	3	18 (16.22)	0.54	6.78***	3.195±1.974		

Notes: Mean ± standard deviation: 4.25 ± 2.31, variance: 5.35, skewness: 0.18, kurtosis: -0.16, standard error of mean: 0.22, standard error of measurement: 0.92, coefficient alpha: 0.84. *p<0.05, **p<0.01, ***p<0.001

Table S2: Rasch analysis statistics for the Effort scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	-0.059	0.150	0.84 (0.74-1.26)	-1.2	0.92 (0.73-1.27)	-0.6	-3.59, 0.43, 2.98	-3.61, 0.38, 3.05
Item 2	0.449	0.157	1.13 (0.74-1.26)	1.0	1.18 (0.73-1.27)	1.2	-3.10, 0.89, 3.56	-3.09, 0.94, 3.49
Item 3	-0.390	0.153	0.98 (0.74-1.26)	-0.1	1.07 (0.73-1.27)	0.5	-3.94, 0.05, 2.72	-3.93, 0.10, 2.65
Category 0			3.81 (0.74-1.26)	12.6	1.32 (0.55-1.45)	1.3		
Category 1	-3.535	0.363	1.06 (0.74-1.26)	0.5	1.19 (0.74-1.26)	1.3		
Category 2	0.493	0.182	1.42 (0.74-1.26)	2.8	1.06 (0.73-1.27)	0.5		
Category 3	3.042		0.84 (0.74-1.26)	-1.2	1.12 (0.55-1.45)	0.5		

Notes: Separation reliability 0.818, chi-square test of parameter equality (2) = 8.35, p=0.015

Table S3: Differential item functioning statistics for the Effort scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Separation reliability	Chi-square test of parameter equality (2)	p-value
Gender	Female	1	-0.195	0.153	0.78 (0.59-1.41)	-1.1	0.727	3.67	0.160
		2	0.222	0.155	1.56 (0.59-1.41)	2.4			
		3	-0.027	0.150	1.05 (0.60-1.40)	0.3			
	Male	1	0.195	0.153	0.84 (0.62-1.38)	-0.9			
		2	-0.222	0.155	0.89 (0.62-1.38)	-0.5			
		3	0.027	0.150	0.91 (0.63-1.37)	-0.4			
Age	18-44 years	1	0.072	0.151	0.92 (0.60-1.40)	-0.4	0.000	0.40	0.819
		2	-0.063	0.151	1.15 (0.60-1.40)	0.7			
		3	-0.008	0.148	1.05 (0.63-1.37)	0.2			
	>44 years	1	-0.072	0.151	0.80 (0.61-1.39)	-1.0			
		2	0.063	0.151	1.14 (0.60-1.40)	0.7			
		3	0.008	0.148	0.95 (0.62-1.38)	-0.2			
Socioeconomic status	Lower	1	0.046	0.153	0.95 (0.61-1.39)	-0.2	0.000	1.74	0.419
		2	0.197	0.153	1.18 (0.62-1.38)	0.9			
		3	-0.242	0.153	1.25 (0.63-1.37)	1.3			
	Higher	1	-0.046	0.153	0.81 (0.59-1.41)	-1.0			
		2	-0.197	0.153	1.10 (0.60-1.40)	0.5			
		3	0.242	0.153	0.80 (0.60-1.40)	-1.0			
Type of organisation	Education	1	-0.081	0.171	0.83 (0.49-1.51)	-0.6	0.000	0.56	0.758
		2	-0.099	0.172	0.97 (0.50-1.50)	-0.1			
		3	0.180	0.168	0.93 (0.50-1.50)	-0.3			
	Performance	1	0.081	0.171	0.92 (0.68-1.32)	-0.5			
		2	0.099	0.172	1.21 (0.68-1.32)	1.2			
		3	-0.180	0.168	1.05 (0.69-1.31)	0.3			

Reward scale

Table 4: Traditional statistics for the Reward scale

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	5 (4.50)	-0.38	-4.35***	-1.411±0.781	0.64	0.77
	1	18 (16.22)	-0.34	-3.77***	-0.514±0.589		
	2	62 (55.86)	0.01	0.13	0.192±0.625		
	3	26 (23.42)	0.47	5.56***	0.996±0.877		
2	0	26 (23.64)	-0.35	-3.88***	-0.486±0.831	0.51	0.69
	1	42 (38.18)	-0.12	-1.23	0.002±0.557		
	2	34 (30.91)	0.24	2.55*	0.632±0.583		
	3	8 (7.27)	0.37	4.13***	1.638±1.282		
3	0	7 (6.36)	-0.32	-3.46**	-1.099±0.907	0.38	0.56
	1	27 (24.55)	-0.12	-1.30	-0.028±0.728		
	2	60 (54.55)	0.09	0.93	0.259±0.745		
	3	16 (14.55)	0.24	2.62*	0.933±1.031		
4	0	11 (9.91)	-0.17	-1.84	-0.444±1.128	0.14	0.40
	1	24 (21.62)	-0.05	-0.56	-0.110±0.753		
	2	48 (43.24)	0.12	1.29	0.276±0.719		
	3	28 (25.23)	0.03	0.32	0.563±1.039		
5	0	7 (6.31)	-0.34	-3.74***	-1.010±0.917	0.54	0.70
	1	21 (18.92)	-0.34	-3.74***	-0.463±0.679		
	2	68 (61.26)	0.24	2.54*	0.349±0.613		
	3	15 (13.51)	0.29	3.15**	0.972±1.214		
6	0	13 (11.82)	-0.32	-3.45**	-0.619±0.875	0.57	0.71
	1	38 (34.55)	-0.30	-3.27**	-0.204±0.691		
	2	52 (47.27)	0.29	3.16**	0.482±0.593		
	3	7 (6.36)	0.41	4.63***	1.824±1.091		
7	0	9 (8.18)	-0.16	-1.66	-0.597±0.847	0.25	0.46
	1	35 (31.82)	-0.14	-1.49	-0.058±0.713		
	2	53 (48.18)	0.11	1.20	0.281±0.704		
	3	13 (11.82)	0.16	1.70	1.017±1.409		

Notes: Mean ± standard deviation: 11.75±3.45, variance: 11.89, skewness: -0.07, kurtosis: 1.10, standard error of mean: 0.33, standard error of measurement: 1.91, coefficient alpha: 0.69. *p<0.05, **p<0.01, ***p<0.001

Table 5: Rasch analysis statistics for the Reward scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	-0.650	0.138	0.78 (0.74-1.26)	-1.7	0.80 (0.73-1.27)	-1.5	-2.16, -1.15, 1.36	-2.42, -0.97, 1.43
Item 2	0.921	0.132	1.03 (0.74-1.26)	0.3	1.00 (0.77-1.23)	0.1	-0.59, 0.43, 2.93	-0.85, 0.60, 3.01
Item 3	-0.175	0.129	0.97 (0.74-1.26)	-0.2	0.97 (0.74-1.26)	-0.2	-1.69, -0.67, 1.83	-1.94, -0.50, 1.91
Item 4	-0.323	0.131	1.59 (0.74-1.26)	3.8	1.64 (0.74-1.26)	4.1	-1.84, -0.82, 1.69	-2.09, -0.65, 1.76
Item 5	-0.284	0.130	0.72 (0.74-1.26)	-2.2	0.75 (0.74-1.26)	-2.0	-1.80, -0.78, 1.73	-2.05, -0.61, 1.80
Item 6	0.416	0.126	0.77 (0.74-1.26)	-1.8	0.77 (0.76-1.24)	-2.0	-1.10, -0.08, 2.43	-1.35, 0.09, 2.50
Item 7	0.095	0.126	1.13 (0.74-1.26)	0.9	1.14 (0.75-1.25)	1.1	-1.42, -0.40, 2.11	-1.67, -0.23, 2.18
Category 0			1.56 (0.74-1.26)	3.6	1.58 (0.65-1.35)	2.8		
Category 1	-1.514	0.139	1.47 (0.74-1.26)	3.1	1.57 (0.74-1.26)	3.6		
Category 2	-0.496	0.102	1.95 (0.74-1.26)	5.6	1.99 (0.75-1.25)	6.1		
Category 3	2.010		2.41 (0.74-1.26)	7.6	1.96 (0.68-1.32)	4.7		

Notes: Separation reliability 0.948, chi-square test of parameter equality (6) = 94.44, p<0.001

Reward scale without Item 4

Table S6: Traditional statistics for the Reward scale with Item 4 omitted

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	5 (4.50)	-0.32	-3.54**	-1.966±0.952	0.62	0.76
	1	18 (16.22)	-0.36	-4.09***	-0.776±0.581		
	2	62 (55.86)	0.00	0.02	0.270±0.785		
	3	26 (23.42)	0.47	5.60***	1.278±1.280		
2	0	26 (23.64)	-0.40	-4.56***	-0.658±1.066	0.53	0.72
	1	42 (38.18)	-0.07	-0.77	0.004±0.841		
	2	34 (30.91)	0.24	2.58*	0.773±0.816		
	3	8 (7.27)	0.37	4.09***	2.136±1.581		
3	0	7 (6.36)	-0.29	-3.14**	-1.556±1.047	0.35	0.55
	1	27 (24.55)	-0.12	-1.24	-0.223±0.747		
	2	60 (54.55)	0.09	0.96	0.361±0.949		
	3	16 (14.55)	0.22	2.30*	1.358±1.532		
4	0	7 (6.31)	-0.34	-3.72***	-1.341±1.272	0.57	0.73
	1	21 (18.92)	-0.40	-4.49***	-0.888±0.536		
	2	68 (61.26)	0.29	3.13**	0.527±0.850		
	3	15 (13.51)	0.28	3.07**	1.223±1.482		
5	0	13 (11.82)	-0.36	-3.97***	-1.036±1.044	0.59	0.74
	1	38 (34.55)	-0.31	-3.43**	-0.378±0.701		
	2	52 (47.27)	0.36	3.99***	0.750±0.883		
	3	7 (6.36)	0.35	3.89***	2.181±1.416		
6	0	9 (8.18)	-0.21	-2.28*	-0.801±1.052	0.30	0.52
	1	35 (31.82)	-0.17	-1.74	-0.292±0.900		
	2	53 (48.18)	0.16	1.66	0.539±0.972		
	3	13 (11.82)	0.18	1.86	1.122±1.798		

Notes: the item numbers refer to original Items 1, 2, 3, 5, 6, 7. Mean ± standard deviation: 9.92±3.18, variance: 10.14, skewness: -0.16, kurtosis: 0.83, standard error of mean: 0.30, standard error of measurement: 1.69, coefficient alpha: 0.72. *p<0.05, **p<0.01, ***p<0.001

Table S7: Rasch analysis statistics for the Reward scale without Item 4

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	-0.831	0.151	0.88 (0.74-1.26)	-0.9	0.91 (0.72-1.28)	-0.6	-2.71, -1.37, 1.59	-2.91, -1.23, 1.64
Item 2	1.022	0.144	1.05 (0.74-1.26)	0.4	1.06 (0.76-1.24)	0.5	-0.86, 0.48, 3.44	-1.06, 0.63, 3.49
Item 3	-0.274	0.139	1.24 (0.74-1.26)	1.7	1.24 (0.73-1.27)	1.6	-2.15, -0.82, 2.15	-2.35, -0.67, 2.20
Item 4	-0.396	0.141	0.77 (0.74-1.26)	-1.8	0.81 (0.73-1.27)	-1.4	-2.28, -0.94, 2.03	-2.47, -0.79, 2.07
Item 5	0.427	0.136	0.79 (0.74-1.26)	-1.6	0.82 (0.75-1.25)	-1.5	-1.45, -0.11, 2.85	-1.65, 0.03, 2.90
Item 6	0.052	0.136	1.15 (0.74-1.26)	1.1	1.20 (0.74-1.26)	1.4	-1.83, -0.49, 2.47	-2.02, -0.34, 2.52
Category 0			2.76 (0.74-1.26)	9.1	1.32 (0.63-1.37)	1.6		
Category 1	-1.880	0.167	1.30 (0.74-1.26)	2.1	1.41 (0.73-1.27)	2.7		
Category 2	-0.541	0.112	1.61 (0.74-1.26)	3.9	1.64 (0.75-1.25)	4.3		
Category 3	2.422		2.15 (0.74-1.26)	6.5	1.58 (0.66-1.34)	2.9		

Notes: Item numbers refer to the original Items 1, 2, 3, 5, 6, 7. Separation reliability 0.962, chi-square test of parameter equality (5) = 101.88, p<0.001

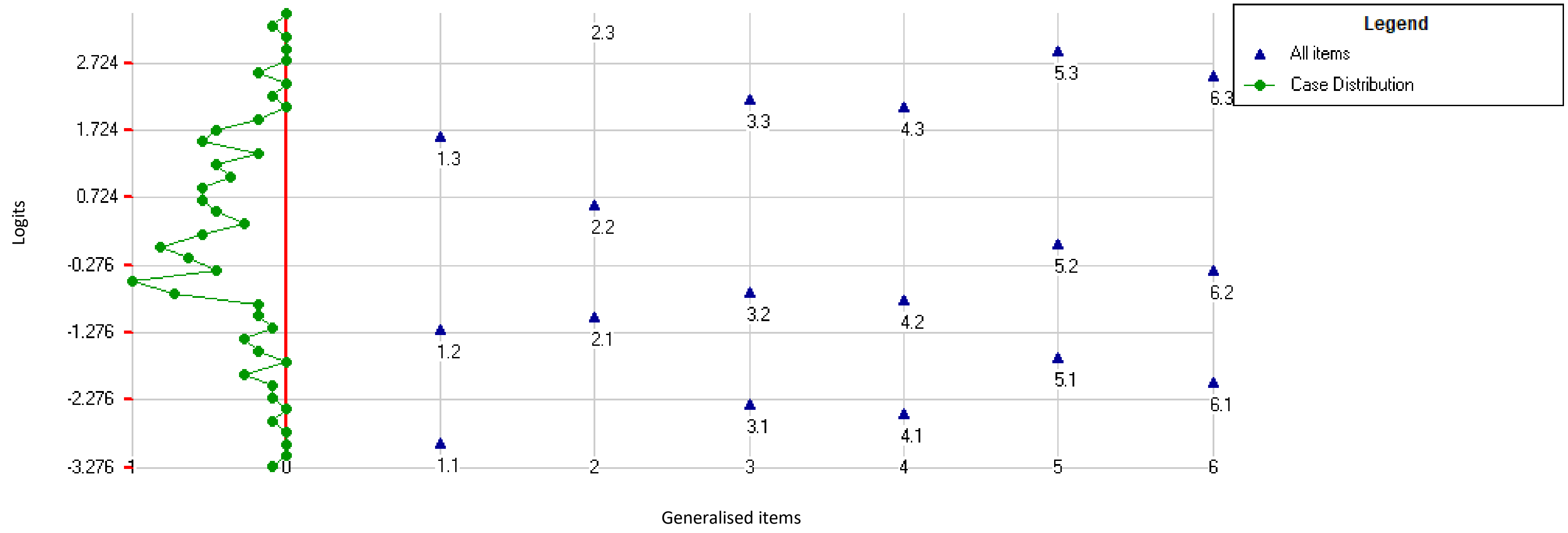


Figure S1: Wright map for the Reward scale (without Item 4)

Notes: The Wright map represents the Thurstonian Thresholds and Case Latent Distribution. MML estimation, Gaussian distribution

Table S8: Differential item functioning statistics for the Reward scale (without Item 4)

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Separation reliability	Chi-square test of parameter equality (5)	p-value
Gender	Female	1	-0.152	0.141	0.78 (0.61-1.39)	-1.2	0.129	4.59	0.468
		2	0.113	0.131	1.03 (0.65-1.35)	0.2			
		3	-0.108	0.140	1.22 (0.62-1.38)	1.1			
		4	-0.038	0.144	0.77 (0.60-1.40)	-1.2			
		5	0.201	0.142	0.77 (0.65-1.35)	-1.3			
		6	-0.016	0.137	1.36 (0.63-1.37)	1.8			
	Male	1	0.152	0.141	0.94 (0.61-1.39)	-0.2			
		2	-0.113	0.131	1.00 (0.66-1.34)	0.0			
		3	0.108	0.140	1.12 (0.62-1.38)	0.6			
		4	0.038	0.144	0.96 (0.59-1.41)	-0.2			
		5	-0.201	0.142	1.08 (0.64-1.36)	0.5			
		6	0.016	0.137	1.11 (0.64-1.36)	0.6			
Age	18-44 years	1	0.030	0.142	0.75 (0.61-1.39)	-1.3	1.85	5.16	0.397
		2	-0.288	0.140	0.83 (0.66-1.34)	-1.0			
		3	0.123	0.140	1.10 (0.63-1.37)	0.5			
		4	-0.011	0.147	0.78 (0.59-1.41)	-1.1			
		5	0.041	0.140	0.63 (0.64-136)	-2.3			
		6	0.105	0.138	1.18 (0.64-1.36)	1.0			
	>44 years	1	-0.030	0.142	0.95 (0.60-1.40)	-0.2			
		2	0.288	0.140	1.24 (0.64-1.36)	1.3			
		3	-0.123	0.140	1.24 (0.62-1.38)	1.2			
		4	0.011	0.147	0.99 (0.61-1.39)	0.0			
		5	-0.041	0.140	1.15 (0.65-1.35)	0.8			
		6	-0.105	0.138	1.27 (0.64-1.36)	1.4			
Socioeconomic status	Lower	1	0.075	0.141	1.03 (0.61-1.39)	0.2	0.000	1.76	0.882
		2	0.066	0.129	1.00 (0.67-1.33)	0.1			
		3	0.113	0.140	1.33 (0.63-1.37)	1.7			
		4	0.104	0.144	0.79 (0.60-1.40)	-1.0			
		5	-0.021	0.139	0.81 (0.65-1.35)	-1.1			
		6	-0.338	0.145	1.11 (0.64-1.36)	0.6			
	Higher	1	-0.075	0.141	0.71 (0.60-1.40)	-1.5			
		2	-0.066	0.129	0.93 (0.64-1.36)	-0.3			
		3	-0.113	0.140	1.07 (0.61-1.39)	0.4			
		4	-0.104	0.144	1.05 (0.58-1.42)	0.3			
		5	0.021	0.139	1.05 (0.63-1.37)	0.3			
		6	0.338	0.145	1.32 (0.63-1.37)	1.6			*(continued)*

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Separation reliability	Chi-square test of parameter equality (5)	p-value
Type of organisation	Education	1	0.119	0.156	1.24 (0.48-1.52)	0.9	0.382	7.11	0.213
		2	-0.326	0.144	0.92 (0.54-1.46)	-0.3			
		3	0.147	0.156	1.23 (0.51-1.49)	0.9			
		4	0.070	0.159	0.90 (0.47-1.53)	-0.3			
		5	-0.083	0.153	0.70 (0.53-1.47)	-1.4			
		6	0.075	0.153	1.30 (0.53-1.47)	1.2			
				0.156	0.70 (0.67-1.33)	-2.0			
	Performance	1	-0.119	0.144	0.98 (0.72-1.28)	-0.1			
		2	0.326	0.156	1.13 (0.68-1.32)	0.8			
		3	-0.147	0.159	0.92 (0.65-1.35)	-0.4			
		4	-0.070	0.153	0.92 (0.70-1.30)	-0.5			
		5	0.083	0.153	1.23 (0.69-1.31)	1.4			
		6	-0.075						

Reward scale without Items 2 and 4

Table S9: Traditional statistics for the Reward scale with Items 2 and 4 omitted

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	5 (4.50)	-0.37	-4.16***	-1.478±1.304	0.65	0.80
	1	18 (16.22)	-0.36	-4.08***	-0.283±0.573		
	2	62 (55.86)	0.02	0.16	0.310±0.800		
	3	26 (23.42)	0.48	5.71***	1.562±0.867		
2	0	7 (6.36)	-0.25	-2.72**	-0.682±1.658	0.31	0.56
	1	27 (24.55)	-0.10	-1.07	-0.146±0.844		
	2	60 (54.55)	0.07	0.69	0.549±0.842		
	3	16 (14.55)	0.21	2.19*	1.425±1.170		
3	0	7 (6.31)	-0.30	-3.24**	-1.231±1.034	0.57	0.76
	1	21 (18.92)	-0.45	-5.32***	-0.342±0.749		
	2	68 (61.26)	0.32	3.49**	0.604±0.833		
	3	15 (13.51)	0.28	3.03**	1.472±1.115		
4	0	13 (11.82)	-0.32	-3.49**	-0.660±1.232	0.55	0.74
	1	38 (34.55)	-0.27	-2.96**	-0.007±0.759		
	2	52 (47.27)	0.28	3.04**	0.812±0.819		
	3	7 (6.36)	0.38	4.27***	1.944±1.395		
5	0	9 (8.18)	-0.20	-2.17*	-0.664±0.958	0.26	0.53
	1	35 (31.82)	-0.15	-1.57	-0.095±0.905		
	2	53 (48.18)	0.18	1.85	0.737±0.861		
	3	13 (11.82)	0.12	1.23	0.1258±1.383		

Notes: the item numbers refer to original Items 1, 3, 5, 6, 7. Mean ± standard deviation: 8.70±2.62, variance: 6.88, skewness: -0.30, kurtosis: 0.86, standard error of mean: 0.25, standard error of measurement: 1.50, coefficient alpha: 0.67. *p<0.05, **p<0.01, ***p<0.001

Table S10: Rasch analysis statistics for the Reward scale without Items 2 and 4

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	-0.634	0.147	0.88 (0.74-1.26)	-0.9	0.91 (0.73-1.27)	-0.7	-2.53, -1.20, 1.83	-2.73, -1.05, 1.87
Item 2	-0.070	0.137	1.15 (0.74-1.26)	1.1	1.17 (0.73-1.27)	1.2	-1.97, -0.63, 2.39	-2.17, -0.48, 2.44
Item 3	-0.194	0.138	0.81 (0.74-1.26)	-1.5	0.84 (0.73-1.27)	-1.2	-2.09, -0.76, 2.27	-2.29, -0.61, 2.31
Item 4	0.637	0.138	0.85 (0.74-1.26)	-1.1	0.85 (0.75-1.25)	-1.3	-1.26, 0.07, 3.10	-1.46, 0.22, 3.14
Item 5	0.261	0.135	1.22 (0.74-1.26)	1.6	1.24 (0.74-1.26)	1.7	-1.64, -0.30, 2.72	-1.83, -0.15, 2.77
Category 0			1.86 (0.74-1.26)	5.2	1.37 (0.58-1.42)	1.6		
Category 1	-1.897	0.194	1.15 (0.74-1.26)	1.1	1.27 (0.73-1.27)	1.8		
Category 2	-0.563	0.126	1.61 (0.74-1.26)	3.9	1.65 (0.76-1.24)	4.4		
Category 3	2.46		2.00 (0.74-1.26)	5.9	1.63 (0.67-1.33)	3.1		

Notes: Item numbers refer to the original Items 1, 3, 5, 6, 7. Separation reliability 0.929, chi-square test of parameter equality (4) = 42.00, p<0.001

Table S11: Differential item functioning statistics for the Reward scale without Items 2 and 4

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Separation reliability	Chi-square test of parameter equality (4)	p-value
Gender	Female	1	-0.125	0.137	0.75 (0.61-1.39)	-1.3	0.186	3.68	0.450
		2	-0.085	0.136	1.31 (0.62-1.38)	1.5			
		3	-0.011	0.140	0.85 (0.59-1.41)	-0.7			
		4	0.218	0.139	0.81 (0.65-1.35)	-1.1			
		5	0.002	0.134	1.29 (0.63-1.37)	1.5			
	Male	1	0.125	0.137	0.86 (0.62-1.38)	-0.7			
		2	0.085	0.136	0.99 (0.63-1.37)	0.0			
		3	0.011	0.140	1.02 (0.60-1.40)	0.2			
		4	-0.218	0.139	0.99 (0.64-1.36)	0.0			
		5	-0.002	0.134	1.22 (0.64-1.36)	1.2			
Age	18-44 years	1	-0.026	0.139	0.83 (0.61-1.39)	-0.8	0.000	0.50	0.974
		2	0.065	0.137	1.12 (0.63-1.37)	0.7			
		3	-0.067	0.143	0.77 (0.59-1.41)	-1.1			
		4	-0.018	0.137	0.76 (0.64-1.36)	-1.4			
		5	0.046	0.135	1.06 (0.64-1.36)	0.4			
	>44 years	1	0.026	0.139	0.89 (0.60-1.40)	-0.5			
		2	-0.065	0.137	1.26 (0.62-1.38)	1.3			
		3	0.067	0.143	0.99 (0.60-1.40)	0.0			
		4	0.018	0.137	1.10 (0.65-1.35)	0.6			
		5	-0.046	0.135	1.38 (0.64-1.36)	1.9			
Socioeconomic status	Lower	1	0.053	0.152	1.10 (0.49-1.51)	0.5	0.000	1.36	0.851
		2	0.080	0.151	1.29 (0.52-1.48)	1.1			
		3	0.004	0.154	0.84 (0.48-1.52)	-0.6			
		4	-0.146	0.149	0.66 (0.53-1.47)	-1.6			
		5	0.009	0.149	1.22 (0.53-1.47)	0.9			
	Higher	1	-0.053	0.152	0.65 (0.67-1.33)	-2.3			
		2	-0.080	0.151	1.11 (0.68-1.32)	0.7			
		3	-0.004	0.154	0.89 (0.65-1.35)	-0.6			
		4	0.146	0.149	1.01 (0.70-1.30)	0.1			
		5	-0.009	0.149	1.25 (0.69-1.31)	1.5			
Type of organisation	Education	1	0.053	0.152	1.07 (0.50-1.50)	0.3	0.000	1.36	0.851
		2	0.080	0.151	1.42 (0.52-1.48)	1.6			
		3	0.004	0.154	0.82 (0.48-1.52)	-0.7			
		4	-0.146	0.149	0.75 (0.53-1.47)	-1.1			
		5	0.009	0.149	1.24 (0.53-1.47)	1.0			
	Performance	1	-0.053	0.152	0.71 (0.67-1.33)	-1.9			
		2	-0.080	0.151	1.17 (0.68-1.32)	1.0			
		3	-0.004	0.154	0.90 (0.66-1.34)	-0.6			
		4	0.146	0.149	0.99 (0.70-1.30)	0.0			
		5	-0.009	0.149	1.20 (0.70-1.30)	1.3			

Job Security sub-scale

Table S12: Traditional statistics for the Job Security sub-scale

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	7 (6.36)	-0.16	-1.73	-0.557±0.383	0.20	0.73
	1	27 (24.55)	-0.05	-0.50	-0.003±0.700		
	2	60 (54.55)	0.01	0.15	0.432±0.552		
	3	16 (14.55)	0.15	1.60	1.075±0.492		
2	0	10 (9.09)	-0.07	-0.74	-0.308±0.591	0.20	0.81
	1	24 (21.82)	-0.22	-2.29*	-0.012±0.623		
	2	48 (43.64)	0.12	1.22	0.455±0.584		
	3	28 (25.45)	0.12	1.24	0.725±0.707		

Notes: Mean ± standard deviation: 3.59±1.34, variance: 1.81, skewness: -0.45, kurtosis: 0.21, standard error of mean: 0.13, standard error of measurement: 1.06, coefficient alpha: 0.37. *p<0.05, **p<0.01, ***p<0.001

Table S13: Rasch analysis statistics for the Job Security sub-scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	0.060	0.090	0.89 (0.74-1.26)	-0.8	0.87 (0.75-1.25)	-1.0	-1.04, -0.39, 1.61	-1.37, -0.19, 1.73
Item 2	-0.060	0.090	1.15 (0.74-1.26)	1.1	1.17 (0.75-1.25)	1.3	-1.16, -0.51, 1.49	-1.49, -0.31, 1.61
Category 0			1.11 (0.74-1.26)	0.8	1.04 (0.56-1.44)	0.2		
Category 1	-1.099	0.292	1.18 (0.74-1.26)	1.3	1.20 (0.74-1.26)	1.5		
Category 2	-0.454	0.194	1.37 (0.74-1.26)	2.5	1.39 (0.81-1.19)	3.6		
Category 3	1.553		1.27 (0.74-1.26)	1.9	1.26 (0.72-1.28)	1.7		

Notes: Chi-square test of parameter equality (1) = 0.45

Table S14: Differential item functioning statistics for the Job Security sub-scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	0.098	0.092	1.15 (0.63-1.37)	0.8	1.13
		2	-0.098	0.092	0.95 (0.65-1.35)	-0.2	
	Male	1	-0.098	0.092	0.88 (0.63-1.37)	-0.6	
		2	0.098	0.092	1.09 (0.67-1.33)	0.5	
Age	18-44 years	1	0.021	0.091	0.95 (0.63-1.37)	-0.2	0.05
		2	-0.021	0.091	0.73 (0.66-1.34)	-1.6	
	>44 years	1	-0.021	0.091	1.07 (0.63-1.37)	0.4	
		2	0.021	0.091	1.21 (0.66-1.34)	1.2	
Socioeconomic status	Lower	1	0.066	0.091	1.09 (0.64-1.36)	0.5	0.51
		2	-0.066	0.091	0.95 (0.66-1.34)	-0.2	
	Higher	1	-0.066	0.091	0.86 (0.62-1.38)	-0.7	
		2	0.066	0.091	1.03 (0.67-1.33)	0.2	
Type of organisation	Education	1	0.196	0.105	1.07 (0.54-1.46)	0.4	3.5
		2	-0.196	0.105	1.09 (0.54-1.46)	0.4	
	Performance	1	-0.196	0.105	0.98 (0.68-1.32)	-0.1	
		2	0.196	0.105	0.93 (0.72-1.28)	-0.5	

Esteem sub-scale

Table S15: Traditional statistics for the Esteem sub-scale

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	5 (4.5)	-0.42	-4.80***	-3.147±0.676	0.65	0.91
	1	18 (16.22)	-0.46	-5.35****	-2.051±1.212		
	2	62 (55.86)	0.20	2.14*	1.590±1.536		
	3	26 (23.42)	0.37	4.10***	4.723±1.892		
2	0	7 (6.31)	-0.34	-3.72***	-2.508±1.744	0.65	0.91
	1	21 (18.92)	-0.47	-5.61***	-1.616±1.591		
	2	68 (61.26)	0.27	2.97**	2.126±1.728		
	3	15 (13.51)	0.39	4.44***	5.046±2.156		

Notes: Mean ± standard deviation: 3.80±1.37, variance: 1.87, skewness: -0.69, kurtosis: 0.46, standard error of mean: 0.13, standard error of measurement: 0.63, coefficient alpha: 0.79. *p<0.05, **p<0.01, ***p<0.001

Table S16: Rasch analysis statistics for the Esteem sub-scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	-0.41	0.162	1.01 (0.74-1.26)	0.2	1.08 (0.72-1.28)	0.5	-4.14, -1.37, 4.28	-4.20, -1.32, 4.28
Item 2	0.41	0.162	0.89 (0.74-1.26)	-0.8	0.95 (0.72-1.28)	-0.4	-3.32, -0.55, 5.10	-3.38, -0.50, 5.10
Category 0			1.07 (0.74-1.26)	0.5	1.19 (0.35-1.65)	0.6		
Category 1	-3.728	0.658	0.81 (0.74-1.26)	-1.5	1.29 (0.66-1.34)	1.5		
Category 2	-0.960	0.278	1.10 (0.74-1.26)	0.8	1.19 (0.74-1.26)	1.4		
Category 3	4.688		6.87 (0.74-1.26)	20.2	1.10 (0.65-1.35)	0.5		

Notes: Chi-square test of parameter equality (1) = 6.41

Table S17: Differential item functioning statistics for the Esteem sub-scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.133	0.153	1.01 (0.58-1.42)	0.1	0.54
		2	0.113	0.153	0.94 (0.57-1.43)	-0.2	
	Male	1	0.113	0.153	0.97 (0.59-1.41)	-0.2	
		2	-0.113	0.153	0.98 (0.58-1.42)	-0.1	
Age	18-44 years	1	0.045	0.156	0.92 (0.60-1.40)	-0.4	0.09
		2	-0.045	0.156	0.88 (0.59-1.41)	-0.6	
	>44 years	1	-0.045	0.156	1.05 (0.56-1.44)	0.3	
		2	0.045	0.156	1.12 (0.56-1.44)	0.6	
Socioeconomic status	Lower	1	-0.021	0.152	0.97 (0.61-1.39)	-0.2	0.02
		2	0.021	0.152	0.80 (0.59-1.41)	-1.0	
	Higher	1	0.021	0.152	1.00 (0.59-1.41)	0.0	
		2	-0.021	0.152	1.31 (0.56-1.44)	1.3	
Type of organisation	Education	1	0.044	0.171	1.07 (0.46-1.54)	0.3	0.07
		2	-0.044	0.171	0.87 (0.44-1.56)	-0.5	
	Performance	1	-0.044	0.171	0.99 (0.68-1.32)	-0.1	
		2	0.044	0.171	1.05 (0.65-1.35)	0.3	

Promotion Opportunities sub-scale

Table S18: Traditional statistics for the Promotion Opportunities sub-scale

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	26 (23.64)	-0.36	-4.07***	-1.275±0.790	0.50	0.81
	1	42 (38.18)	-0.06	-0.68	-0.366±0.777		
	2	34 (30.91)	0.20	2.11*	0.450±0.675		
	3	8 (7.27)	0.36	4.05***	1.865±1.508		
2	0	13 (11.82)	-0.28	-2.98**	-1.308±1.277	0.48	0.76
	1	38 (34.55)	-0.31	-3.37**	-0.750±0.728		
	2	52 (47.27)	0.38	4.25***	0.343±0.789		
	3	7 (6.36)	0.19	2.03*	1.339±1.855		
3	0	8 (7.34)	-0.23	-2.47*	-1.731±0.642	0.35	0.69
	1	35 (32.11)	-0.18	-1.88	-0.674±0.898		
	2	53 (48.62)	0.15	1.54	0.011±0.795		
	3	13 (11.93)	0.22	2.31*	1.111±1.729		

Notes: Mean ± standard deviation: 4.32±1.91, variance: 3.64, skewness: -0.01, kurtosis: 0.29, standard error of mean: 0.18, standard error of measurement: 1.18, coefficient alpha: 0.62. *p<0.05, **p<0.01, ***p<0.001

Table S19: Rasch analysis statistics for the Promotion Opportunities sub-scale

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	0.537	0.129	1.05 (0.74-1.26)	0.4	1.06 (0.76-1.24)	0.5	-1.44, 0.14, 2.91	-1.61, 0.24, 2.97
Item 2	-0.074	0.120	0.89 (0.74-1.26)	-0.8	0.89 (0.75-1.25)	-0.8	-2.05, -0.47, 2.30	-2.22, 0.37, 2.36
Item 3	-0.463	0.129	1.08 (0.74-1.26)	0.6	1.08 (0.74-1.26)	0.6	-2.44, -0.84, 1.91	-2.61, -0.75, 1.97
Category 0			1.51 (0.74-1.26)	3.3	1.19 (0.66-1.34)	1.1		
Category 1	-1.980	0.243	1.18 (0.74-1.26)	1.3	1.26 (0.76-1.24)	2.0		
Category 2	-0.394	0.155	1.39 (0.74-1.26)	2.6	1.67 (0.76-1.24)	2.8		
Category 3	2.375		2.95 (0.74-1.26)	9.8	1.51 (0.58-1.42)	2.1		

Notes: Separation reliability 0.917. Chi-square test of parameter equality (2) = 17.64, p<0.001

Table S20: Differential item functioning statistics for the Promotion Opportunities sub-scale

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Separation reliability	Chi-square test of parameter equality (2)	p-value
Gender	Female	1	-0.007	0.119	1.04 (0.64-1.36)	0.2	0.000	0.65	0.7254
		2	-0.100	0.125	0.78 (0.64-1.36)	-1.2			
		3	0.107	0.123	1.14 (0.63-1.37)	0.8			
	Male	1	0.007	0.119	0.93 (0.66-1.34)	-0.4			
		2	0.100	0.125	1.19 (0.63-1.37)	1.0			
		3	-0.107	0.123	1.01 (0.64-1.36)	0.1			
Age	18-44	1	0.260	0.127	0.85 (0.66-1.34)	-0.9	0.739	4.70	0.095
	years	2	-0.090	0.126	0.66 (0.64-1.36)	-2.2			
		3	-0.171	0.126	1.25 (0.64-1.36)	1.3			
	>44	1	-0.260	0.127	1.05 (0.63-1.37)	0.3			
	years	2	0.090	0.126	1.31 (0.64-1.36)	1.6			
		3	0.171	0.126	1.00 (0.63-1.37)	0.1			
Socioeconomic status	Lower	1	-0.166	0.120	0.93 (0.66-1.34)	-0.4	0.000	2.28	0.319
		2	-0.075	0.125	0.93 (0.64-1.36)	-0.4			
		3	0.241	0.129	0.97 (0.64-1.36)	-0.1			
	Higher	1	0.166	0.120	1.04 (0.64-1.36)	0.3			
		2	0.075	0.125	1.04 (0.63-1.37)	0.3			
		3	-0.241	0.129	1.19 (0.63-1.37)	1.0			
Type of organisation	Education	1	0.233	0.133	0.86 (0.54-1.46)	-0.6	0.470	3.12	0.210
		2	-0.029	0.137	0.83 (0.53-1.47)	-0.7			
		3	-0.203	0.138	1.23 (0.52-1.48)	0.9			
	Performance	1	-0.233	0.133	0.93 (0.71-1.29)	-0.4			
		2	0.029	0.137	1.04 (0.70-1.30)	0.3			
		3	0.203	0.138	1.02 (0.69-1.31)	0.1			

Promotion Opportunities sub-scale without Item 1

Table S21: Traditional statistics for the Promotion Opportunities sub-scale without Item 1

Item	Score	Count (%)	Point biserial correlation	t-value	Predicted values (mean ± standard deviation)	Item-rest correlation	Item-total correlation
1	0	13 (11.93)	-0.13	-1.31	-0.427±1.257	0.29	0.80
	1	38 (34.86)	-0.22	-2.28*	-0.201±0.772		
	2	51 (46.79)	0.21	2.18*	0.512±0.735		
	3	7 (6.42)	0.16	1.73	1.930±0.842		
2	0	8 (7.34)	-0.22	-2.29*	-1.205±1.014	0.29	0.80
	1	35 (32.11)	-0.17	-1.76	-0.235±0.702		
	2	53 (48.62)	0.20	2.15*	0.473±0.759		
	3	13 (11.93)	0.10	1.05	1.374±0.981		

Notes: Mean ± standard deviation: 3.11±1.29, variance:1.66, skewness: -0.30, kurtosis: 0.23, standard error of mean: 0.12, standard error of measurement: 0.97, coefficient alpha: 0.43. *p<0.05, **p<0.01, ***p<0.001

Table S22: Rasch analysis statistics for the Promotion Opportunities sub-scale without Item 1

	Estimates	Errors	Unweighted fit		Weighted fit		Item deltas	Item thresholds
			Mean square (95% CI)	t-value	Mean square (95% CI)	t-value		
Item 1	0.181	0.105	1.03 (0.74-1.26)	0.2	1.03 (0.75-1.25)	0.2	-1.71, -0.22, 2.47	-1.89, -0.11, 2.53
Item 2	-0.181	0.105	0.99 (0.74-1.26)	-0.1	0.98 (0.74-1.26)	-0.1	-2.07, -0.58, 2.11	-2.25, -0.47, 2.17
Category 0			1.28 (0.74-1.26)	2.0	1.23 (0.59-1.41)	1.1		
Category 1	-1.891	0.331	1.21 (0.74-1.26)	1.5	1.24 (0.78-1.22)	2.0		
Category 2	-0.400	0.187	1.22 (0.74-1.26)	1.6	1.25 (0.80-1.20)	2.3		
Category 3	2.291		1.34 (0.74-1.26)	2.4	1.25 (0.58-1.42)	1.1		

Notes: Chi-square test of parameter equality (1) = 2.99, p<0.001

Table S236: Differential item functioning statistics for the Promotion Opportunities sub-scale without Item 1

	Group	Items	Estimates	Errors	Weighted fit mean square (95% confidence interval)	t-value	Chi-square test of parameter equality (1)
Gender	Female	1	-0.097	0.103	0.90 (0.65-1.35)	-0.5	0.87
		2	0.097	0.103	1.03 (0.64-1.36)	0.2	
	Male	1	0.097	0.103	1.10 (0.63-1.37)	0.6	
		2	-0.097	0.103	0.98 (0.65-1.35)	0.0	
Age	18-44 years	1	0.036	0.103	0.90 (0.64-1.36)	-0.5	0.12
		2	-0.036	0.103	0.95 (0.64-1.36)	-0.3	
	>44 years	1	-0.036	0.103	1.17 (0.64-1.36)	0.9	
		2	0.036	0.103	1.02 (0.64-1.36)	0.2	
Socioeconomic status	Lower	1	-0.144	0.106	0.80 (0.65-1.35)	-1.2	1.86
		2	0.144	0.106	0.90 (0.64-1.36)	-0.6	
	Higher	1	0.144	0.106	1.11 (0.64-1.36)	0.6	
		2	-0.144	0.106	1.04 (0.64-1.36)	0.3	
Type of organisation	Education	1	0.074	0.113	0.99 (0.54-1.46)	0.0	0.43
		2	-0.074	0.113	1.05 (0.53-1.47)	0.2	
	Performance	1	-0.074	0.113	1.05 (0.70-1.30)	0.3	
		2	0.074	0.113	1.03 (0.70-1.30)	0.2	

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