How do we assess musicians’ musculoskeletal symptoms?: a review of outcomes and tools used

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Abstract: Recent reviews of musicians’ musculoskeletal symptoms (MSS) have reported heterogeneity in the outcomes reported and data collection tools used, making it difficult to compare and synthesise findings. The purpose of this present review was to improve the consistency of future research, by documenting the outcomes reported in recent studies of musicians’ MSS and the data collection tools used. All English language, peer-reviewed studies, published 2007–2016 that reported musicians’ self-reported MSS outcomes were identified. Details of the types of outcomes reported and the tools used were extracted, and synthesised descriptively. A range of MSS outcomes were reported, including MSS with a temporal relationship to activities performed, and the consequences of symptoms. Only 24% of studies used standardised questionnaires, with the Nordic Musculoskeletal Questionnaire (NMQ) being the most commonly used. To improve the homogeneity of outcomes and data collection tools when investigating musicians’ MSS, we recommend using the NMQ, where appropriate. Recall periods of 12-months and 7-d are the most appropriate for prevalence, and 7-d recall periods for ratings. Importantly, outcomes and the tools used to collect data should be reported in sufficient detail to ensure that the study can be replicated, critiqued, and accurately interpreted.

Key words: Musicians, Outcomes, Measures, Rating scales, Questionnaires, Musculoskeletal, Pain, Review

Background

Musculoskeletal symptoms (MSS) include pain, stiffness, weakness, numbness, and loss of control in soft tissue, peripheral joints and the axial spine1, 2). When assessing MSS, there are a number of parameters that need to be considered. These parameters include the MSS quality (e.g. pain, tingling), intensity, location, and frequency of symptoms, and temporal relationship of MSS to a particular activity, as well as activity and participation limitations due to MSS, and whether MSS are perceived to be due to a particular factor (e.g. resulting from work). The variability in the assessment of each of these parameters (e.g. which scale was used to measure MSS intensity), the potential combination of parameters, and the recall periods of interest (e.g. last 12-months, current) result in a seemingly endless range of potential outcomes relating to MSS.

Recent systematic reviews of various occupational groups3–7), including musicians8–14), have identified inconsistencies in the case definitions used for MSS, the specific outcomes of interest, and the methods of data collection (e.g. questionnaires). In the first systematic review12) of musicians’ MSS, published in 1998, the authors recommended that clear case definitions be used and reported, and that these allowed for comparison with other studies. Despite this recommendation, issues remain8–11, 13, 14).
Recently there have been calls for guidelines regarding the data collection tools used to assess musicians’ MSS (14). One of the potential barriers to improving the consistency of terminology and case definitions is that there has not been a comprehensive investigation of the outcomes and tools used for studies examining musicians’ MSS. The present review builds on previous systematic reviews regarding the prevalence (8-12) and incidence of (11, 12), or risk factors for (8, 13, 14) MSS in musicians, by looking specifically at the types of outcomes reported and the data collection tools used, rather than focusing on study findings. Additionally, the present review considers types of studies which have not been addressed in existing reviews (e.g. interventions) and includes a broader range of outcomes (e.g. symptom intensity, seeking treatment). In addition, we include all types of musicians, making this review the most comprehensive examination of the topic to date, and providing the foundation for the suggested guidelines regarding future data collection tools to assess musicians’ MSS (14).

We aimed to improve the consistency of research regarding musicians’ MSS, by reviewing the reported outcomes (e.g. recall periods, severity), and data collection tools used (e.g. questionnaires, rating scales). By doing so, future research can be designed to ensure that findings can be compared and/or synthesised with the existing literature, thus improving the overall evidence base for developing and testing appropriate strategies to reduce the burden of MSS for musicians.

**Methods**

A broad systematic search was first performed to identify any studies regarding musicians’ MSS (including reviews). Studies were identified through a systematic search seven library databases, and screening of the table of contents and abstracts section of *Medical Problems of Performing Artists* to identify any studies regarding musicians’ MSS (Appendix 1). The citation and reference lists of musicians’ MSS were screened to identify additional potentially relevant studies. From the resultant list of studies, we included studies reporting self-reported MSS outcomes. Outcomes included, but were not limited to: MSS which were attributed to or aggravated by specific factors; the consequences of MSS (e.g. sick leave, consulting a health professional); MSS with a temporal relationship to an activity (e.g. MSS while playing); and more general outcomes, which were reported as the presence or absence of an outcome, and ratings of frequency or intensity. Studies were only eligible if they were published in English language, within peer-reviewed journals from 2007–2016. The first author determined study inclusion and exclusion, with another reviewer consulted where there was any uncertainty.

Extracted data included: the questionnaire(s) and ratings scales used (including scale type, rating type, scale length, anchors); body charts used; ‘music-related’ MSS terminology and definitions; MSS quality, recall-period, location, duration, severity, and frequency; MSS with a temporal relationship to activities; MSS resulting from perceived aggravating or risk factors; and MSS consequences (e.g. impact on playing, management strategies used). Data from included studies were manually extracted twice by one reviewer, and checked by another reviewer, with discrepancies resolved through discussion with a third reviewer, if required. Verification by a second reviewer is an accepted approach for systematic reviews (15), with evidence suggesting that review findings do not differ whether there has been double extraction or single extraction with verification (16).

Following the methods used by Smith *et al.* (17), if the questionnaire was included in the appendix, or a published questionnaire was cited with no mention of any modifications having been made, the data extracted were checked against the questionnaire used, to fill in gaps from the text and to identify discrepancies. If the modifications made to questionnaires were described, it was assumed that other elements of the questionnaire remained the same and thus these questionnaires were also checked. If papers reported on the same study, it was assumed the same questionnaire was used.

Data were reported descriptively, and in tabulated form. Outcomes were only reported where the recall-periods were clearly stated, as this is integral to defining outcomes. The outcomes were classified as temporal relationship of MSS to an activity, MSS with perceived aggravating or risk factors, the consequences of MSS (including management strategies), and MSS in general. The latter category included outcomes where the term music-related or similar (e.g. playing-related) was used, but not defined in such a way that the relationship between MSS and musical activity could be determined.

Because we were interested in describing the types of outcomes and the tools used to collect the data, rather than the findings of the included studies per se, we did not assess methodological bias, as is typical of reviews of this nature (e.g. 18-20).
Results

A total of 125 articles met the inclusion criteria (Fig. 1). Of these articles, there were 110 unique studies, with some articles reporting on the same dataset. Values reported throughout this review refer to the 110 unique studies, unless otherwise indicated.

Questionnaires used

Few studies (24%) used existing standardised questionnaires that have been used with the general population; however, there appears to be an increase in their usage with 33% of studies published from 2012 onwards using such questionnaires. The most commonly used questionnaires (including translations) were the Nordic Musculoskeletal Questionnaire (NMQ, also known as the Standardised Nordic Questionnaire\(^{51}\), the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire\(^{52}\), and the Neck Disability Index\(^{53-55}\) (Table 1). Of note, while there was no mention of modifications to the NMQ there appear to have been some discrepancies in the symptoms reported\(^{43, 44, 56, 57}\), recall periods\(^{58, 59}\), and the body regions\(^{60}\) in some studies.

In addition to the published modifications of the NMQ (Table 1), seven studies reported modifying the NMQ. Kaufman-Cohen and Ratzon\(^{75}\) added additional up-
Table 1. Published questionnaires used

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic Musculoskeletal Questionnaire (NMQ)51, 61, 62)</td>
<td>43, 44, 56, 57, 60)</td>
</tr>
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<td>Portuguese translation53–65)</td>
<td>58, 59, 66)</td>
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<td>Extended version67)</td>
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</tr>
<tr>
<td>Engqvist et al.’s69) modification for musicians</td>
<td>70)</td>
</tr>
<tr>
<td>Paarup et al.’s33) modified versiona</td>
<td>32, 33(b)</td>
</tr>
<tr>
<td>Dutch Musculoskeletal Questionnaire (which includes the NMQ)71)</td>
<td>72)</td>
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<tr>
<td>Disability of the Arm, Shoulder and Hand Questionnaire52, 73)</td>
<td>74, 75)</td>
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<tr>
<td>Turkish version76)</td>
<td>77)</td>
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<td>Spanish version75)</td>
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<tr>
<td>Disability of the Arm, Shoulder and Hand Questionnaire: Performing art/sports module52, 73)</td>
<td>79, 80)</td>
</tr>
<tr>
<td>Portuguese translation53–65)</td>
<td>77)</td>
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<td>Spanish version73)</td>
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<td>Quick Disability of the Arm, Shoulder and Hand Questionnaire81, 82)</td>
<td>83)</td>
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<tr>
<td>Quick Disability of the Arm, Shoulder and Hand Questionnaire: Performing arts/sports module81, 82)</td>
<td>83)</td>
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<td>Brief Pain Short Form84)</td>
<td>85)</td>
</tr>
<tr>
<td>West Haven Yale Multidimensional Pain Inventory66)</td>
<td>87)</td>
</tr>
<tr>
<td>McGill Pain Questionnaire Short Form88)</td>
<td>89)</td>
</tr>
<tr>
<td>Neck Disability Index53–55</td>
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<td>Spanish version85)</td>
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</tr>
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<td>Temporomandibular Joint Disorder questionnaire102)</td>
<td>103)</td>
</tr>
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<td>Temporomandibular Joint Disorder screening questions108)</td>
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<td>111)</td>
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<td>Dutch version</td>
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<td>Patient Specific Functional Scale123)</td>
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<tr>
<td>Health-Pain-Injury Inventory133)</td>
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</tr>
<tr>
<td>Ranelli’s114) modification of the Young People’s Activity Questionnaire115)</td>
<td>27–29, 45, 46, 116(b)</td>
</tr>
<tr>
<td>Musculoskeletal Pain Intensity and Interference Questionnaire for professional orchestra musicians117)</td>
<td>118)</td>
</tr>
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<td>120)</td>
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<td>Marching Unit Incident Report Form122)</td>
<td>122)</td>
</tr>
<tr>
<td>Ackermann &amp; Driscoll’s123) questionnairea</td>
<td>34–37, 124</td>
</tr>
<tr>
<td>Allsop &amp; Ackland’s125) questionnairea</td>
<td>125)</td>
</tr>
<tr>
<td>Hatheway &amp; Chesky’s126) questionnairea</td>
<td>126)</td>
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<tr>
<td>Kava et al.’s127) questionnairea</td>
<td>127)</td>
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<tr>
<td>Stanhope et al.’s128) questionnairea</td>
<td>128)</td>
</tr>
<tr>
<td>Steinmetz et al.’s129) questionnairea</td>
<td>129)</td>
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<tr>
<td>Steinmetz et al.’s130) questionnairea</td>
<td>130)</td>
</tr>
<tr>
<td>Woldendorp et al.’s131) questionnairea</td>
<td>131)</td>
</tr>
<tr>
<td>Wood’s132) questionnairea</td>
<td>133)</td>
</tr>
</tbody>
</table>

a have only been used by those who developed the questionnaires. b Ranelli et al.27–29 reported the use of a modification of the Young People’s Activity Questionnaire115 but did not cite the modification114 however it is assumed that this modification was used as the articles27–29 appear to report on the same project as two later articles45, 46 which cite the modification114. Paarup et al.32 did not cite the modified Nordic Musculoskeletal Questionnaire used, but appears to report on the same study33 where the questionnaire was published. c Lima et al.85 also referred to it by its former name the Wisconsin’s Pain Inventory.
per limb regions, while Leaver et al.\textsuperscript{134} added a 4-wk recall period and also added items regarding ‘disabling pain’, which they defined as “pain in the past 12 months present for at least a month which prevented attendance at work for at least 1 d”.\textsuperscript{75} Similarly, Kok et al.\textsuperscript{79} and Bruno et al.\textsuperscript{135} integrated Zaza et al.’s\textsuperscript{2} definition for playing-related musculoskeletal disorders into the NMQ, although different variations of the definition were used, as will be discussed below. Bruno et al.\textsuperscript{135} also changed the time period to 4-wk, and both studies\textsuperscript{79, 135} appear to have changed the body regions. Changes made to the NMQ were reported, but not described, in three studies\textsuperscript{32, 136, 137}.

Regarding Paarup\textsuperscript{et al.}, although different variations of the definition were used, as will be discussed below. Bruno et al.\textsuperscript{135} also changed the time period to 4-wk, and both studies\textsuperscript{79, 135} appear to have changed the body regions. Changes made to the NMQ were reported, but not described, in three studies\textsuperscript{32, 136, 137}.

Regarding Paarup et al.’s\textsuperscript{32} study, it is possible that the changes to the NMQ were using a rating scale for MSS in the last 7-d rather than a dichotomous response, as this modification was published in their other article\textsuperscript{53}, which appears to report on the same study.

To guide the collection of data for specific body regions, 14 studies reported using a body chart\textsuperscript{27–30, 33, 35, 38, 39, 43–46, 56, 66, 68, 74, 80, 89, 131, 138}; six studies including the body chart within the article\textsuperscript{33, 80, 89}, or the questionnaire in the appendix\textsuperscript{39, 131, 138}. While 11 studies did not specifically report that a body chart was used\textsuperscript{111, 32, 34, 36, 37, 57–60, 72, 116, 118, 124}, they reported using questionnaires that include body charts\textsuperscript{30, 33, 51, 64, 71, 114, 117, 123}. Based on the questionnaire\textsuperscript{121} used in one study\textsuperscript{34–37} a body chart was only used for current pain, with lifetime prevalence determined without a body chart. Assuming no changes were made to the questionnaire body charts, nine studies used blank body charts\textsuperscript{27–29, 34–37, 45, 46, 48, 80, 89, 116, 124, 131, 138}, and 11 used body charts with the regions marked\textsuperscript{10–33, 38, 39, 43, 44, 57–60, 66, 68, 72} (10 of which used the NMQ body chart\textsuperscript{3, 13}, 43, 44, 56–60, 66, 68, 72). While Bragge et al.’s\textsuperscript{138} questionnaire had a blank body chart, the body chart reported included the regions marked; hence the reader can ascertain how the authors defined each body region.

**Music-related terminology**

‘Music-related’ terminology refers to the use of terms such as ‘playing-related’, ‘performance related’ and ‘associated with playing’. There were 53 studies (49%)\textsuperscript{27–31, 34–39, 43, 45, 46, 49, 50, 57, 60, 75, 77, 79, 80, 89, 91–93, 113, 116, 118, 120, 121, 124, 125, 127, 128, 133, 135, 136, 138–161) that used ‘music-related’ MSS in the title or aim of the study, for inclusion into the study, and/or to describe a MSS outcome. The terms ‘non-playing-related problems’\textsuperscript{147, 162}, work-related\textsuperscript{56, 85, 163, 164} ‘relative to profession’\textsuperscript{70}, or education-related\textsuperscript{165} were also used, and while it could be argued that work or education was music-related, because this remained uncertain, these outcomes have not been reported further within this section.

The specific musical tasks reported were: playing\textsuperscript{27–29, 38, 39, 43, 45, 46, 49, 50, 57, 60, 75, 79, 80, 91–93, 116, 118, 120, 121, 125, 128, 135, 136, 138, 142–145, 147, 149–153, 155, 157, 159} (‘performance’\textsuperscript{30, 31, 34–37, 77, 127, 133, 140–142, 146, 148, 154, 156, 158, 160}), practice/performance\textsuperscript{133}, marching\textsuperscript{140}, drum-corp\textsuperscript{140}, instrument\textsuperscript{135}, flute\textsuperscript{148, 150}, trombone\textsuperscript{39}, piano\textsuperscript{166}, and ‘voice usage’\textsuperscript{161}. Two studies used the term ‘music-related’\textsuperscript{113, 139}. Some terms were used interchangeably\textsuperscript{133, 135, 136, 140, 142, 146, 148, 150}, although in the case of Wood\textsuperscript{133} the author made it clear that the term performance-related musculoskeletal disorders included both practice and performance. A further study\textsuperscript{124} reported ‘PRMD’ without indicating what this stood for, however the questionnaire used\textsuperscript{123} indicates that this referred to ‘performance-related musculoskeletal disorders’.

‘Music-related’ and more generic terminology, e.g. pain or injuries, appear to have been used interchangeably in 25 articles (21 studies)\textsuperscript{34–39, 43, 50, 57, 60, 75, 80, 89, 118, 121, 124, 136, 138, 140, 142, 146, 150, 151, 161, 166}. How musical activity and MSS were related was not clear in 31 studies\textsuperscript{34, 38, 39, 43, 46, 50, 57, 60, 75, 77, 89, 91, 92, 113, 120, 121, 125, 139–142, 145–151, 157–159, 162}. A total of 17 studies defined ‘music-related’ MSS as MSS that interfered with musical activity\textsuperscript{27–31, 35–37, 45, 46, 79, 93, 116, 118, 124, 128, 135, 136, 138, 143, 153, 154, 156, 160} (all bar one\textsuperscript{143}, using Zaza et al.’s\textsuperscript{2, 167, 168} definition of playing-related musculoskeletal disorders (“any pain, weakness, numbness, tingling or other physical symptoms that interfere with your ability to play your instrument at the level you are accustomed”\textsuperscript{2}) or a slight variation thereof). ‘Music-related’ MSS were also defined as MSS attributed to musical activity\textsuperscript{80, 133, 155}, or MSS with a temporal relationship with musical activity\textsuperscript{27–29, 45, 46, 116, 127, 143, 144, 161, 166}, with one additional study\textsuperscript{152} defining ‘music-related’ MSS as MSS that were caused by or affected performance. One study\textsuperscript{127} stated defining ‘performance-related musculoskeletal disorders’ according to Zaza et al.’s\textsuperscript{2}, stating this term referred to “neuromusculoskeletal disorders that develop from playing an instrument, rather than problems that may interfere with playing”\textsuperscript{127}, which is in contrast with Zaza et al.’s\textsuperscript{2} definition. The authors\textsuperscript{127} later went on to state with regards to data collection that pain while playing was deemed a symptom associated with performance-related musculoskeletal disorders, again citing Zaza et al.’s\textsuperscript{2}. This example highlights the need to clearly state the definition used.

Two studies\textsuperscript{27–29, 45, 46, 116} used the term playing-related MSS to refer to symptoms that had a temporal relationship...
with musical activity, and playing-related musculoskeletal disorders to refer to MSS that impaired musical activity; these were collectively referred to as playing-related musculoskeletal problems. Yoshimura et al.\(^\text{43}\) used the term ‘playing-related pain’ as an over-arching term to encompass questions regarding pain when playing, pain after playing, pain that stopped the pianist from playing and how much playing was affected.

Steinmetz et al.\(^\text{49}\) stated that the term ‘playing-related musculoskeletal disorders’ was used as an umbrella term encompassing both musculoskeletal pain and disorders, contrasting their definition with that of Zaza et al.\(^\text{167}\), suggesting that within their study,\(^\text{49}\) playing-related musculoskeletal disorders simply refer to MSS experienced by musicians. It is possible that this interpretation is also the case in the studies that did not state how musical activity and MSS were related, however unlike Steinmetz et al.\(^\text{49}\) the definition was not made clear.

In some studies\(^\text{27–29, 35, 36, 43, 45, 46, 57, 60, 80, 124, 161}\), where the questionnaire used was reported, we were unable to find corresponding questionnaire items for some or all of the reported ‘music-related’ MSS outcomes, even where the author had indicated the items specifically related to the corresponding outcome\(^\text{80}\). Additionally, two articles\(^\text{43, 44}\) reported one study, with many of the same outcomes, however one reported the same MSS finding as ‘playing-related’\(^\text{43}\) while the other did not\(^\text{44}\).

‘Music-related’ terminology referred to MSS which: impaired musical activity; were attributed to musical activity; and/or had a temporal relationship with musical activity; or were not clear in their relationship with musical activity. Notably, not all outcomes where musical activity was in some way related to MSS (e.g. impaired musical activity) used ‘music-related’ terminology, instead describing the outcome. The outcomes described in the following sections relate to the type of outcome reported (e.g. temporal relationship between MSS and an activity), irrespective of whether the authors of the included studies used ‘music-related’ terminology, or not.

### Outcomes reported

Of the included studies, only 35 had all outcomes extracted\(^\text{27, 28, 32, 33, 38, 39, 45, 46, 56, 58, 59, 66, 75, 79, 103, 116, 118, 122, 126, 134, 135, 138–140, 142, 145, 152, 154, 160, 166, 169–175}\). 42 had some\(^\text{29, 34–37, 40–44, 49, 50, 57, 60, 68, 70, 72, 74, 77, 80, 83, 89, 91, 93, 94, 98, 120, 121, 124, 128, 130, 131, 133, 137, 149–151, 153, 159, 177, 178}\), and 44 had no outcomes extracted\(^\text{30, 31, 47, 48, 85, 87, 90, 92, 101, 107, 109, 110, 113, 125, 127, 129, 136, 141, 143, 144, 146–148, 155–158, 161–165, 180–192}\) as the recall periods could not be determined.

### Temporal relationship to activity

MSS with a temporal relationship to musical activity were reported in 10 studies\(^\text{27–29, 37, 45, 46, 116, 121, 126, 130, 139, 145, 149, 166}\) and non-musical activities in three studies\(^\text{46, 74, 116}\) (Table 2). A total of 10 of these studies reported MSS during specific activities\(^\text{27–29, 37, 45, 46, 74, 116, 121, 126, 139, 145, 149, 166}\), while others reported MSS before\(^\text{145}\), or after the activity\(^\text{121, 126, 145}\), or reported combinations of before, during and after activity\(^\text{145, 166}\). Four reports of one study\(^\text{27–29, 46}\) indicate that playing-related musculoskeletal symptoms referred to symptoms during and after, while another report of the same study referred to during or after playing\(^\text{45}\). However, the questionnaire\(^\text{114}\) used only asked about symptoms during playing; hence we have classified the outcome as symptoms during playing only. With the exception of two studies\(^\text{126, 166}\), all reported the percentage of participants who had experienced MSS while doing the specified activity. Three studies\(^\text{28, 46, 126}\) reported the frequency of MSS\(^\text{46, 126}\), and another\(^\text{166}\) reported the intensity of pain, and tension while playing (Table 2).

In addition to the abovementioned outcomes, Damian and Zalpour\(^\text{94}\) reported the mean rating from the pain subscale of the Shoulder Pain and Disability Index\(^\text{99}\), which includes items relating to pain during certain activities combined with pain at its worst, which will be reported in full in the other outcomes section.

### Symptoms attributed to an activity

The prevalence of MSS aggravated by\(^\text{145}\), or caused by\(^\text{35, 36, 121, 133, 138, 178}\) various factors were reported in six studies. The MSS types were injury\(^\text{133}\), pain or injuries\(^\text{35}\), musculoskeletal problems\(^\text{145}\), lip pain\(^\text{178}\), playing-related symptoms\(^\text{121}\), in the last 12-months\(^\text{121, 178}\), and over the musicians’ lifetime\(^\text{35, 133, 145}\). In one study\(^\text{138}\) the participants were asked an open-response question, and in another\(^\text{35}\) participants were asked to rate the effect of each factor on an 11-point numeric rating scale (NRS) “no effect at all” to “greatest effect of all”, reporting the percentage who endorsed each factor, and the percentage who indicated that the factor was “important”; however cut-point for this classification was not reported\(^\text{35}\). In the remaining studies, participants appear to have been asked to endorse each factor. In two of the studies where the questionnaire was published\(^\text{35, 121}\), there were discrepancies with the questionnaires used\(^\text{121, 123}\).

Perceived risk/causative factors (Table 3) were grouped as musculoskeletal, playing-related, work environment and psychosocial, based on Chimenti et al.’s study. Bragge et al.\(^\text{138}\) (who used open response categories) also
### Table 2. Temporal relationship between activity and symptoms

<table>
<thead>
<tr>
<th>Activity, temporal relationship &amp; symptoms</th>
<th>Time period</th>
<th>Scale (if appropriate)</th>
<th>Questionnaire references</th>
<th>Reported as</th>
<th>Studies</th>
</tr>
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<tr>
<td><strong>Musical</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pain or discomfort when playing</td>
<td>Lifetime</td>
<td>NA</td>
<td>NR</td>
<td>Percentage</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>NA</td>
<td>NR</td>
<td>Percentage</td>
<td>139</td>
</tr>
<tr>
<td>Musculoskeletal symptoms before, during, after, before and after, during and after playing</td>
<td>Lifetime</td>
<td>NA</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Soreness while playing</td>
<td>Lifetime</td>
<td>NA</td>
<td>11-4</td>
<td>Percentage</td>
<td>27–29, 45, 46, 110</td>
</tr>
<tr>
<td></td>
<td>Last month</td>
<td>NA</td>
<td>11-4</td>
<td>Percentage</td>
<td>27–29, 45, 46</td>
</tr>
<tr>
<td></td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>20</td>
</tr>
<tr>
<td>Soreness while playing in the neck, right shoulder, left and right hand</td>
<td>Last month</td>
<td>NA</td>
<td>11-4</td>
<td>Percentage</td>
<td>46</td>
</tr>
<tr>
<td>Pain during and/or after practice/performance</td>
<td>Current</td>
<td>NA</td>
<td>130</td>
<td>Percentage</td>
<td>130</td>
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<tr>
<td>Pain during a practice session</td>
<td>Current</td>
<td>NA</td>
<td>114</td>
<td>Percentage</td>
<td>149</td>
</tr>
<tr>
<td>Pain during performance</td>
<td>Current</td>
<td>NA</td>
<td>114</td>
<td>Percentage</td>
<td>116</td>
</tr>
<tr>
<td>Playing-related symptoms that occur while playing</td>
<td>Last 12-months</td>
<td>NA</td>
<td>121</td>
<td>Regression outcome only</td>
<td>37</td>
</tr>
<tr>
<td>Playing-related symptoms that persist for &lt;15 min after playing</td>
<td>Last 12-months</td>
<td>NA</td>
<td>121</td>
<td>Percentage</td>
<td>121</td>
</tr>
<tr>
<td>Playing-related symptoms that persist for &gt;15 min after playing</td>
<td>Last 12-months</td>
<td>NA</td>
<td>121</td>
<td>Percentage</td>
<td>121</td>
</tr>
<tr>
<td>Rating of the frequency of pain during marching rehearsal</td>
<td>Current semester</td>
<td>Horizontal 100 mm VAS from “never” to “always”</td>
<td>126</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Rating of the frequency of pain after marching rehearsal</td>
<td>Current semester</td>
<td>Horizontal 100 mm VAS from “never” to “always”</td>
<td>126</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Rating of the frequency of pain during non-marching playing</td>
<td>Current semester</td>
<td>Horizontal 100 mm VAS from “never” to “always”</td>
<td>126</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Rating of the frequency of pain after non-marching playing</td>
<td>Current semester</td>
<td>Horizontal 100 mm VAS from “never” to “always”</td>
<td>126</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Number of body regions affected by pain during marching band</td>
<td>Current semester</td>
<td>NR</td>
<td>126</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Intensity of pain while playing</td>
<td>Standardized task</td>
<td>10 cm VAS (anchors NR)</td>
<td>NR</td>
<td>Mean</td>
<td>106</td>
</tr>
<tr>
<td>Intensity of tension while playing</td>
<td>Standardized task</td>
<td>10 cm VAS (anchors NR)</td>
<td>NR</td>
<td>Mean</td>
<td>166</td>
</tr>
<tr>
<td><strong>Non-musical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soreness while writing</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>40</td>
</tr>
<tr>
<td>Soreness while doing intensive hand activity</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>40</td>
</tr>
<tr>
<td>Soreness while watching television/videos</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>40</td>
</tr>
<tr>
<td>Soreness during vigorous physical activity</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>40</td>
</tr>
<tr>
<td>Soreness while using electronic games</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage for any, &amp; each frequency</td>
<td>40</td>
</tr>
<tr>
<td>Soreness during non-musical activities</td>
<td>Last month</td>
<td>“none”, “once a month”, “once a week”, “two to three times a week” or “daily”</td>
<td>11-4</td>
<td>Percentage</td>
<td>116</td>
</tr>
<tr>
<td>Upper extremity pain during an activity</td>
<td>Last 7-d</td>
<td>Likert: “none”, “mild”, “moderate”, “severe”, “extreme”</td>
<td>52, 73</td>
<td>Mean</td>
<td>740</td>
</tr>
</tbody>
</table>

NA: not applicable; NR: not reported; VAS: visual analogue scale; “The questionnaire states “soreness while playing” however the two studies each report different definitions. There was no related question in the questionnaires. The authors(114) combined this outcome with consequences of MSS such that the categories were exclusive (more information is presented in the Other Outcomes section). There was a discrepancy between the article and questionnaire, with the tabulated information reflecting that of the questionnaire. “reported as ‘non-music musculoskeletal soreness’ without explanation, however based on the questionnaire it appears to relate to soreness while writing, doing intensive hand activities, watching television/videos, doing vigorous physical activity or using of electronic games.”
<table>
<thead>
<tr>
<th>Table 3. Perceived aggravating or risk factors for musculoskeletal symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Studies</strong></td>
</tr>
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<td><strong>Studies</strong></td>
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<td><strong>Studies</strong></td>
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</tr>
</tbody>
</table>
reported that ‘muscle tension’, ‘practice time’, ‘technique’, ‘posture’ and ‘stress’ were the top five perceived risk factors.

In addition to the outcomes reported in Table 3, two reports of the same study, reported the current prevalence of pain/injury attributed to work\textsuperscript{35} and playing\textsuperscript{36}, however neither outcome matches the questionnaire items\textsuperscript{123}. Grier \textit{et al.}\textsuperscript{173} reported an outcome that combined MSS being attributed to band activities, and the impact on daily life, hence this combined outcome will be reported in detail in the Other Outcomes section.

\textbf{Consequences outcomes}

\textbf{Impact on musical activity}

The prevalence of MSS that influenced musical activity was reported in 18 studies (Table 4). Eight studies\textsuperscript{27–29, 45, 46, 79, 116, 118, 123, 135, 138, 153} used Zaza\textit{et al.}\textsuperscript{52} definition of playing-related musculoskeletal disorders, or slight variations thereof.

In addition to the outcomes summarised in Table 4, one study\textsuperscript{153} reported the prevalence of current MSS that impaired playing for periods of >7 d, <4 wk, 4–12 wk, and ≥3 months, and another\textsuperscript{130} reporting the prevalence of MSS in the last 7-d that impaired playing, for 1–7, 8–30 and ≥30 d duration.

Berque \textit{et al.}\textsuperscript{118} also reported the percentage of musicians reporting one, two or three or more body regions affected by symptoms that impaired playing, during the last 7-d (reported as ‘current’), and Bruno \textit{et al.}\textsuperscript{135} reported the percentage of participants who reported MSS that impaired their playing in more than one body region in the last 4-wk. What defined a region was not clear from the paper.

The lifetime prevalence of self-reported carpal tunnel syndrome, hypermobility, tendinitis, and scoliosis that affected playing were also reported in one study, as well as the lifetime prevalence of ‘temporomandibular joint’ affecting playing\textsuperscript{151}; presumably referring to MSS in this region.

Six studies used the performing arts module from the Disability of the Arm Shoulder and Hand (DASH) questionnaire\textsuperscript{52}, to provide a measure of musical disability in the last 7-d. Two studies\textsuperscript{68, 80} reported the percentages for each response category (Table 4), while others reported the overall mean\textsuperscript{77, 83} or median score\textsuperscript{72}, or were unclear as to whether the mean, median, or another statistic was reported\textsuperscript{79}.

The Patient Specific Functional Scale\textsuperscript{112} was used by Steinmetz \textit{et al.}\textsuperscript{91} to collect data regarding the musical impairment from pain. Participants are asked to “rate any reduced function due to pain in up to three issues related to playing their instrument”\textsuperscript{91}, with these issues nominated by the participant. The degree of impairment on the day of data collection was rated on a scale from 0 “unable to perform activity” to 10 “able to perform activity at the same level as before”\textsuperscript{112}. It was not specified whether these ratings were for the impairment at its worst, on average, or its least.

The degree or frequency of musical impairment outcomes for the remaining four studies are reported in Table 5, where three used Zaza\textit{et al.}\textsuperscript{2, 167, 168} definition, or a slight variation thereof\textsuperscript{153, 154, 160}. Although Árnason \textit{et al.}\textsuperscript{153} reported that the career rating was for the worst playing-related musculoskeletal disorder (using Zaza\textit{et al.}\textsuperscript{2, 167, 168} definition) experienced, they did not specify whether this rating was for the disorder at its worst, on average, or at its least. Similarly, the other studies reporting the degree of musical impairment failed to report this detail. Finally, the mean number of days off playing due to MSS in the last 12-months was also reported in one study\textsuperscript{137}.

\textbf{Non-musical consequences}

The impact of MSS on daily life was reported in 18 unique studies\textsuperscript{32, 68, 72, 74, 75, 77, 83, 94, 98, 126}, five studies\textsuperscript{32, 35, 68, 121, 134} reported consequences related to work, seven studies\textsuperscript{32, 40, 68, 121, 131, 145, 150} reported the management strategies used, and one\textsuperscript{38} combined impairment of musical activity and management strategies used (Table 6). For consequences, the percentage of affected participants were reported, with the exception of two studies\textsuperscript{36, 75} that used the number of days off from work as an outcome in a regression analysis only. For the interference of MSS on general life, ratings were reported as the mean and/or median.

Ratings of interference tended to have a 7-d recall period, while the prevalence of MSS consequences was most commonly reported over a 12-month period (Table 6).

Chimenti \textit{et al.}\textsuperscript{121} also reported the 12-month prevalence of playing-related symptoms that influenced daily activities, as part of a broader scale. Similarly, Grier \textit{et al.}\textsuperscript{173} reported an outcome that combined consequence on daily life and attribution of MSS to band activities. Both combined outcomes will be reported in the Other Outcomes section.

\textbf{Symptoms in general}

This section includes outcomes that did not have a
Table 4. Prevalence outcomes of musical consequences due to musculoskeletal symptoms

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Time periods</th>
<th>Body regions (if specified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected playing ability</td>
<td>Lifetime145</td>
<td></td>
</tr>
<tr>
<td>Affected performance</td>
<td>Lifetime145</td>
<td></td>
</tr>
<tr>
<td>Influenced performing ability</td>
<td>Career70</td>
<td></td>
</tr>
<tr>
<td>Change or impaired playing</td>
<td>12-months70</td>
<td>Neck/back/upper extremity21</td>
</tr>
<tr>
<td>Distracted from performing</td>
<td>Lifetime70</td>
<td></td>
</tr>
<tr>
<td>Interfere with playing or rehearsals or performances</td>
<td>Lifetime70</td>
<td></td>
</tr>
<tr>
<td>Change in technique</td>
<td>Lifetime70</td>
<td></td>
</tr>
<tr>
<td>Trouble using your usual technique</td>
<td>7-d68, 80</td>
<td>Shoulder/arm/hand68, 80, neck/back80</td>
</tr>
<tr>
<td>Trouble playing the musical instrument</td>
<td>7-d68, 80</td>
<td>Shoulder/arm/hand68, neck/back80, neck/back/upper extremity21</td>
</tr>
<tr>
<td>Trouble playing as well as you want to</td>
<td>7-d68, 80</td>
<td>Shoulder/arm/hand68, neck/back80, neck/back/upper extremity21</td>
</tr>
<tr>
<td>Trouble playing the instrument for the time usually devoted to it</td>
<td>7-d68, 80</td>
<td>Shoulder/arm/hand68, neck/back80, neck/back/upper extremity21</td>
</tr>
<tr>
<td>Affect playing time</td>
<td>Lifetime145</td>
<td></td>
</tr>
<tr>
<td>Decrease playing</td>
<td>Lifetime145</td>
<td></td>
</tr>
<tr>
<td>Cannot play</td>
<td>Lifetime145</td>
<td></td>
</tr>
<tr>
<td>Paused from practice alone</td>
<td>12-months52</td>
<td>Neck/back/upper extremity21</td>
</tr>
<tr>
<td>Paused from rehearsal</td>
<td>12-months52</td>
<td>Neck/back/upper extremity21</td>
</tr>
<tr>
<td>Omitted playing at concerts</td>
<td>12-months52</td>
<td>Neck/back/upper extremity21</td>
</tr>
<tr>
<td>Warm-up</td>
<td>Lifetime52</td>
<td></td>
</tr>
<tr>
<td>Time off from playing</td>
<td>Lifetime51</td>
<td></td>
</tr>
<tr>
<td>Missed at least 1 rehearsal, but no competitions</td>
<td>12-months51</td>
<td></td>
</tr>
<tr>
<td>Missed 1–3 rehearsals, &amp; 1 competition</td>
<td>Previous summer40</td>
<td></td>
</tr>
<tr>
<td>Missed 4–7 rehearsals, &amp; &gt;1 competition</td>
<td>Previous summer40</td>
<td></td>
</tr>
<tr>
<td>Missed &gt;7 rehearsals, &amp; &gt;1 competition</td>
<td>Previous summer40</td>
<td></td>
</tr>
</tbody>
</table>

- Skinner-D'Costa, 2020 reported the outcome as the lifetime prevalence, however according to the questionnaire used and other reports of the same study this should have been the prevalence in the last month.
- Career prevalence, but the questionnaire asks about musculoskeletal symptoms during their lifetimes.
- From the Disability of the Arm, Shoulder and Hand (DASH) performing arts module and reported for the response categories “no difficulty”, “mild difficulty”, “moderate difficulty”, “severe difficulty”, or “unable”.

L: left; R: Right.
temporal relationship to playing, were not necessarily perceived to have been the result of specific factors, or resulted in consequences (e.g. impact on musical activity, treatment sought). It also includes ‘music-related’ MSS outcomes, where the relationship between musical activity and MSS remained unclear.

How common these outcomes are

The majority of studies reporting outcomes in this section relate to the prevalence of general MSS (32–36, 40–44, 49, 50, 56–60, 66, 68, 72, 75, 83, 103, 124, 134, 135, 139, 140, 142, 145, 150, 151, 170–172, 176–178). Exceptions were the episodic incidence of MSS (122), the number of participants who had experienced MSS (131, 152, 174, 177, 178), or where MSS outcomes were used only to investigate the association with other variables (37). Of note, Chimenti et al.’s (121) report of the body regions where musicians experienced injuries, referred to the percentage of injuries in those body regions, rather than the percentage of affected musicians, while Heredia et al.’s (152) reported the number of musculoskeletal complaints per musician. It is, however, unclear whether this outcome refers to the body regions affected, the quality of symptoms, or a combination.

Most studies used generic terms, like ‘injury’ or ‘symptoms’, or had more than three specific symptom qualities listed. In a number of studies there appeared to be interchangeable or inconsistent use of terms (33–36, 43, 56, 83, 121, 124, 150, 151), including specific (e.g. pain) and more general (e.g. ‘injury’) terms (34, 35, 43, 56, 150, 151), for these we extracted the most general term. When a specific symptom quality was considered, the most common was pain, with combinations of pain with ache, discomfort and/or tension also being used commonly (Table 7). Only one of the eight studies (68) that used the NMQ (51) reported the outcome as ache, pain or discomfort, as per the original questionnaire, with others reporting pain (43, 44, 48–60), pain or ache (56), or more general MSS terms (57, 66). None of these studies reported modifying the NMQ, hence it is unclear whether the questionnaire was changed to reflect these reported outcomes, or whether the reporting did not match the data collection. It is therefore possible that additional studies reported ache, pain or discomfort outcomes.

The most commonly used recall periods were lifetime, 12-months, 7-d and current (Table 7). A wide range of body areas were investigated, with the most common matching the NMQ (51) body chart, with the laterality of MSS most commonly reported for the upper limbs (Table 8). In addition to the outcomes reported in Tables 7 and 8, three studies reported the prevalence of MSS of various durations. Ackermann et al. (34) reported the prevalence of those with current performance-related musculoskeletal disorders (a term used interchangeably with others) experienced for more than one week, and for at least three months. In another report of the same study (35), the prevalence of current pain of <4-wk, 4- to 12-wk and >12-wk duration was reported. Paarup et al. (32) reported the percentage of participants who had ache, pain or discomfort for more than seven days, and more than 30 d over the last 12-months, which was reported for the neck, upper back, lower back, left and right shoulder, left and right elbow, and left and right hand, and these regions combined (i.e. spine and upper limb).

Kok et al. (40) reported the prevalence of current mus-

Table 5. Measures of the degree and frequency of musical impairment from musculoskeletal symptoms

<table>
<thead>
<tr>
<th>Time period</th>
<th>Outcome</th>
<th>Scale</th>
<th>Anchors</th>
<th>Reported as</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>Affected performance</td>
<td>Likert-style</td>
<td>“entirely”, “partially”, “not at all”</td>
<td>Percentage</td>
<td>172</td>
</tr>
<tr>
<td>Career</td>
<td>Impaired playing</td>
<td>100-mm VAS</td>
<td>0% to 100%</td>
<td>Mean</td>
<td>153</td>
</tr>
<tr>
<td>Current semester</td>
<td>Impaired marching</td>
<td>100-mm horizontal VAS</td>
<td>0% to 100%</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Current semester</td>
<td>Impaired playing</td>
<td>100-mm horizontal VAS</td>
<td>0% to 100%</td>
<td>Mean</td>
<td>128</td>
</tr>
<tr>
<td>7-d</td>
<td>Impaired playing</td>
<td>11-point ordinal</td>
<td>“nil” to “worst imaginable”</td>
<td>Mean</td>
<td>160</td>
</tr>
<tr>
<td>7-d</td>
<td>Impaired playing</td>
<td>11-point VAS</td>
<td>“nil” to “worst imaginable”</td>
<td>Mean</td>
<td>154</td>
</tr>
<tr>
<td>Current</td>
<td>Impaired playing</td>
<td>100-mm VAS</td>
<td>“entirely”, “partially”, “not at all”</td>
<td>Percentage</td>
<td>172</td>
</tr>
</tbody>
</table>

VAS: visual analogue scale; mm: millimetres; NR: not reported. *using Zaza et al.’s (2, 167, 168) definition or slight variations thereof.
Table 6. Consequences of musculoskeletal symptoms

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Time period: symptom(s)</th>
<th>Questionnaire &amp; scale (if appropriate)</th>
<th>Reported as</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>General life</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Degree of disability</td>
<td>Last 7-d: MSS in the arm, shoulder, and/or hand</td>
<td>DASH(^{52, 73})</td>
<td>Mean</td>
<td>68, 74, 77</td>
</tr>
<tr>
<td></td>
<td>Last 7-d: shoulder pain</td>
<td>QuickDASH(^{73})</td>
<td>Median</td>
<td>68, 72</td>
</tr>
<tr>
<td></td>
<td>Last 24-h: MSS in the shoulder</td>
<td>Shoulder Pain and Disability Index(^{99})</td>
<td>Regression only</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shoulder Disability Questionnaire(^{96, 97})</td>
<td>Mean</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>98</td>
</tr>
<tr>
<td>Degree of difficulty in opening a tight or new jar</td>
<td>Last 7-d: MSS in the arm, shoulder, and/or hand</td>
<td>DASH(^{73})</td>
<td>Mean</td>
<td>74</td>
</tr>
<tr>
<td>Degree of difficulty recreational activities which require some force or impact through the arm, shoulder or hand</td>
<td>Last 7-d: MSS in the arm, shoulder, and/or hand</td>
<td>DASH(^{73})</td>
<td>Mean</td>
<td>74</td>
</tr>
<tr>
<td>Degree of pain interference</td>
<td>Last 7-d: pain in any region</td>
<td>Berque et al.’s(^{117}) pain interference scale</td>
<td>Mean</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NRS from 0 “does not interfere” to 10 “completely interferes” for the interference scale and 0 “no difficulty” to 10 “unable” for the playing items</td>
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<td></td>
</tr>
<tr>
<td>Frequency of pain interference with daily life</td>
<td>Current semester: pain in any region</td>
<td>Hatheway and Chesky’s(^{226}) questionnaire 100 mm horizontal VAS from “never” to “always”</td>
<td>Mean</td>
<td>126</td>
</tr>
<tr>
<td>Functional limitations</td>
<td>Last 12-months: MSS in any region</td>
<td>Modified NMQ</td>
<td>Regression only</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Last 12-months: MSS in the upper limb</td>
<td>Modified NMQ</td>
<td>Regression only</td>
<td>75</td>
</tr>
<tr>
<td>Daily activities at home affected</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>Leisure time activities affected</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>Sleep affected</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>Work/study</td>
<td></td>
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</tr>
<tr>
<td>Changes made to jobs/duties</td>
<td>Lifetime: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee &amp; ankle/foot</td>
<td>NMQ Extended version(^{67})</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td>Making a workers’ compensation claim</td>
<td>Career(^a): playing-related symptoms(^a)</td>
<td>Chimienti et al.’s(^{121}) questionnaire</td>
<td>Percentage(^a)</td>
<td>121</td>
</tr>
<tr>
<td>Prevented from doing normal work</td>
<td>Last 12-months: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee &amp; ankle/foot</td>
<td>NMQ Extended version(^{67})</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td>Number of days off from work</td>
<td>Last 18-months: physical pain or injury in any region</td>
<td>Ackermann &amp; Driscoll’s(^{123}) questionnaire</td>
<td>Regression only</td>
<td>36</td>
</tr>
<tr>
<td>Consequence</td>
<td>Time period: symptom(s)</td>
<td>Questionnaire &amp; scale (if appropriate)</td>
<td>Reported as</td>
<td>Studies</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>Sick leave/time off from work or study</td>
<td>Last 18-months: physical pain or injury in any region</td>
<td>Ackermann &amp; Driscoll’s questionnaire</td>
<td>Percentage</td>
<td>35, 36</td>
</tr>
<tr>
<td></td>
<td>Last 12-months: MSS in the neck, shoulder, elbow, wrist/hand, upper back, lower back, hip/thigh, knee &amp; ankle/foot</td>
<td>NMQ Extended version</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>At least one day off from work</td>
<td>Last 12-months: pain of at least 1 month duration in the neck, shoulder, elbow, wrist/hand or lumber spine</td>
<td>Modified NMQ</td>
<td>Percentage</td>
<td>134</td>
</tr>
<tr>
<td>Number of missed services</td>
<td>Last 12-months: playing-related symptoms in any region</td>
<td>Chimenti et al.’s questionnaire</td>
<td>Percentage</td>
<td>121</td>
</tr>
<tr>
<td>Management strategies</td>
<td>Life time: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Taken medication</td>
<td>Life time: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>Last 12-months: MSS in any body region</td>
<td>NMQ Extended version</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td>Taken NSAIDs</td>
<td>Life time: flue playing-related pain in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Last 12-months: MSS in any body region</td>
<td>NMQ Extended version</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td>Taken pain killers</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>Woldendorp et al.’s questionnaire</td>
<td>Percentage</td>
<td>131</td>
</tr>
<tr>
<td>Taken over-the-counter pain killers</td>
<td>Life time: flue playing-related pain in any region</td>
<td>Not reported</td>
<td>Percentage</td>
<td>150</td>
</tr>
<tr>
<td>Taken paracetamol</td>
<td>Current: pain in any region</td>
<td>Woldendorp et al.’s questionnaire</td>
<td>Percentage</td>
<td>131</td>
</tr>
<tr>
<td>Taken other pain medications</td>
<td>Current: pain in any region</td>
<td>Woldendorp et al.’s questionnaire</td>
<td>Percentage</td>
<td>131</td>
</tr>
<tr>
<td>Perform stretches</td>
<td>Life time: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Change posture</td>
<td>Life time: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Professional care</td>
<td>Career: playing-related symptoms in any region</td>
<td>Chimenti et al.’s questionnaire</td>
<td>Percentage</td>
<td>121</td>
</tr>
<tr>
<td>Consulted a health professional</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>Consulted a doctor, physiotherapist, chiropractor or any such person</td>
<td>Last 12-months: MSS in the neck, shoulders, elbows, wrists/hands, upper back, lower back, hip/thighs, knees, ankles/feet</td>
<td>NMQ Extended version</td>
<td>Percentage</td>
<td>68</td>
</tr>
<tr>
<td>Medical care</td>
<td>Last 12-months &amp; current: MSS in the arm/neck/shoulder</td>
<td>NR</td>
<td>Percentage</td>
<td>40</td>
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</table>
Table 6 continued

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Time period: symptom(s)</th>
<th>Questionnaire &amp; scale (if appropriate)</th>
<th>Reported as</th>
<th>Studies</th>
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</thead>
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<tr>
<td>Consulted a medical professional</td>
<td>Lifetime: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
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<tr>
<td>Consulted a general practitioner</td>
<td>Last 12-months &amp; current&lt;sup&gt;4&lt;/sup&gt;: MSS in the arm/neck/shoulder; Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>40</td>
</tr>
<tr>
<td>Consulted a specialist</td>
<td>Last 12-months &amp; current&lt;sup&gt;4&lt;/sup&gt;: MSS in the arm/neck/shoulder; Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>40</td>
</tr>
<tr>
<td>Consulted a physiotherapist</td>
<td>Lifetime: MSS in any region; Last 12-months &amp; current&lt;sup&gt;4&lt;/sup&gt;: MSS in the arm/neck/shoulder; Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>40</td>
</tr>
<tr>
<td>Consulted an occupational therapist</td>
<td>Lifetime: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Consulted a chiropractor</td>
<td>Last 12-months: ache, pain or discomfort in the neck/back/upper extremity</td>
<td>NR</td>
<td>Percentage</td>
<td>32</td>
</tr>
<tr>
<td>Consulted an alternative medicine therapist</td>
<td>Lifetime: MSS in any region; Last 12-months &amp; current&lt;sup&gt;4&lt;/sup&gt;: MSS in the arm/neck/shoulder</td>
<td>NR</td>
<td>Percentage</td>
<td>40</td>
</tr>
<tr>
<td>Did Alexander technique</td>
<td>Lifetime: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Did Feldenkrais</td>
<td>Lifetime: MSS in any region</td>
<td>NR</td>
<td>Percentage</td>
<td>145</td>
</tr>
<tr>
<td>Hospitalised</td>
<td>Last 12-months: MSS in the neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, ankles/feet</td>
<td>NMQ Extended version&lt;sup&gt;37&lt;/sup&gt;</td>
<td>Percentage</td>
<td>67</td>
</tr>
</tbody>
</table>

Combined

| Impaired musical activity and took medication | Last month: MSS in any region | Ranelli <i>et al.</i>’s<sup>14</sup> questionnaire | Percentage | 28 |
| Impaired musical activity and consulted a health professional | Last month: MSS in any | Ranelli <i>et al.</i>’s<sup>14</sup> questionnaire | Percentage | 28 |

MSS: musculoskeletal symptoms; DASH: Disability of the Arm, Shoulder and Hand; VAS: visual analogue scale; NMQ: Nordic Musculoskeletal Questionnaire; NSAIDs: non-steroidal anti-inflammatory drugs. NR: not reported; NRS: numeric rating scale.<sup>a</sup>the percentage of injuries for which workers’ compensation was claimed was reported for the head, neck, shoulder/upper arm, elbow/forearm, wrist/hand/fingers, upper back, lower back, hip/buttock/thigh, knee/lower leg, and ankle/foot/ toes, <sup>b</sup>there was no time period specified in the questionnaire<sup>211</sup>, <sup>c</sup>defined as 2–2.5 hours of playing, with a 15-minute break, <sup>d</sup>also reported for those who have had their current musculoskeletal symptoms for at least 3-months.
culoskeletal complaints, and pain, problems with gross motor skills, and fine motor skills, loss of speed, control, power and endurance, cramp, swelling and redness specifically, in the arm/neck/shoulder regions of at least 3-months duration. Woldendorp et al.\(^{131}\) reported the number of participants who had experienced current pain for <3-months, and those reporting recurrent or continuous pain for >3-months duration.

Some authors reported the number of body regions/sites where symptoms were experienced as prevalence (e.g. percentage with \(\geq 10\) pain regions\(^{35, 40, 75, 89, 124}\), or mean number of regions\(^{89}\), during the last 12-months\(^{40, 75, 89}\) or currently\(^{35, 124}\). None of the studies clearly reported what constituted a region, although in some studies it was implied. In addition, McCrary et al.\(^{174}\) reported the number of participants with one, two, or three or more current symptoms, but it is unclear whether this refers to symptomatic body regions, or the quality of symptoms.

Additionally, the mean age when playing-related pain first appeared was reported by Ioannou and Altenmüller\(^{159}\), however the time from starting playing to the onset of playing-related pain was not included.

### Symptom frequency

Two studies reported the frequency of MSS. One reported the prevalence of “rare”, “frequent” and “permanent”
Table 8. Prevalence period and body regions for studies reporting the prevalence of general symptoms

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Lifetime</th>
<th>Career</th>
<th>18-months</th>
<th>12-months</th>
<th>6-months</th>
<th>Previous summer</th>
<th>3-months</th>
<th>1-month/4-wk</th>
<th>2wk</th>
<th>1-week/7d</th>
<th>Point/Current</th>
<th>Any time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any region</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>25</td>
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<tr>
<td>Back of head/neck/shoulders</td>
<td>1</td>
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<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
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<td>Head/neck</td>
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<td>1</td>
<td>10</td>
<td>25</td>
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<tr>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Face/jaw/temple/front of ear</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>25</td>
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<td>Orofacial: head/sinuses/nose/lips/teeth/tongue/jaw/throat/face</td>
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<td>1</td>
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<td>1</td>
<td>1</td>
<td>10</td>
<td>25</td>
<td></td>
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<tr>
<td>Cheeks/jaw/temple</td>
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<td>Face</td>
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<tr>
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<td>Jaw/mouth</td>
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pain over their careers\cite{49}, however the word “permanent” implies perceptions about the pain in the future, rather than pain frequency experienced in the past. The other study\cite{177} reported the prevalence of reporting MSS as “often” or “always” during the last 3-months. The latter study\cite{177} also reported the prevalence of “symptoms longer than three months ago”, however as this descriptor was used interchangeably with greater than three months; hence these outcomes are unclear. Both studies reported outcomes specific to body regions: teeth/jaw\cite{49}, temporomandibular joint\cite{49}, head\cite{49}, neck\cite{49, 177}, shoulder\cite{49, 177}, upper arm\cite{177}, elbows\cite{49, 177}, lower arm\cite{177}, wrists\cite{49, 177}, fingers\cite{49, 177}, back\cite{177}, upper back\cite{49}, and lower back\cite{49}, with all upper limb symptoms being reported separately for each side. Woldendorp et al.\cite{177} also reported the median number of affected regions where MSS reportedly occurred often or always during the last 3-months.

Symptom intensity

The intensity of MSS was reported in 16 studies, with the most common time periods being current and 7-d (Table 9). Only two studies\cite{33, 93} reported either within the article\cite{33} or the questionnaire included in the appendix\cite{33}, sufficient detail of the MSS intensity rating (according to the criteria reported by Smith et al.\cite{17}). For one study\cite{118}, however, adequate details were included within the published questionnaire\cite{177}.

In addition to the outcomes reported in Table 9, Kreutz et al.\cite{172} reported the number of body regions (0, 1, 2, ..., 10, >10) for which pain ratings of 4–5, then 3–5 were made on a scale from 1 “non existent” to 5 “severe” pain in the last 7-d. The type of rating was not reported. The same scale was used by Ginsborg et al.\cite{171} where the number of body regions where the ratings were 2–5 was used as a regression outcome. Kreutz et al.\cite{172} reported the maximum number of regions was 28, and asked participants to rate their pain in 30 regions, while Ginsborg et al.\cite{171} did not clearly report what constituted a region in their analysis (although it appears ratings were asked for 11 body regions).

Damian and Zalpour\cite{94} reported the mean pain intensity from the pain sub-scale of the Shoulder Pain and Disability Index\cite{99}, which includes pain during certain activities, which is discussed in full in the next section.

Other outcomes

This section includes outcomes that did not fit into the above categories. The 12-month prevalence of musculoskeletal pain which was perceived to be caused by or which affected performance was reported by Heredia et al.\cite{152}, being a combination of consequences of MSS and musical activity-attributed MSS.

Chimenti et al.\cite{121} reported the 12-month prevalence for musicians who indicated that they had not had any
Table 9. Musculoskeletal symptom intensity rating scales

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<td>NR</td>
<td>Overall</td>
<td>Type NR (0–10)</td>
<td>“without pain” to “worst imaginable pain”</td>
<td>Regression outcome</td>
<td>(39)</td>
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<td>Overall</td>
<td>NR</td>
<td>Number with mild, moderate, severe ratings⁹</td>
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<td>4-wk</td>
<td>Pain</td>
<td>On average</td>
<td>Neck, upper back, L &amp; R shoulder, L &amp; R elbow, L &amp; R wrist, L &amp; R thumb, L &amp; R index finger, L &amp; R middle finger, L &amp; R ring finger, L &amp; R little finger, lower back, hips, knees, ankles</td>
<td>VAS (length NR)</td>
<td>NR</td>
<td>Mean</td>
<td>(68)</td>
</tr>
<tr>
<td>7-d</td>
<td>Pain</td>
<td>NR</td>
<td>Overall</td>
<td>VAS⁵ (length NR, reported as 1–10)</td>
<td>“minimal pain” to “intense or unbearable pain”</td>
<td>Mean</td>
<td>(40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Neck, shoulders, upper back, elbows, wrist/hand, lower back, hip/thighs, knees, ankles/feet</td>
<td>VAS⁵ (length NR, reported as 1–10)</td>
<td>“minimal pain” to “intense or unbearable pain”</td>
<td>NR</td>
<td>(43)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Back, neck, upper trapezius, shoulder, hand, face, jaw</td>
<td>11-point NRS</td>
<td>“no pain to “worst possible pain”</td>
<td>Median &amp; percentage for each of the 11 points</td>
<td>(155)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>L shoulder, R wrist</td>
<td>11-point NRS</td>
<td>“no pain” to “worst pain”</td>
<td>Mean &amp; percentage with 3 or less</td>
<td>(177)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shoulder, arm, hand</td>
<td>5-point Likert (from DASH⁷³):</td>
<td></td>
<td>Mean</td>
<td>(74)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Overall (asked for 30 regions)</td>
<td>Type NR (1–5)</td>
<td>1 “non existent” to 5 “severe”</td>
<td>Percentage rating 4–5</td>
<td>(172)</td>
</tr>
<tr>
<td></td>
<td>Pain or soreness⁴</td>
<td>Maximum</td>
<td>Neck, upper back, lower back, L &amp; R shoulder, L &amp; R elbow, L &amp; R hand/wrist, hips, knees, ankles/ knees</td>
<td>Borg’s CR10 scale⁸ :</td>
<td>0 “no trouble”, 1 “very very mild”, 2 “very mild”, 3 “mild”, 4 “mild to moderate”, 5 “moderate”, 6 “moderate to severe”, 7 “severe”, 8 “very severe”, 9 “very very severe”</td>
<td>Sensitivity/ specificity analysis (any, moderate or severe, less than severe, none/mild, none)</td>
<td>(33)</td>
</tr>
<tr>
<td></td>
<td>Stiffness</td>
<td>NR</td>
<td>Shoulder, arm, hand</td>
<td>5-point Likert (from DASH⁷³):</td>
<td>1 “none”, 2 “mild”, 3 “moderate”, 4 “extreme”, 5 “extreme”</td>
<td>Mean</td>
<td>(74)</td>
</tr>
<tr>
<td>24-h</td>
<td>Pain</td>
<td>NR</td>
<td>Unclear. Study focuses on neck and shoulder</td>
<td>VAS (length NR, reported as 0–10)</td>
<td>NR</td>
<td>Mean</td>
<td>(94)</td>
</tr>
<tr>
<td>Current</td>
<td>Symptom</td>
<td>Current</td>
<td>R shoulder, R wrist</td>
<td>Type NR (0–10)</td>
<td>NR</td>
<td>Mean</td>
<td>(54)</td>
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Table 9 continued

<table>
<thead>
<tr>
<th>Time period</th>
<th>Symptoms</th>
<th>Rating type</th>
<th>Body regions</th>
<th>Scale: Anchors</th>
<th>Anchors</th>
<th>Reported as</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>Current</td>
<td>Overall</td>
<td>Overall type</td>
<td>Type NR (0–10)</td>
<td>“without pain” to “worst imaginable pain”</td>
<td>Regression outcome</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overall</td>
<td>10 cm VAS</td>
<td>NR</td>
<td>Mean</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shoulder, neck</td>
<td>11-point NRS</td>
<td>“no pain” to “maximum pain”</td>
<td>Mean</td>
<td></td>
<td>93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neck, back/trunk, shoulder, upper arm, elbow, forearm, wrist, palm, fingers, hips, thigh, knee, calf, ankle/foot</td>
<td>Type NR (1–5)</td>
<td>“trivial pain” to “severe pain”</td>
<td>NR</td>
<td></td>
<td>38, 39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neck/shoulder/between scapula</td>
<td>Likert (0–4)</td>
<td>0 “completely healthy”, 1 “a little pain, but no problem”, 2 “quite a bit of pain, but it is possible to play”, 3 “very much pain, have to avoid certain movements”, 4 “so much pain that I sometimes cannot work”</td>
<td>Percentage rating ≥2 / in ≥1 of the 3 regions</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Combined 4 scales</td>
<td>Current</td>
<td>Upper extremity, neck, teeth/temporomandibular</td>
<td>Likert (0–5)</td>
<td>“no pain”, “very weak”, “weak”, “medium”, “heavy”, “very heavy”</td>
<td>Mean</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>(3 × 6 months &amp; current)</td>
<td>Overall</td>
<td>Type NR (1–10)</td>
<td>NR</td>
<td>Regression outcome</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined 4 scales</td>
<td>Pain</td>
<td>Worst, on average, least (6 months), and current</td>
<td>Type NR (0–10)</td>
<td>NR</td>
<td>Regression outcome</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>(3 × last 7-d &amp; current)</td>
<td>Percentage rating ≥2 / in ≥1 of the 3 regions</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VAS: visual analogue scale; NRS: numeric rating scale; CR10: Category Ratio 10; NR: not reported; L: left; R: right; DASH: Disability of the Arm, Shoulder and Hand.

*a* ranges for these classifications were not reported. 
*b* also reported as a “numeric scale”.
*c* also described as a “numeric visual analogue scale”.
*d* used a range of terminology in the report.
*e* the range and anchors are not the same as Borg’s CR10 scale, and Borg’s[93] instructions were not used.
*f* regions reported were different to the questionnaire.
*reported overall but according to the questionnaire.
*participants were asked to rate the one region they perceived to be the worst.
*p* Pain ratings prior to treatment referred to the last 24 h; however, the recall period for the post-treatment (25-min treatment) was not reported.
*c* The data were collected at follow-up for a treatment (mean 27 months), with current rating for the ‘post’ treatment rating, with the ‘pre’ treatment rating made retrospectively at follow-up with no time period specified.
*d* ratings were for the tooth, jaw, ear, head, neck, right shoulder, left shoulder, right elbow, left elbow, right wrist, left wrist, right fingers, left fingers, upper back, lower back and sciatica, and it was unclear how the regions were combined to produce the results for the three regions above.
symptoms related to playing, had symptoms after playing but not while playing, had symptoms that stopped within 15-minutes after stopping playing and while playing, had symptoms that persisted for more than 15-minutes after stopping playing and while playing, and those who had symptoms that make it difficult to perform daily activities, as well as symptoms while playing that persisted for more than 15-minutes after stopping playing. These outcomes do not match what was asked in the questionnaire.

Ranelli et al.28) reported a combined outcome, whereby the percentage of those with MSS that impaired their playing, who took medication, and who saw a health professional, during the last month. Similarly, Grier et al.172) combined the attribution and consequences, such that their outcome was foot MSS within the last 12-months that impacted upon daily activities and that foot MSS was attributed to band activities.

The mean pain sub-scale ratings from the Shoulder Pain and Disability Index99), was reported by Damian and Zalpour94). The measure refers to pain at its worst and during specific activities during the last 7-d with responses given on 11 point numeric rating scales for each item, from “no difficulty” to “so difficult it requires help”, with an overall score produced99).

One study35) reported the lifetime prevalence of MSS among participants with a past injury who had recovered from it, reporting this for whole body, as well as the head/face/lips, neck, left and right upper limb, back, jaw, mid back, lower back, left and right shoulders, left and right elbows, left and right forearms, left and right wrists, left and right hands, left and right fingers, left and right hip, left and right knee, and left and right ankle/foot. Another article34) from the same project reported this outcome only for the shoulder region, as well as the percentage of those with a history of playing-related injury who had recovered fully. These data were collected using a questionnaire developed specifically for that project23), where participants were asked to rate the amount they had recovered from their injury on a NRS (0% not recovered at all to 100% fully recovered), in 10% increments. Because the time between the onset of symptoms, and data collection was not considered, this outcome is perhaps better described as the intensity of symptoms in relation to what they were when at their worst. There were inconsistencies in the terminology used between these two reports.

Discussion

This is the first targeted review of the types of outcomes reported and data collection tools used in studies of musicians’ MSS. We built on previous systematic reviews8–14), that identified the heterogeneity of outcomes and data collection tools used, but have been limited in their inclusiveness of musical populations, in the types of studies (e.g. prevalence) covered, and in that they have focused on study findings, rather than an in-depth examination of outcomes and data collection tools.

Consistent with the existing systematic reviews8–14), we found heterogeneity in the types of outcomes reported and the data collection tools used, limiting the opportunities for synthesis of findings or comparison of findings across studies. The most common outcome type was MSS in general, following by the musical impact of MSS; most frequently using Zaza et al.’s2, 167, 168) definition of playing-related musculoskeletal disorders or slight variations thereof.

Questionnaires

Relatively few studies (24%) used existing, standardized questionnaires that had previously been used with the general population. The use of standardized questionnaires that had been used with the general population appears to be increasing, with 33% of studies published 2012–2016 using such questionnaires.

Where existing questionnaires were used, the most commonly used was the Nordic Musculoskeletal Questionnaire (NMQ)51). The NMQ is valid and reliable, in its original, translated and extended forms51, 61, 62, 64, 67), and has been used in studies with a wide range of populations194), including a national study of workers195, 196). Thus, its use with musicians allows for comparison with other groups. The recall periods (7-d and 12-months), and the body regions from the NMQ were also commonly used, suggesting that NMQ is an appropriate tool for use in most studies, which would improve the consistency of outcomes.

For functional impairment, the Neck Disability Index53–55) was also commonly used, however as the Index does not have a clear recall period, we do not recommend its use in future studies of musicians’ MSS, unless a recall period is added.

One of the potential reasons for the large number of studies not using existing standardized questionnaires is the interest in music-specific outcomes. The DASH performing arts/sports module52) was an existing measure for music-specific outcomes relating the upper limb disability due to MSS in the last 7-d. The performing arts module has only recently been investigated in terms of validity197).
While the DASH performing arts module was found to have good construct validity, discriminative validity and internal consistency\textsuperscript{197}, only traditional psychometric methods were used. Traditional psychometric methods, including Cronbach’s alpha, are underpinned by Classical Test Theory, and both the Cronbach’s alpha and Classical Test Theory have a range of limitations\textsuperscript{198–201}. As with any measure where items are combined (e.g. summed, averaged), Rasch analysis should be used to examine the measures’ utility\textsuperscript{202, 203}. Further limitations of the DASH averaged), Rasch analysis should be used to examine the any measure where items are combined (e.g. summed, allowing for critique of the methods used, as well as repli-}


cation when investigating musicians’ MSS, however these limitations must be overcome.

Regarding the prevalence of music-specific outcomes, the approach taken by Kok et al.\textsuperscript{79} and Bruno et al.\textsuperscript{135} may provide a valid means of collecting these data, by substituting Zaza et al.’s\textsuperscript{2} definition for playing-related musculoskeletal disorders, into the NMQ\textsuperscript{51}. An advantage of such an approach is that when used with the original NMQ\textsuperscript{51}, perhaps with the added regions, researchers can investigate the transition of MSS that do not impair musical activity to MSS which do impair musical activity. As this approach currently only has face validity, future research should investigate its validity and reliability.

There have only been two other questionnaires validated for use with musicians specifically\textsuperscript{117, 119}. Both integrated modified items from the DASH\textsuperscript{52} sports/performing arts module, along with either the Brief Pain Inventory\textsuperscript{204} or Chronic Pain Classification Scale\textsuperscript{205}. As with the DASH sports/performing arts module, testing of these scales\textsuperscript{117, 119} did not use modern psychometric methods, like Rasch analysis, which should be considered in further testing of these scales.

We identified a range of discrepancies between reported outcomes and the questionnaires used. These may be due to inaccurate reporting of the outcomes, or modifications being made to the questionnaires without acknowledgement and description of these changes. Accurate reporting of data collection methods and outcomes is paramount in allowing for critique of the methods used, as well as replication of, or comparison between, studies.

Music-related outcomes

Almost half (49%) of the included studies\textsuperscript{27–31, 34–39, 43, 45, 46, 49, 50, 57, 60, 75, 77, 79, 80, 89, 91–93, 113, 116, 118, 120, 121, 124, 125, 127, 128, 133, 135, 136, 138–161} reported on ‘music-related’ outcomes, with the relationship between musical activity and MSS being unclear in 58% of these studies\textsuperscript{34, 38, 39, 43, 46, 50, 57, 60, 75, 77, 89, 91, 92, 113, 120, 121, 125, 139–142, 145–151, 157–159, 162}. This lack of clarity is a problem also present in qualitative studies (e.g.\textsuperscript{206–210}), as well as studies where clinicians ‘diagnose’ ‘music-related’ MSS without reporting the diagnostic criteria (e.g.\textsuperscript{47, 48, 211}).

Where the relationship between musical activity and MSS was clearly reported, it referred to MSS which impaired musical activity\textsuperscript{27–31, 35–37, 45, 46, 79, 93, 116, 118, 124, 128, 135, 136, 138, 143, 153, 154, 156, 160}, with all bar one of the studies\textsuperscript{135} using Zaza et al.’s\textsuperscript{2, 167, 168} definition of playing-related musculoskeletal disorders. We therefore suggest that ‘music-related’ terminology be reserved for MSS that impair musical activity, using Zaza et al.’s\textsuperscript{2, 167, 168} definition. As there are some discrepancies in the definitions reported by Zaza et al.’s\textsuperscript{2, 167, 168}, the definition should still be stated to allow for accurate interpretation of the study findings. Zaza et al.\textsuperscript{2} developed the definition and question regarding ‘playing-related musculoskeletal disorders’ through focus groups with professional musicians and health professionals, with the question posed as “do you have pain, weakness, lack of control, numbness, tingling, or other symptoms that interfere with your ability to play your instrument at the level you are accustomed to?”\textsuperscript{52} We recommend this question be used in data collection, where appropriate. The applicability of Zaza et al.’s\textsuperscript{2} definition of ‘playing-related musculoskeletal disorders’ to children should be examined.

A limitation of the term ‘playing-related musculoskeletal disorder’ and corresponding definition\textsuperscript{2, 167, 168} is that it only relates to instrumentalists. Hence, where other musicians (e.g. singers, conductors) are being investigated the term ‘music-related musculoskeletal disorders’ may be more appropriate, and ‘musical activities’ substituted for ‘playing’. We would caution against the term ‘performance-related’ which has been used in a number of studies\textsuperscript{30, 31, 34–37, 77, 124, 127, 133, 140–142, 146, 148, 154, 156, 158, 160}, because it implies the symptoms relate to undertaking a public performance. However, where a definition was provided for these studies\textsuperscript{35–37, 124, 127, 133, 154, 156, 160} it referred to playing, not performing per se, which may lead to confusion. Similarly, statements such as ‘associated with playing’ which was used in some studies\textsuperscript{121, 145, 155, 157} should be avoided due to potential confusion with a statis-
tical association between playing and MSS\textsuperscript{179}.

**Rating scales**

Regarding the rating scales used, only two studies\textsuperscript{33, 93} reported the measure in sufficient detail to allow for accurate interpretation of the findings. The key problems were ambiguity in the types of scales being reported, not reporting of the scale length and anchors, as well as not reporting the type of rating made (e.g. at its worst, or on average). Such problems are not isolated to this group of studies. Smith et al.\textsuperscript{17} recently reviewed pain intensity ratings used in studies published in the three main pain journals and identified similar issues concerning reporting.

Both the VAS and NRS were used frequently, with no clear difference between the two regarding improving consistency. Looking at the broader literature, both the NRS and VAS have good reliability and validity\textsuperscript{212}, however the 11-point NRS is generally recommended, over the VAS\textsuperscript{212, 213}, as it is preferred by both respondents\textsuperscript{214, 215} and researchers (given it has better compliance than the VAS\textsuperscript{212, 213, 215, 216}, and is considered easier to use\textsuperscript{212}).

The NRS appears to be the most commonly used rating scale for pain intensity\textsuperscript{17}, and it has also been deemed an appropriate measure of pain intensity for children and adolescents\textsuperscript{217}, potentially allowing for comparisons between child and adult musicians’ MSS experiences.

The advantage of the NRS is that it is easy to comprehend\textsuperscript{212}, which may be more important in self-administered questionnaires where clarification of the instructions cannot be sought. As the VAS requires participants to indicate their level of pain on a 100 mm line, resulting in a 101-point scale, the VAS requires high levels of motor control to provide an accurate rating\textsuperscript{212}, which may be an important consideration when administering to people who may be experiencing upper limb symptoms. The NRS does not require this level of fine motor control. The NRS can also be completed verbally, allowing for data to be collected over the telephone\textsuperscript{212}.

The disadvantage of the NRS is that it might not have ratio properties\textsuperscript{212}. While it has been argued in the past that the VAS does\textsuperscript{212}, recent studies have questioned this\textsuperscript{218, 219}. Ordinal data should not be analysed using parametric statistics\textsuperscript{202}, however we identified a number of studies\textsuperscript{98, 72, 74, 77, 83, 93, 94, 98, 118, 130, 160, 171, 177} analysing ordinal data using parametric statistics. Ordinal data are inappropriate for longitudinal studies (e.g. intervention studies)\textsuperscript{202}, however a number of included longitudinal studies reported changes in ordinal data\textsuperscript{94, 98, 130, 160}. Although the NRS appears to be the most appropriate measure for rating the intensity and frequency of MSS and their consequences; the accurate and complete reporting of the scales and correct selection of statistical methods is vital, and for longitudinal studies aggregate scales should be used, so that the data can be transformed into interval level data, via Rasch analysis.

Few studies specified the type of intensity rating being made (e.g. at its worst or on average), which may influence the validity of the scales; an issue again evident in the broader literature\textsuperscript{17}. There is evidence to suggest that aggregate measures\textsuperscript{212}, like those in the Brief Pain Inventory\textsuperscript{204}, of pain at its worst, on average, at its least, and sometimes current pain improve the validity of the ratings\textsuperscript{220–222}, as was done in two studies\textsuperscript{118, 120}. This approach has not however been tested using modern psychometric methods, such as Rasch analysis; hence, it cannot be assumed a valid and reliable measure. Where only a single item is included, it has been recommended that participants be asked to rate the intensity of their MSS on average over specific time period\textsuperscript{212}, an approach which has been found to be valid\textsuperscript{223}; however, the implications of using ordinal data must be considered. Caution should be exercised when asking participants about their current pain intensity, as pain intensity is susceptible to diurnal variation, as well as to changes in behaviour (e.g. medications, activities\textsuperscript{212, 221, 222}). As such, these factors should be controlled when current measures as taken. Regardless of the scales being used, future studies should refer to the recommendations made by Smith et al.\textsuperscript{17}, to ensure that these scales are adequately reported.

We found little consistency in the anchors used for pain rating scales, which may impact upon findings\textsuperscript{224}. For consistency, we recommend using “no pain” and “pain as bad as you can imagine”, which are the anchors from the Brief Pain Inventory\textsuperscript{204}, that have been recommended for use to improve consistency for chronic pain trials\textsuperscript{215}.

**Body regions**

Regarding the body regions reported, the regions from the NMQ\textsuperscript{51} were most frequently reported, and the laterality of symptoms most commonly investigated in the upper limb, as per the NMQ\textsuperscript{51}. As musicians have unique physical demands, other regions may be of interest. We have seen the diaphragm/abdominal muscle and lip/oral regions added in Engquist et al.\textsuperscript{’s}\textsuperscript{69} modified NMQ, while Kok et al.\textsuperscript{79} added the head and jaw/mouth regions.

Few studies referred to using body charts, while others are likely to have used the body charts from the cited questionnaires. Body charts assist in terms of identifying
what is meant by terms like the ‘arm’ where in some cases this appears to be the area between the shoulder and wrist, while others may indicate that the arm includes the shoulder, wrist and hand. Body charts make this clearer both for the participants, and for the users of the research. Again clear reporting of the body regions, ideally with the aid of a body chart, is required to allow for synthesis and comparison of findings between studies.

**Recall periods**

The recall periods used were generally not reported clearly enough to allow meaningful data to be extracted. A total of 28 studies did not report recall periods for any outcome, and 32 did not do so for some outcomes. The lack of reporting regarding time periods has been identified in reviews of pain outcomes177, and broader health issues in other groups225, 226, indicating that this is not an issue unique to the research of musicians’ MSS, but rather a widespread issue which needs addressing.

The most commonly used recall periods identified in this review were lifetime, 12-months, 7-d, and current. There were a number of examples of recall periods being used interchangeably and/or not matching the recall periods used in the questionnaire28, 35, 57, 79, 83, 118, 121, 153. One of the most common problems was with use of the terms ‘point prevalence’ or ‘current MSS’ where this referred to recall periods as long as three months177. Furthermore, the studies34–37, 124 using Ackermann and Driscoll’s123 questionnaire have ambiguous estimates of current symptoms or the intensity of symptoms because the questionnaire specifies that these outcomes referred to current pain/injury as “pain or injury present, or that has been present for at least the past 7 d”123. Reference to this statement was not made in any of these studies34–37, 124. The terms current and point prevalence should be reserved for MSS at the time of data collection, consistent with normal epidemiological practice227. As discussed earlier, data regarding current symptoms may be susceptible to diurnal variation and behaviours prior to data collection212, 221, 222, hence caution must be applied with these measures.

Both lifetime and career prevalence may be problematic given the differences in one’s age or career duration; however career prevalence highlighted some additional concerns. For instance, Árnason et al.153 referred to career prevalence, however their population of interest was university students; hence this may indicate university career, or perhaps the time from commencing their musical studies. Regarding the selection of recall periods, it has been suggested that prevalence studies use recall periods of 12-months or less, to reduce the influence of memory decay211. As the most common recall periods for prevalence of MSS were 12-months and 7-d, we suggest these recall periods be used in future studies.

Regarding the ratings of the intensity of MSS or their consequences, we saw that most studies used 7-d or current ratings. The 7-d recall periods for pain intensity are valid223, 228–230 and reliable229, and are not considered difficult for most people228. The 7-d recall period is also in keeping with the recommendation that recall periods for pain intensity ratings be less than 3-months to maintain validity of the ratings212. While current ratings reduce recall bias, they are also susceptible to diurnal variation212, hence current pain ratings for research purposes may be inappropriate. Where these are used, there should be standardisation of the data collection methods to minimise the influence of potential confounders (e.g. time of day).

For ratings of MSS consequences, we found the most commonly used recall periods were 7-d. In other populations, it has been recommended that recall periods should not exceed one month231, with no significant differences in 1-, 3–7- and 28-d recall periods for pain interference231. Considering the findings of our review, and the broader literature, 7-d recall periods are therefore also recommended for ratings of the consequences of MSS.

**Limitations**

As outlined above, this is the first review to focus on the types of MSS outcomes reported in studies of musicians, and the data collection methods used, without restricting the review to a type of musician or type of study.

Given the broad nature of the review, and to maximise the relevance to future research, we focused on studies published in a 10 year period (2007–2016). While there may be other outcomes or data collection methods used in studies prior to 2007, if these have not been used more recently, the inclusion of earlier studies would not have altered the recommendations of our review.

Our review was restricted to studies published in English language, and we may therefore have missed some potentially relevant studies published in other languages; however, the addition of non-English studies would be unlikely to change the findings and recommendations of the present review. As recently discussed by Tsertsvadze et al.232 excluding non-English studies in reviews does not tend alter the findings233–235, however this may depend upon the study topic234, 236, 237. It has been suggested that as the proportion of studies published in English increases, language biases decrease238; hence our review is
unlikely to be impacted by such a bias. Further, two recent reviews\(^9\)\(^,\)\(^14\) of musicians’ musculoskeletal symptoms did not restrict the language of included studies, yet no non-English studies were included. Although these reviews\(^9\)\(^,\)\(^14\) considered a narrower range of topics and musician types, this finding again indicates that the findings of the present review would not be expected to change.

The search, study selection and data extraction were carried out by one reviewer, with uncertainties regarding study selection checked by a second reviewer and data extraction performed twice by one reviewer and checked by another reviewer. With a comprehensive search strategy employed, involving searching databases, screening the titles of *Medical Problems of Performing Artists*, and screening the citation and reference lists of relevant studies it is unlikely that any relevant studies were missed. Regarding data extraction, evidence suggests that review findings do not change whether double extraction or single extraction with verification is performed\(^16\), and the latter is therefore deemed an acceptable approach\(^15\).

**Summary of recommendations**

Our recommendations regarding MSS assessment for musicians, based on the current evidence for both the types outcomes and data collection methods used, and on the broader literature around validity and reliability, are summarized in Table 10. Regardless of the MSS assessment tools used, these must be reported in sufficient detail to allow for replication (e.g. recall period, body regions, questionnaires used, the type and length of rating scales used).

**Conclusion**

We aimed to improve the consistency of reported outcomes and tools used in musicians’ MSS research, by documenting and reviewing parameters from published papers. Based on the most common outcomes and tools used with musicians, and the broader literature, we developed recommendations, as summarised in Table 10, to improve the consistency of outcomes and data collection tools used in future studies of musicians’ MSS. We also identified that there is a need for consistency and clear reporting of the tools used and outcomes reported for musicians’ MSS research. Opportunities for future research into music-specific data collection tools, as well as validation of existing tools for use with musicians were identified. By improving this consistency, as well as developing valid tools of music-specific MSS outcomes, it is anticipated that the quality and consistency of research into musicians’ MSS will improve, along with opportunities for synthesis and comparison of research findings across studies. Strengthening the body of evidence around musicians’ MSS should lead to improved recommendations for prevention and management of MSS for this population.

**Acknowledgements**

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**References**


*Industrial Health* 2019, 57, 454–494
Table 10. Summary of recommendations

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Supporting evidence from the present review</th>
<th>Other evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questionnaire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For the prevalence of MSS the NMQ is recommended</td>
<td>Most commonly used standardised questionnaire</td>
<td>Valid and reliable&lt;sup&gt;51, 61, 62, 64, 67&lt;/sup&gt; Used with a range of populations&lt;sup&gt;194-196&lt;/sup&gt;</td>
</tr>
<tr>
<td>For MSS which impair musical activity the NMQ&lt;sup&gt;51, 167, 168&lt;/sup&gt; definition for playing-related musculoskeletal disorders incorporated is suggested</td>
<td>Most commonly used standardised questionnaire</td>
<td>Zaza et al.’s&lt;sup&gt;2, 167, 168&lt;/sup&gt; definition for playing-related musculoskeletal disorders was developed through focus groups with musicians</td>
</tr>
<tr>
<td><strong>Rating Scales</strong></td>
<td></td>
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<tr>
<td>NRS (11-point) is recommended</td>
<td>The 11-point NRS and VAS were often used</td>
<td>The NRS is preferred over the VAS&lt;sup&gt;212-216&lt;/sup&gt; Valid and reliable&lt;sup&gt;212&lt;/sup&gt; Most commonly used rating scale for pain intensity&lt;sup&gt;7&lt;/sup&gt; Recommended for pain intensity ratings&lt;sup&gt;215&lt;/sup&gt;</td>
</tr>
<tr>
<td>For pain intensity, the anchors “no pain” to “pain as bad as you can imagine” should be used</td>
<td>Used in a study of pain intensity&lt;sup&gt;118&lt;/sup&gt; with similar anchors used in others&lt;sup&gt;175, 177, 179&lt;/sup&gt;</td>
<td>Recommended anchors for pain intensity&lt;sup&gt;215&lt;/sup&gt;</td>
</tr>
<tr>
<td>Multiple measures (e.g. worst, on average, least) should be considered, if this is not possible pain on average should be used (except in longitudinal studies)</td>
<td>Aggregate measures were used in two studies of musicians&lt;sup&gt;118, 120&lt;/sup&gt;</td>
<td>Aggregate measures to improve the validity&lt;sup&gt;212, 220-222&lt;/sup&gt; Ratings of pain intensity ‘on average’ are valid&lt;sup&gt;223&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Body regions</strong></td>
<td></td>
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<tr>
<td>The body regions from the NMQ&lt;sup&gt;51&lt;/sup&gt; are suggested, along with the NMQ body chart</td>
<td>The NMQ&lt;sup&gt;51&lt;/sup&gt; is the most commonly used standardised questionnaire The NMQ body regions are the most commonly reported</td>
<td>Allow for comparison with a range of other populations&lt;sup&gt;194-196&lt;/sup&gt;</td>
</tr>
<tr>
<td>The addition of the head, orofacial and chest/abdomen regions should be considered</td>
<td>The head and orofacial regions have been investigated previously and added to the NMQ&lt;sup&gt;79&lt;/sup&gt;</td>
<td>These body regions may be of particular interest for wind instrumentalists, singers and upper string players</td>
</tr>
<tr>
<td><strong>Recall periods</strong></td>
<td></td>
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<tr>
<td>For the prevalence of symptoms, we recommend recall periods of 12-months and/or 7-d</td>
<td>Most commonly used recall periods were 12-months, 7-d and current, however ‘current’ poses issues of validity and reliability Most commonly used standardised questionnaire</td>
<td>Recall periods for the prevalence of symptoms should not exceed 12-months to reduce memory decay&lt;sup&gt;21&lt;/sup&gt; Allow for comparison with a range of other populations&lt;sup&gt;194-196&lt;/sup&gt;</td>
</tr>
<tr>
<td>For ratings of MSS, we recommend a 7-d recall period</td>
<td>Most commonly used recall period for ratings are 7-d for MSS intensity and frequency, and MSS consequences intensity and frequency</td>
<td>7-d recall periods are valid&lt;sup&gt;223, 228-230&lt;/sup&gt; and reliable&lt;sup&gt;229&lt;/sup&gt; for MSS intensity, and valid for pain interference ratings&lt;sup&gt;231&lt;/sup&gt; 7-d recall periods are not considered difficult by most people&lt;sup&gt;228&lt;/sup&gt; Recall periods for ratings of pain intensity should not exceed 3-months to improve validity&lt;sup&gt;212&lt;/sup&gt; Recall periods for ratings of pain interference should not exceed 1-month to improve validity&lt;sup&gt;211&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

NMQ: Nordic Musculoskeletal Questionnaire; MSS: musculoskeletal symptoms; VAS: visual analogue scale; NRS: numerical rating scale. *the definition may need to be modified for use with non-instrumental musicians, but should be clearly reported.

instrumental musicians: a systematic review. Med Probl Perform Art 30, 8–19. [Medline] [CrossRef]


35) Kenny D, Ackermann B (2015) Performance-related...
musculoskeletal pain, depression and music performance anxiety in professional orchestral musicians: a population study. Psychol Music 43, 43–60. [CrossRef]


82) Dixon D, Johnston M, McQueen M, Court-Brown C (2008) The Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH) can measure the impairment, activity limitations and participation restriction constructs from the International Classification of Functioning, Disability and Health (ICF). BMC Musculoskelet Disord 9, 114. [Medline] [CrossRef]
87) Zamorano AM, Riquelme I, Kleber B, Altenmüller E, Hatem SM, Montoya P (2015) Pain sensitivity and tactile spatial acuity are altered in healthy musicians as in chronic pain patients. Front Hum Neurosci 8, 1016. [Medline] [CrossRef]


the Pain Numeric Rating Scale when applied to multiple body regions among professional musicians. PLoS One 11, e0161874. [CrossRef]


ASSESSING MUSICIANS’ MUSCULOSKELETAL SYMPTOMS


Joint Bone Spine 78, 510–5. [Medline] [CrossRef]


234) Pham B, Klassen TP, Lawson ML, Moher D (2005) Language of publication restrictions in systematic reviews gave different results depending on whether the intervention was conventional or complementary. J Clin Epidemiol 58, 769–76. [Medline] [CrossRef]


Appendix 1. Search strategy

Database search
Using the search terms reported in Appendix Table 1, seven databases (Web of Science Core Collection, Cochrane Library, EbscoHost Music Index, EbscoHost Health Source: Nursing and Academic Edition, EbscoHost Cumulative Index to Nursing and Allied Health Literature, Ovid Embase and Ovid Medline) were searched in January 2017. Where possible the search was limited to English language and the publication dates 2007–2016.

Titles of articles published in Medical Problems of Performing Artists from 2007–2016 were screened, as well as the Abstracts section of the journal. Any titles that reported performing artists or musicians, and health, medical or musculoskeletal conditions were added to the Endnote library.

Within the Endnote library, duplicates were removed, before the titles and abstracts were screened. At this stage any studies that were not published in English language, in full text, within peer reviewed journals (according to Ulrich’s Web Serial Analysis System), from 2007–2016 were excluded, as were studies where musicians’ musculoskeletal symptoms (MSS) were not reported, nor broader terminology (e.g. performing artists’ health problems) which may have included musicians’ MSS. Full texts were then screened using the same criteria, however at this stage they had to clearly report musicians’ MSS. In addition, full text screening excluded studies that only reported symptoms during clinical examinations (e.g. trigger point pain) or musculoskeletal signs in the absence of symptoms. We also excluded correspondence, case reports, editorials and narrative reviews (i.e. reviews which did not meet the Preferred Reporting Items of Systematic Reviews and Meta-Analysis definition of a systematic review); however these studies were retained for citation and reference list screening.

The citation lists (Google Scholar and Web of Science) and reference lists of included studies, and relevant narrative reviews, editorials, correspondence and case reports were screened for potential inclusion. The process continued until no additional studies were identified.
Appendix Table 1. Search terms

| Title or keyword | Musician* OR “music-related” OR “music related” OR conservatory OR conservatories OR conservatorium* OR conservatoire* OR woodwind* OR flute OR flutes OR flautist* OR flutist* OR clarinet* OR sax OR saxes OR saxophone* OR *bassoon* OR oboe* OR oboist* OR “double reed”* OR “Double reed”* OR trumpet* OR trombone* OR tuba OR tubas OR tubist* OR bugle* OR cornet* OR euphonium* OR violin* OR violinist* OR viola OR violas OR violist* OR *cello OR *cellos OR *cellist OR guitar* OR fiddle* OR banjo* OR baritone* OR piano* OR pianist* OR timpani* OR hornist* OR bassist* OR bagpipe* OR drummer* OR percussionist* OR harpist* OR harp OR harps OR harpsichord* OR organist* OR “church organ”* OR “pipe organ”* OR keyboardist* OR instrumentalist* OR vocalist* OR sing OR singer* OR singing OR choir* OR orchestra OR orchestras OR “playing-related” OR “performance-related” OR “playing related” OR “performance related” OR musical* OR (music near/3 (major* OR study* OR teach* OR tuition OR training OR education* OR school* OR perform* OR rehearse* OR play* OR practice* OR concert* OR band* OR ensemble* OR instrument*)) OR ((wind* OR *reed* OR brass OR string* OR horn* OR bass* OR bassoon* OR recorder* OR pipe OR pipes OR pipe OR pipe OR pipes OR drum* OR percussion* OR organ OR organs OR keyboard* OR vocal* OR voice) near/3 (major* OR study* OR teach* OR tuition OR training OR education* OR school* OR perform* OR rehearse* OR play* OR practice* OR concert* OR band* OR ensemble* OR instrument* OR music* OR corp OR corps)) OR “instrumental music”* OR ((band* OR ensemble*) near/3 (music* OR stage OR big OR folk OR country OR brass OR wind OR string OR percussion OR jazz OR baroque OR Dixieland OR traditional OR Irish OR march* OR military OR army OR defence OR navy OR force OR member*)) OR “marching art”* OR “performing art”* OR (conductor* near/3 (music* OR band* OR orchestra* OR ensemble*)) OR “musical director”* OR “drum major”* OR opera OR operas OR operatic

| MeSH^ | Musculoskeletal diseases OR pain OR “wounds and injuries” |
| Emtree^ | Musculoskeletal disease OR pain OR injury |
| CINAHL subject heading^ | Musculoskeletal diseases OR pain OR “wounds and injuries” |
| Health Source subject headings^ | Musculoskeletal system – diseases OR pain or “wounds & injuries” |

*indicates truncation, near/3 means 3 words between, ^ all terms were exploded where this was available in the database.
Appendix Table 2. Recall periods and symptom quality of general symptom prevalence

<table>
<thead>
<tr>
<th>Symptoms(^a)</th>
<th>Lifetime</th>
<th>Career</th>
<th>18-months</th>
<th>12-months</th>
<th>6-months</th>
<th>Previous summer</th>
<th>3-months</th>
<th>1-month/4-wk</th>
<th>2wk</th>
<th>1-week/7-d</th>
<th>Point/current</th>
</tr>
</thead>
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<td>Ache/pain/discomfort</td>
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<td>40–42, 57, 83, 121, 137, 152</td>
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<td>178</td>
<td>57, 66, 83, 124, 139, 174, 178</td>
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<tr>
<td>Pain/discomfort/tension</td>
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<td>70</td>
<td>32, 68</td>
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<td>32</td>
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<td>Clicking/popping</td>
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<td>Reduced range of motion</td>
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<td>Cramp</td>
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<td>40, 152</td>
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<td>Muscle fatigue</td>
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<td>Loss of speed</td>
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<td>Redness</td>
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<td>Numbness</td>
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<td>Weakness</td>
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</table>

\(^a\)where more than three symptom types were specified these were classified only as symptoms.
Appendix Table 3. Prevalence period and body regions for studies reporting the prevalence of general symptoms

<table>
<thead>
<tr>
<th>Region</th>
<th>Lifetime</th>
<th>Career</th>
<th>18-months</th>
<th>12-months</th>
<th>6-months</th>
<th>Previous summer</th>
<th>3-months</th>
<th>1-month/4-wk</th>
<th>2wk</th>
<th>1-week/7d</th>
<th>Point/Current</th>
</tr>
</thead>
<tbody>
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<td>Any region</td>
<td></td>
<td></td>
<td>34, 35, 139, 142, 145, 151</td>
<td>70)</td>
<td>124)</td>
<td>41, 42, 57, 60, 75, 89, 121, 137, 152</td>
<td>120)</td>
<td>140)</td>
<td>49)</td>
<td>170)</td>
<td>57, 72, 171)</td>
</tr>
<tr>
<td>Back of head/neck/shoulders</td>
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<td>178)</td>
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<tr>
<td>Head/neck</td>
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<td></td>
<td>72)</td>
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<tr>
<td>Head/face/lips</td>
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<td>35)</td>
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<tr>
<td>Head</td>
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<td>49)</td>
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<td>Orofacial: head/sinuses/nose/lips/teeth/tongue/jaw/throat/face</td>
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<td>171)</td>
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<tr>
<td>Cheeks/jaw/temple</td>
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<td>Temporomandibular joint</td>
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<td>49, 50)</td>
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<td>Jaw/mouth</td>
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<td>178)</td>
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L: left, R: right, L/R: the sides were reported separately. *Appears to be an overall measure, but the studies focused on specific body regions (i.e. the upper limb83 and the neck/shoulder/arm40) so these values may relate only to these body region.