Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

Date: Diane Alicia Longstreet
Dedication

This thesis is dedicated to the memory of my parents

Professor James Rubert Longstreet and Wilda Graul Longstreet

They led by example, and their faith in me was without measure.

I just wish they were here to see it finished.
PUBLICATIONS AND PRESENTATIONS

The following articles have been published or accepted for publication or presentation during the period of PhD candidature, and sections of these articles have been included in the present thesis.

Published Journal Papers:


Submitted Journal Papers:


**Published Abstracts:**


**Conference Presentations:**

“Magnesium and diabetes in an urban Indigenous population” Presented 9 September 2006 at the Dietitians Association of Australia– Queensland Professional Development Day, Brisbane, Queensland, Australia

“Lower serum magnesium levels in Indigenous Australians: Potential causes and their relationship to type 2 diabetes” Presented 26 October 2006 at the 11th International Magnesium Symposium, Kashikojima, Japan

“Lower serum magnesium found in Indigenous Australians and its implication for type 2 diabetes”. Oral abstract presented 9 July 2008 at the 68th scientific sessions of the American Diabetes Association, San Francisco, California, USA

**Other Scientific Presentations:**

“A Study of Magnesium and Diabetes among Urban Indigenous Australians” Presented 22 July 2004, Department of Pathology, University of Adelaide, Adelaide, South Australia, Australia

“Magnesium, Diabetes, and the Urban Indigenous Peoples: What have we learned thus far?” Presented 17 May 2006, Medical staff in-service, Townsville Aboriginal & Islander Health Service, Ltd, Townsville, Queensland, Australia

“Magnesium and diabetes: Implications for the Australian Indigenous people” Presented 21 August 2006 Townsville Hospital Professional Journal Club, Townsville, Queensland, Australia

“The impact of magnesium on diabetes and its implication for the health of Indigenous Australians” Presented 16 January 2008 to the Townsville Aboriginal and Islander Health Service Board of Directors, Townsville, Queensland, Australia; in completion of the ethical obligation to return research to the Aboriginal and Torres Strait Islander peoples.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>ACR</td>
<td>Albumin to creatinine ratio</td>
</tr>
<tr>
<td>ADA</td>
<td>American Diabetes Association</td>
</tr>
<tr>
<td>AI</td>
<td>Adequate Intake</td>
</tr>
<tr>
<td>ATP</td>
<td>Adenosine triphosphate</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>BMR</td>
<td>Basal Metabolic Rate</td>
</tr>
<tr>
<td>BP</td>
<td>Blood pressure</td>
</tr>
<tr>
<td>BSL</td>
<td>Blood glucose</td>
</tr>
<tr>
<td>Ca$_i$</td>
<td>Ionic Calcium</td>
</tr>
<tr>
<td>CRP</td>
<td>C-reactive protein</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>EAR</td>
<td>Estimated Average Requirement</td>
</tr>
<tr>
<td>ESRD</td>
<td>End stage renal disease</td>
</tr>
<tr>
<td>GP</td>
<td>General Practitioner</td>
</tr>
<tr>
<td>HbA1c</td>
<td>Glycosylated haemoglobin</td>
</tr>
<tr>
<td>HDL</td>
<td>High density lipoprotein</td>
</tr>
<tr>
<td>HOMA</td>
<td>Homeostasis model assessment</td>
</tr>
<tr>
<td>LDL</td>
<td>Low density lipoprotein</td>
</tr>
<tr>
<td>LGA</td>
<td>Local Government Area</td>
</tr>
<tr>
<td>MgATP</td>
<td>Magnesium- Adenosine triphosphate complex</td>
</tr>
<tr>
<td>Mg$_i$</td>
<td>Ionic or free serum magnesium</td>
</tr>
<tr>
<td>Mg$_s$</td>
<td>Total serum magnesium</td>
</tr>
<tr>
<td>NHLIBI</td>
<td>National Heart Lung and Blood Institute</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>NNS</td>
<td>1995 National Nutrition Survey</td>
</tr>
<tr>
<td>NRV</td>
<td>Nutrient Reference Value</td>
</tr>
<tr>
<td>RDA</td>
<td>Recommended Daily Allowance</td>
</tr>
<tr>
<td>RDI</td>
<td>Recommended Dietary Intake</td>
</tr>
<tr>
<td>RNA</td>
<td>Ribonucleic acid</td>
</tr>
<tr>
<td>SD</td>
<td>Statistical Division</td>
</tr>
<tr>
<td>sd</td>
<td>standard deviation</td>
</tr>
<tr>
<td>sem</td>
<td>standard error of the mean</td>
</tr>
<tr>
<td>TAIHS</td>
<td>Townsville Aboriginal and Islander Health Service, Ltd</td>
</tr>
<tr>
<td>TCA cycle</td>
<td>Tricarboxylic acid cycle</td>
</tr>
<tr>
<td>UL</td>
<td>Upper Level of Intake</td>
</tr>
<tr>
<td>WAT</td>
<td>Walkabout Together Program</td>
</tr>
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ABSTRACT

Diabetes in Indigenous Australians occurs at a younger age and at almost four times the rate of non-Indigenous Australians. While the cause for this health disparity is multifactorial, recent studies suggest that nutrition, and particularly magnesium intake, may play a role in onset of diabetes and related pathologies. No study has ever examined whether there is any relationship between diabetes and magnesium intake in Indigenous Australians, and the present study therefore sought to establish whether any such interrelationship existed. As part of this study, dietary magnesium intake was estimated in an urban cohort of Aboriginal and Torres Strait Islander subjects and compared to the average Australian dietary intake. An ecological study then explored environmental correlates, and specifically the magnesium level in drinking water, to diabetes mortality. Finally, total and free serum magnesium concentrations were determined to identify any differences in magnesium status between diabetic and non-diabetic Indigenous and non-Indigenous Australians, and also to compare which of the two parameters was a more sensitive measure of magnesium status and diabetic risk.

All Aboriginal and Torres Strait Islander people that were recruited for this study were patients of the Townsville Aboriginal and Islander Health Services, Townsville, North Queensland, who presented for health monitoring and subsequently required fasting blood tests as part of that routine care. Additional non-Indigenous people were recruited from five GP practices in the Townsville area. Inclusion criteria included persons over the age of 15 (Tanner Stage 5) who had lived in the Townsville area for at least ten days. Exclusion criteria included chronic diarrhoea, alcoholism or binge drinking in the past two weeks, use of diuretics, consumption of magnesium supplements, reduced renal function (urinary albumin to creatinine ratio exceeding > 2.5 mg/mmol in men and > 3.5 mg/mmol in women), severe mental illness, pregnancy, or breastfeeding. Our results indicated that 60% of the Indigenous people assessed in this study had a dietary intake of magnesium that
was below the estimated average magnesium requirement for half the national population. Additionally, the average magnesium intake in Indigenous Australians was significantly less than the intake of non-Indigenous Australians (p<0.001). A significant negative correlation was found between the incidence of diabetes related mortality and the concentration of magnesium in drinking water in Queensland, confirming previous reports from the USA that drinking water magnesium may be an important factor in development of diabetes. The needs assessment study confirmed that diabetes in both Indigenous and non-Indigenous Australians was associated with reduced levels of total serum magnesium, and more importantly, that total serum magnesium was lower in Indigenous Australians who did not have diabetes compared with their non-Indigenous counterparts (p=< 0.001).

In the absence of diabetes, the prevalence of hypomagnesaemia was 17.2% for the non-Indigenous but 36.9% for the Indigenous subjects. Finally, the ionic serum magnesium analysis confirmed the results of the total serum magnesium study, and demonstrated that ionic magnesium was strongly correlated to the total magnesium concentration (r: 0.75. p < 0.001), with the relationship being apparent irrespective of either diabetic (r: 0.66 to 0.81. p<0.001) or ethnicity (r = 0.71 to 0.81. p<0.001)." We conclude that although not causal, the evidence suggests that magnesium may be a significant contributing factor to diabetes in Australia, especially for Aboriginal and Torres Strait Islander peoples, and that further investigation of the potential relationship between magnesium and diabetes in the Australian Indigenous populations, and possible corrective interventions, is highly warranted.