Aboriginal and Torres Strait Islander readers are warned that this thesis may contain images of deceased people.



Theme: In Kaurna language "Paiendi Kokotinna Tidna" means "Seeking Healthy Feet".

Title: An investigation into ankle joint dorsiflexion, musculoskeletal injury, arch height, foot pressure and diabetes in association with poor foot health outcomes in an Aboriginal population.

> James Charles M Pod The Wollotuka Institute University of Newcastle

Declarations

Statement of Originality

I hereby certify that to the best of my knowledge and belief this thesis is my own work and contains no material previously published or written by another person except where due references and acknowledgements are made. It contains no material which has been previously submitted by me for the award of any other degree or diploma in any university or other tertiary institution.

James Charles

Thesis by Publication

I hereby certify that this thesis is in the form of a series of *papers. I have included as part of the thesis a written statement from each co-author, endorsed in writing by the Faculty Assistant Dean (Research Training), attesting to my contribution to any jointly authored papers. (*Refer to clause 39.2 of the Rules Governing Research Higher Degrees for acceptable papers).

Candidate

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I would like to acknowledge and thank Mr Terry Johnston (Aboriginal Artist) for providing some fantastic Aboriginal art. Figure 1 and figure 2 were produced specifically to represent this research project and the podiatry service provided to the Aboriginal and Torres Strait Islander communities involved.

I would like to acknowledge several Aboriginal and Torres Strait Islander communities named below for their support and contribution to this PhD.

Aboriginal Communities Involved: The Awabakal, Worimi, Kaurna, Biripi, Darug, Paakantji, Ngiyampaa and the Mutthi Mutthi Aboriginal communities.



Figure 1: Aboriginal Art, Feet Health.

Terry Johnston Painting Story: Middle circle representing practice, people standing around practice, footprints around circle showing people coming and going.



Figure 2: Aboriginal Art, Tree of Medicine

Terry Johnston Painting Story: Showing tree of medicine, knowledge, showing people seated around service, footprints around practice showing people walking more healthily.

List of publications included as part of the thesis

Journal Articles

- Charles J. (2015) An investigation into the foot health of Aboriginal and Torres Strait Islander peoples: a literature review. *Australian Indigenous HealthBulletin* 15(3). http://healthbulletin.org.au/articles/an-investigati...erature-review/
- Charles J, Scutter SD, Buckley J. Static Ankle Joint Equinus: Toward a Standard Definition and Diagnosis. *Journal of the American Podiatric Medical Association*. 2010;100(3):195-203.
 doi: <u>http://dx.doi.org/10.7547/1000195</u>
- Charles J. The design, development, and reliability testing of a new innovative device to measure ankle joint dorsiflexion. *Journal of American Podiatric Medical Association* 2016; (In Press) Manuscript Number 14-051R2 Accepted 01/06/15.
- 4. Charles J. (2015) An evaluation and comprehensive guide to successful Aboriginal health promotion. *Australian Indigenous HealthBulletin* 16(1). <u>http://healthbulletin.org.au/articles/an-evaluation-and-comprehensive-guide-to-successful-aboriginal-health-promotion</u>
- Charles J, Coda A, Chuter V. The relationship between ankle joint range of dorsiflexion, arch height and barefoot plantar pressures in Aboriginal Australians. Submitted to *Gait and Posture* 16/06/16.
- Charles J, Spink M, Chuter V. The relationship between ankle equinus, barefoot plantar pressures and diabetic neuropathy in Aboriginal Australians. Submitted to *Diabetes Research and Clinical Practice* 14/04/16, under review from 02/05/16, Manuscript number DIAB-D-16-00406.

Conference Presentations

Mungabareena Aboriginal Men's Health Summit 19th – 21st Oct 2015, Wodonga Victoria.

• Key Note Speaker. The history and evolution of foot biomechanics and musculoskeletal injury in Aboriginal Australians. Charles J, and Chuter V (Appendix 7).

FIP World Congress of Podiatry Conference 26th – 28th May 2016, Montreal, Quebec Canada.

- The design, development, and reliability testing of a new innovative device to measure ankle joint dorsiflexion. Charles J.
- The relationship between ankle equinus, barefoot plantar pressures and diabetic neuropathy in Aboriginal Australians. Charles J, Spink M, Chuter V.
- The history and evolution of foot biomechanics and musculoskeletal injury in Aboriginal Australians. Charles J, and Chuter V (Appendix 7).

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- Appendix 6 (b): UoN HREC Ethics Approval.

Appendix 7: Charles J, and Chuter V. The history and evolution of foot biomechanics and musculoskeletal injury in Aboriginal Australians. Submitted to *Aboriginal History Journal* 27/06/16, currently under review.

Thesis Abstract

Aboriginal and Torres Strait Islander Peoples suffer from high rates of chronic disease, including peripheral vascular disease, and diabetes, and the associated increases in morbidity and mortality has an enormous impact on both life span and quality of life. Foot health in Aboriginal and Torres Strait Islander Peoples is widely accepted to be poor. In those with diabetes there is a high incidence of neuropathy, foot ulceration, infection and amputation. However, there is little available literature investigating the nature and extent of foot disease in Aboriginal and Torres Strait Islander Peoples, particularly in those with diabetes, or how this can be effectively managed. Anecdotal evidence suggests high rates of restricted ankle joint dorsiflexion (ankle equinus) may exist in the Aboriginal and Torres Strait Islander population and this may be a significant contributing factor to the development of diabetic foot complications including pressure ulcerations.

This research addresses the hypotheses that.

- Chronic disease and lifestyle factors significantly contribute to foot complications in Aboriginal and Torres Strait Islander Peoples.
- Culturally appropriate inclusive health promotion can improve foot health outcomes and support healthy lifestyle choices in an Aboriginal and Torres Strait Islander community.
- High prevalence of ankle equinus significantly contributes to elevated plantar pressures in Aboriginal and Torres Strait Islander Peoples with and without diabetes, which may be a significant factor contributing to poor foot health.

Firstly, a literature review was conducted to establish current risk factors and risk markers for poor foot health in Aboriginal and Torres Strait Islander Peoples. Little data were found relating specifically to Aboriginal foot health, however high prevalence of chronic disease associated with foot complications including diabetes, neuropathy and peripheral vascular disease were evident. Lifestyle factors associated with increased risk of chronic disease, including smoking and obesity were also found to be highly prevalent, particularly in women. No literature investigating the role of lower limb structure or biomechanical function in development of foot complications was found.

Secondly, a review of the literature to determine a reliable method of measuring ankle joint range of motion was conducted. This review showed significant inconsistency in the literature in relation to the definition and diagnosis of ankle equinus, and a lack of standardised method for clinical assessment. Based on these findings a device for accurately measuring ankle equinus was developed, (the Charles device) which was established to have excellent inter- and intra-tester reliability.

Thirdly, a culturally appropriate health promotion program for improving foot health, reducing injury and increasing healthy lifestyle choices was developed for the local Worimi Aboriginal community in Forster/Tuncurry, New South Wales. Evaluation of this program demonstrated that it was effective in improving healthy lifestyle knowledge, behaviours and reducing risk of lower limb injury. These findings suggest appropriate health promotion may be successful in reducing risk of foot complications in Aboriginal and Torres Strait Islander People.

Subsequently two cross-sectional cohort studies, one in Aboriginal and Torres Strait Islander People with diabetes and one in those without diabetes, were undertaken to test the hypothesis that restricted ankle joint dorsiflexion increases plantar pressures under the forefoot. High prevalence of isolated gastrocnemius equinus was found in both cohorts. Reducing ankle joint range of dorsiflexion was found to be significantly associated with higher peak pressures under the forefoot, and to be an independent predictor of increasing pressure-time integral under the forefoot in both populations. These results, limited by cross-sectional design, suggest ankle equinus may play a key role in the development of pressure-related forefoot complications in Aboriginal and Torres Strait Islander Peoples.

Finally, as an appendix to this thesis, visual assessment of Aboriginal skeletal remains of the foot, of a small number of Kaurna People and 21,000 years old footprints of the Paakantji, Ngiyampaa and the Mutthi Mutthi Aboriginal People in Lake Mungo was undertaken. These were examined for arch height, indications of biomechanical characteristics of the foot and ankle and overt osseous pathology. Many of the ancient footprint showed signs of a high arch foot type similar to modern day Aboriginal footprints. In addition, bony spurring on the calcanei on a number of specimens was consistent with possible restriction in ankle dorsiflexion, suggesting ankle equinus may be an evolutionary trait in this population (Appendix 7).

Acknowledgement Traditional Owners

Acknowledgement: I would like to acknowledge the traditional owners of all the many Aboriginal and Torres Strait Islander Nations that make up the great continent of Australia. I would like to pay my respects to the Aboriginal and Torres Strait Islander elders past and present, also the young community members, as the next generation of leaders and representatives.

Disclaimer and Warning

Disclaimer: In some instances in this thesis I will be using the term 'Aboriginal' to describe both Aboriginal and Torres Strait Islander Peoples. No disrespect is intended to any individual or group.

Warning: Aboriginal and Torres Strait Islander Peoples: This thesis has images of skeletal remains of deceased Kaurna People.

Preamble

As an Aboriginal podiatrist working in Aboriginal Medical Services in South Australia, anecdotally I noted a trend of reduced range of dorsiflexion at the ankle (ankle equinus) in Aboriginal and Torres Strait Islander Peoples. When considering the potential impact of a high prevalence of ankle equinus on foot function and injury I hypothesised that this may be contributing to gastrocnemius, ankle and Achilles strains, seen in the Aboriginal Medical Services. The reduced dorsiflexion at the ankle joint could also be contributing to increased pressure and time spent on the midfoot and forefoot during gait. This may be a factor in the development of dermatological conditions associated with high plantar pressures including callus and corn, as well as increasing the risk of pressure ulcerations in people with diabetes. Supporting this premise, I found that in many of the ulcerating wounds I treated in the Aboriginal Medical Service podiatry clinics in Adelaide, there was coexisting ankle equinus. Specifically, I was typically finding that the restriction in dorsiflexion was occurring only when the knee was in an extended position, suggesting it was isolated to the gastrocnemius muscle. This has several potential implications as it appeared to be less likely that the equinus was related to diabetes and the associated process of non-enzymatic glycosylation which causes limited joint mobility. In addition it may suggest that this high prevalence of equinus could possibly be specific to Aboriginal and Torres Strait Islander Peoples.

In these Aboriginal Medical Service podiatry clinics, ankle joint dorsiflexion was routinely measured on all patients as part of a new patient assessment. However, the clinical findings described above were limited by the fact that the measurements were being undertaken with a goniometer, which has been shown to have poor reliability. Furthermore, I could not exclude the fact that this finding could be related to the type of individuals attending the podiatry clinics i.e. those attending would be more likely to have pathology and therefore biomechanical abnormalities. However, as a podiatrist volunteering for the Kaurna Eagles Football Club (Aboriginal AFL team) in Adelaide, doing strapping etc. I noticed that nearly all the players also had an ankle equinus. These men were young and fit, did not have diabetes, had never had ulcerations and had never attended the Aboriginal Medical Service podiatry clinics. This supported the hypothesis that in fact, Aboriginality was related to this reduced dorsiflexion at the ankle and this was caused by isolated gastrocnemius tightness. The potential implications of high prevalence of ankle equinus on foot function and foot health, became the central hypotheses underpinning the research conducted as part of my candidature. Specifically this investigated the potential implications of high prevalence of ankle equinus and how this may contribute to poor foot health in Aboriginal and Torres Strait Islander Peoples.