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Fat flat feet: footwear for the obese child

Annaliese Dowling
University of Wollongong

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Fat Flat Feet: Footwear for the Obese Child

A thesis submitted in partial fulfilment of the
requirements for the award of the degree of

Doctor of Philosophy

from the

University of Wollongong

by

Annaliese Dowling M. Sc. (Hons)

School of Health Sciences

2006

Certification

I, Annaliese M. Dowling, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Health Sciences, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Annaliese M. Dowling

02/09/2006

Dedication

To Mum, Dad, Edwina, Dave and Kate,
who have been involved from the beginning.

Thank you for all for your love, support and encouragement.

To Tim, who has been my pillar of strength and kept me sane throughout
this long journey called a thesis.

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List of Presentations

The presentations listed below have arisen directly from the research conducted for this thesis. Other related publications completed by the author are included in the reference list.

Publications in Conference Proceedings

Dowling AM & Steele JR. Should children's shoes be scaled down versions of men's shoes? Hamill, J., Hardin, E., Williams, K. (Eds). Proceedings of the 7th Symposium on Footwear Biomechanics, Cleveland, OH, USA, July 2005, 134-5.

Dowling AM & Steele JR. How does obesity and gender affect foot shape and structure in children? XXth Congress for the International Society of Biomechanics, Cleveland, OH, USA, July 2005, 512.

Dowling AM & Steele JR. Are in-shoe plantar pressures related to foot comfort as perceived by children? McIntosh, A. (Ed). Proceedings of the 5th Australasian Biomechanics Conference, University of New South Wales, 9-10 December 2004, 2-3.

Dowling AM, Steele JR & Baur LA. Sex, age and plantar pressure: How are they affected by obesity? 2003 Australian Conference of Science and Medicine in Sport, Canberra, Australia, October 2003. *Journal of Science and Medicine in Sport* December 2003, 6(4) Supplement, 47.

Dowling AM & Steele JR. What do parents look for when purchasing school shoes? Milburn, P. D. (Ed). Proceedings of the ISB Technical Group on Footwear Biomechanics, 6th Symposium on Footwear Biomechanics, Queenstown, New Zealand, University of Otago, July 2003, 22-3.

Dowling AM, Steele JR & Baur LA. Obesity and prepubertal plantar pressures: what is the problem? Ninth International Congress on Obesity, Sao Paulo, Brazil, August, 2002. *International Journal of Obesity and Related Metabolic Disorders* August 2002, 26(S1), S123.

Dowling AM, Steele JR & Baur LA. Foot loading and childhood obesity: What is the link? *Proceedings of the Australian Health and Medical Research Congress* November 2002, 2204.

Abstract

Obesity is a global public health problem that affects both children and adults. The consequences and complications of bearing additional mass place an enormous amount of stress on the human body. Musculoskeletally, the feet must endure this excessive mass throughout the tasks of daily living as the feet are the terminus of the body for both stance and gait. Previous studies have reported that obese children display different foot structural characteristics and generate higher plantar pressures, particularly under the midfoot and forefoot, compared to non-obese children. It has been speculated that these higher plantar pressures may potentially place the feet of obese children at risk of injury, although this notion has not been confirmed. Therefore, the aim of this thesis was to develop a shoe to cater for the unique structural and functional characteristics of the obese child and to examine whether the experimental shoe improved the level of shoe fit, comfort and decreased the high forefoot plantar pressures experienced by obese children when walking. To achieve this aim, the thesis was divided into two Experimental Sections, incorporating the development and assessment of the experimental footwear.

In Experimental Section 1 foot shape, foot structure and function were evaluated in 437 children (aged 7-12 years) attending 27 primary schools in New South Wales to form a database of information regarding the feet of Australian children. Gender and age were found to affect the foot measurements obtained for these children, confirming that children's feet develop at different rates and proportions. The boys displayed larger foot dimensions compared to the girls and, as anticipated, the older children displayed larger foot dimensions compared to the younger children. When these data were compared to adult foot dimension values they highlighted differences in proportion between adult and children's feet, indicating the need to develop a children's shoe last, as shoes manufactured as scaled-down versions of adult shoes will not correctly fit the foot shape of children's feet.

From this normative database the foot dimensions, plantar shape and plantar pressure variables for 45 obese children and 45 age and gender-matched controls were compared to establish the effect of obesity and gender on foot structure and function. The obese children displayed significantly greater values for 17 out of the 26 foot/leg dimensions, as well as an increased plantar contact area compared to their matched non-obese counterparts. As no interaction was identified between gender and obesity, it was

confirmed that the effects of obesity were not moderated by gender. In comparison to the non-obese children, the obese children generated higher forces, force-time integrals, peak pressures, pressure-time integrals and increased plantar contact area when walking compared to the non-obese children. Based on these results it was recommended that a shoe should be designed to cater for the larger foot dimensions characteristic of obese children and to cushion the larger plantar pressure distributions generated when these children walk.

A survey was also undertaken to identify factors that influence the purchasing of children's shoes. Parents indicated that fit and comfort were important factors influencing their footwear purchases for their child, even though few parents regularly had their child professionally fitted for shoes. It was anticipated that shoes would need to be replaced because the child had outgrown them, although there was also a high proportion of shoes being replaced because they had been worn out.

An experimental shoe was designed to cater for obese children based on the foot structure, function and survey data. The two main design parameters included in the shoes were an increase in forefoot width to cater for the large foot dimensions of obese children and variations in midsole hardness to cushion the high plantar pressures. Six experimental shoes were evaluated by 14 children who were classified as either overweight and obese children or non-overweight children. Experimental Section 2 investigated how variations in shoe width and midsole hardness affected the fit, comfort, plantar pressures and gait in the two subject groups.

A shoe fit assessment revealed no noticeable differences between the experimental shoes by the children. The shoe comfort and fit parameters, which were assessed via a visual analog scale, demonstrated that these parameters, when used in the evaluation of footwear, relied on individual perceptions of the wearer. The overweight/obese children did report slightly higher shoe fit and comfort values when wearing the wide shoe compared to the narrow shoe although this difference was not significant. However, the non-overweight children reported higher fit and comfort values than the overweight/obese children when wearing the wide shoes.

In general, the plantar pressure distributions at the foot/shoe interface were lower than the previous barefoot values, indicating that footwear moderated the plantar pressure distributions generated during walking. Changes in shoe width and midsole density were found to have negligible affect on the in-shoe plantar pressure variables and spatio-temporal gait parameters, which may be attributable to the small differences

reported in shoe fit assessment. The soft shoes resulted in lower peak pressures being generated under the forefoot but higher peak pressures for the heel and midfoot. The overweight/obese children, regardless of footwear condition, altered their gait to cope with the stresses placed on their feet during walking. Clearly, further research is required to develop shoes to cater for the unique feet of obese children and to better dissipate loading during gait.

It was concluded that a shoe based on the unique foot structure, shape and function of obese children is required by these children. However, the difficulty in designing such a shoe that is universally suitable for obese children because of differential foot development, are acknowledged. Further, perceptions of shoe fit and shoe comfort are highly subjective variables, compounding appropriate shoe design. This thesis highlighted that without good levels of shoe fit, it is difficult to achieve optimal shoe comfort. Although a shoe was developed based on the unique features of obese children's feet, more modifications are required to the experimental shoes, especially in shoe width, in order to improve shoe fit.

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