Journal of Science and Medicine in Sport xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Does participation in a physical activity program impact upon the feet of overweight and obese children?

Diane L. Riddiford-Harland[a,b,*], Julie R. Steele[a], Dylan P. Cliff[b], Anthony D. Okely[b], Philip J. Morgan[c], Louise A. Baur[d]

[a] Biomechanics Research Laboratory, Faculty of Science, Medicine & Health, University of Wollongong, Australia
[b] Interdisciplinary Educational Research Institute, Faculty of Social Sciences, University of Wollongong, Australia
[c] Priority Research Centre for Physical Activity and Nutrition, Faculty of Education and Arts, University of Newcastle, Australia
[d] University of Sydney Discipline of Paediatrics and Child Health, The Children's Hospital at Westmead, Australia

ARTICLE INFO

Article history:
Received 10 February 2014
Received in revised form 8 September 2014
Accepted 7 November 2014
Available online xxx

Keywords:
Skill development
Obesity
Plantar pressure
Childhood
Feet

ABSTRACT

Objectives: To investigate the effect of a weight-bearing physical activity program on foot structure and plantar pressures generated by overweight/obese children.
Design: Descriptive study.
Methods: Measurements were collected for a sample of children participating in an obesity treatment trial (mean ± SD 8.5 ± 1.1 y, 29.4% boys, 2.63 ± 0.61 body mass index z-score). Children were randomised to physical activity (physical activity; n = 24) and no physical activity (no physical activity; n = 10) groups. Foot structure was characterised using anthropometry, an emed® AT-4 system quantified pressure distributions and Actigraph accelerometers objectively measured physical activity.
Results: After 6 months there was a significant decrease in body mass index z-score (physical activity: $p = 0.002$, no physical activity: $p < 0.001$), an increase in foot length (physical activity: $p < 0.001$, no physical activity: $p < 0.001$) and foot height (physical activity: $p < 0.001$, no physical activity: $p = 0.008$), although no change in physical activity. Pressure–time integrals increased after 6 months (lateral midfoot; physical activity: $p = 0.036$, medial forefoot; physical activity: $p = 0.002$, no physical activity: $p = 0.013$, middle forefoot; physical activity: $p = 0.044$, lateral forefoot; physical activity: $p = 0.043$) but there were no between-group differences in plantar pressures after the physical activity program.
Conclusions: Although changes to foot structure and function in overweight/obese children could not be attributed to participating in the physical activity program, their developing feet may still be at risk of pain and discomfort due to higher plantar pressures and pressure–time integrals. Further research investigating ways to reduce plantar pressures generated by overweight/obese children while they are physically active is warranted.

1. Introduction

Physical inactivity has been identified as a major factor contributing to the development of overweight and obesity in children.[1] One specific barrier thought to restrict overweight and obese children from being physically active is the musculoskeletal consequences these children experience due to carrying excess weight.[2,3] For example, overweight and obese children have fatter and flatter feet[4,5] and generate higher pressures beneath the midfoot and forefoot regions when compared to their non-overweight peers.[6–8] Flattening of the foot's medial longitudinal arch and higher plantar pressures are thought to be a cause of foot discomfort, pain or dysfunction and, consequently, a possible deterrent to activity in obese children.[6,9] In support of this notion, we recently showed, in overweight and obese school-aged children, that higher peak plantar pressures generated during walking were significantly associated with lower levels of physical activity.[10]

Increasing physical activity is a recommended approach to combating the high prevalence of obesity among children.[1,11] However, there has been no systematic investigation of the types of activity that obese children should participate in and how this affects plantar pressure distributions and foot development. Although a 5-week weight-loss program successfully reduced body mass and peak plantar pressures generated by obese adolescents,[12] this study did not clarify what movement activities participants were required to perform during the program. Furthermore, no

* Corresponding author.
E-mail address: dianer@uow.edu.au (D.L. Riddiford-Harland).

http://dx.doi.org/10.1016/j.jsams.2014.11.008
1440-2440/

published literature was located examining the consequences of increasing weight-bearing physical activity during an intervention program on peak pressures generated beneath the feet of overweight and obese children.

The purpose of the present study was, therefore, to examine the effects of a weight-bearing physical activity program on foot development and plantar pressures generated by young overweight and obese children. We hypothesised that participating in a weight-bearing physical activity program aimed at increasing physical activity level would result in higher pressure distributions beneath the feet of overweight and obese school-aged children compared to those children who were not involved in any physical activity intervention.

2. Methods

Participants were recruited as a convenience subsample of a child obesity treatment trial known as the Hunter and Illawarra Kids Challenge using Parent Support (HIKCUPS[13]). Participant inclusion criteria for HIKCUPS were children aged between 5 and 9 years who were generally healthy, prepubertal and overweight or obese according to International Obesity Task Force cut points.[14] Extreme obesity (BMI z-score >4), known syndromal causes of obesity, long-term steroid usage, weight gain due to medication, chronic illness and significant dietary restrictions were included in the exclusion criteria.[13]

Participants for HIKCUPS were randomised into one of three groups: a child-centred physical activity program, a combined child-centred physical activity and parent-centred dietary modification program, or a parent-centred dietary modification program,[13] and baseline measurements were collected. Children randomly assigned to the physical activity and combined intervention groups followed a 10-week 90-min face-to-face physical activity program, which commenced 2 weeks after the baseline data were collected. Contact was maintained with these children via telephone calls to their families at 14, 18, and 22 weeks after face-to-face session commencement. A 2-h physical activity booster session was conducted 2 months after the last face-to-face session to support motivation and skill development during this maintenance period.[13] Parents of children randomly assigned to the combined intervention and the dietary intervention were involved in a family-focused dietary modification program during this time.[15] The children who were randomly assigned to the parent-centred dietary modification program received treatment that did not involve or promote physical activity. Six months after baseline data collection (post intervention) all groups were again assessed on all study variables. Researchers were blinded to group allocation during data collection and analysis.

Participants in the Wollongong HIKCUPS cohort were approached to collect foot anthropometry and plantar pressure distribution data, additional variables to those being assessed in the HIKCUPS study.[13] Consenting participants who had complete foot anthropometry and plantar pressure distribution datasets for both the baseline and 6-month testing sessions and participated in either physical activity program (the first and second randomised HIKCUPS groups) were included in the physical activity treatment group (n = 24; physical activity [PA]). Children who had complete datasets but did not participate in either physical activity program (the third randomised HIKCUPS group), formed the activity control group (n = 10; no physical activity [NPA]). When the study commenced, 60 (30 + 30) participants were randomised to the physical activity intervention groups and 20 participants were randomised to the no physical activity intervention group. Of the 60 PA group participants, 5 did not have physical activity, foot anthropometry or plantar pressure data at baseline and 31 did not have these data at the 6-month testing session. Of the 20 NPA group participants, there was no baseline data for 1 participant and no 6-month data for 9 participants. Parents gave written, informed consent and children gave verbal consent to participate. Data for this subsample were collected at the University of Wollongong, Australia, and the University of Wollongong Human Research Ethics Committee [HE05/010] approved all study procedures.

During the 10-week face-to-face physical activity program participants completed weight-bearing tasks aimed at improving their actual competence in performing 12 fundamental movement skills (run, jump, leap, hop, slide gallop, and strike, roll, kick, throw, catch, and bounce a ball) and their perceived competence in physical activity and sports.[16] Tasks were designed to cater for the participant's differing stages of learning and development and were tailored to detect and correct errors in skill performance to allow for the provision of skill-specific feedback.

Children were also provided with 'home challenges' to encourage the practice of fundamental movement skill tasks with family members or friends between sessions. At-home sessions were designed to facilitate participation, improve competency and promote physical activity. A minimum of 30 min of at-home participation, three times each week, during the 10-week physical activity program was recommended.[16]

Tanita HD464 scales (Tanita Corporation of America Inc, Illinois, USA) were used to measure participants' body mass to the nearest 0.01 kg. A PE87 portable stadiometer (Mentone Educational Centre, Victoria, Australia), accurate to 0.1 cm, was used to measure standing height. The mean of two measurements was used to calculate body mass index (BMI; weight (kg)/height (m^2). Age- and sex-adjusted BMI z-scores were then computed using UK reference values.[14,17] Participants were barefoot and wore light-weight clothing during data collection.

The dynamic plantar pressure distributions generated underneath each child's feet were measured as they walked at a prescribed pace across a calibrated emed® AT-4 pressure system ($Novel_{gmbh}$, Munich, Germany), which was embedded in a 3 m walkway. Data were collected as each participant contacted the platform with their second step.[18] Familiarisation trials were performed before data collection of three successful trials for each foot.

Each pressure footprint was divided into 10 regions,[19] which were masked using Novel-ortho automask software ($Novel_{gmbh}$, Munich, Version 13.3.16). For each of these masks, Novel-win multimask software ($Novel_{gmbh}$, Munich, Version 13.3.16) was used to analyse the mean peak pressure footprints to determine peak pressure (kPa) and pressure–time integrals (kPa/s) generated during walking. Only medial and lateral midfoot and medial, middle and lateral forefoot peak pressure and pressure–time integral values have been included in the results section due to previous studies identifying these foot regions being at potential risk for overweight and obese children during exercise.[8,10]

Foot length, ball of foot length, instep length, ball of foot breadth, heel breadth, ball of foot height, dorsal arch height, plantar arch height, ball of foot circumference and instep circumference were measured for both feet of each participant to the nearest millimetre. All anthropometric foot measurements[20] were recorded by the chief investigator [DLRH] using a combination level (Stanley Tools, Connecticut, USA), a metal tape (KDS Corp., Kyoto, Japan), small anthropometer (Lafayette Instrument Co., Indiana, USA) and a custom-designed foot tray. Two measurements (within 3 mm) were taken while participants stood barefoot with equal weight on both feet. The mean score per variable was used in later analysis to represent each foot dimension.

A portable SonoSite® 180PLUS ultrasound system (Washington, USA) with a 38 mm broadband linear array transducer (10–5 MHz,

Please cite this article in press as: Riddiford-Harland DL, et al. Does participation in a physical activity program impact upon the feet of overweight and obese children? *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.11.008