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The effect of sole hardness on the metatarsophalangeal joint in children

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results of Muniz and Bini (2017). Therefore, even though PU had lower mass, increased energy absorption, and reduced hardness, this boot seems unable to reduce impact. Softer midsole material showed increased impact forces during running (Baltich et al., 2015). Loaded walking increased GRF as expected from the addition of mass in the backpack because of larger total weight and increased centre of mass acceleration. Results indicated that midsole material (PU and SBR), hardness, density and mass did not affect vertical GRF differently by adding load during walking. These findings are new because no prior study demonstrated that military boots with different structural and mechanical properties could lead to largely similar responses for GRF and gait patterns during load and unload trials.

Disclosure statement

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The effect of sole hardness on the metatarsophalangeal joint in children

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KEYWORDS offset; stack height; heel-to-toe; heel-to-toe offset; sole; midsoles; sole density; hardness

Introduction

Flexibility is a widely marketed footwear characteristic. It is often listed as a 'reason to buy', by brands and consumers as it is assumed to be associated with a reduced risk of interfering with foot development. However, shoes have been shown to reduce metatarsophalangeal joint (MPJ) motion (Wegener et al., 2015) and inflexible footwear decreased foot muscle strength (Goldmann et al., 2013) and gait efficiency (Wegener et al., 2015; Wolf et al., 2008). Sole thickness and sole material type both affect shoe flexibility but neither have been investigated systematically in children's footwear.

Purpose of the study

The purpose of this study was to investigate the effect of sole density (hardness) on MPJ flexion in children during propulsion.

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Figure 1. Example of shoe worn.

Methods

Ten healthy children (6 Female) aged 4–7 years (Mean 5.4 years ± 0.8 years) were assessed while walking barefoot (BF), in an on-market product (SH55) (55 ± 3 Asker C), a softer version (SH35) (35 ± 3 Asker C), and a harder version (SH65) (65 ± 3 Asker C). The shoe had a single density ethylene vinyl acetate mid/outsole (Figure 1). Sole hardness was manipulated to alter sole stiffness. It has been assumed that increased hardness results in increased stiffness. Mechanical testing is to be undertaken to quantify this.

Kinematic data (Qualisys, 100 Hz) was collected using 26.5 mm markers on the right limb and four tracking markers on the left foot (for event detection). Markers were placed on the shoe rather than cutting the upper because shoe flexibility was the independent variable and is affected by the upper structure. A static trial and virtual foot model defined MPJ 0°. Gait events were defined using foot velocity (O'Connor et al., 2007). Peak MPJ angle during 55–100% of the stance phase was quantified using Visual 3 D (C-Motion Inc., MD, USA). Normality was determined and peak MPJ angle was compared using a repeated measures ANOVA. Footwear conditions were presented as percentage change from BF for comparison.

Results

The largest MPJ dorsiflexion angle occurred during barefoot walking (mean = 49° ± 5°). All shoes significantly reduced peak MPJ angle compared with barefoot walking ($p \leq 0.05$). The MPJ flexion angle was 26% (mean = 35° ± 8°), 27% (mean = 35° ± 7°) and 39% (mean = 29° ± 2°) less than in barefoot walking in SH35, SH55 and SH65 respectively. The largest shod flexion angle occurred in the most flexible shoe (SH35). The difference between most and least flexible shoes (14%) was not statistically significant ($p \geq 0.05$) (Figure 2).

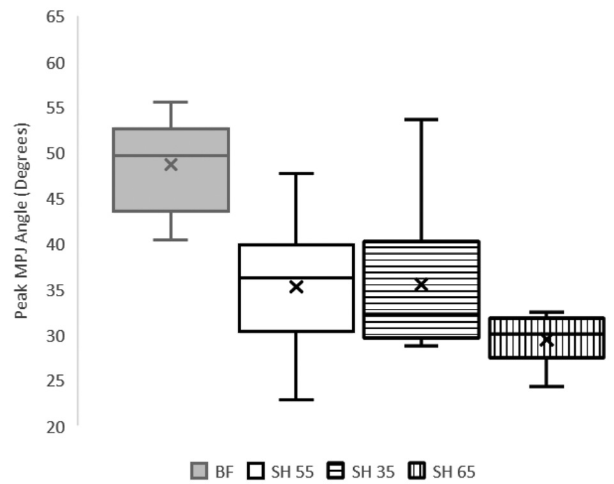

Figure 2. Distribution of peak MPJ flexion angles by condition (BF, SH55, SH35 and SH65) during propulsion. The cross within the box represents mean group MPJ flexion angle. The solid line represents group median value. Error bars illustrate upper and lower extremes.

Discussion and conclusion

Mean peak MPJ angles between SH35 and SH55 are similar despite a larger difference in hardness compared to that between SH55 and SH65. The low variability of MPJ angle in SH65 suggests that hardness values above 55 Asker C restrict motion at the MPJ. Mean values between SH35 and SH55 are similar, though variability is greater for both conditions than that in SH65. Altering sole hardness enables greater motion at the MPJ, though its ability to increase MPJ flexion is limited. Material thickness and compound type should be further evaluated when aiming to provide maximal MPJ flexion.

Increasing sole hardness reduces shoe flexibility which systematically decreases MPJ dorsiflexion during propulsion in children. It is assumed that compensations at the ankle or knee might mitigate the effect of reduced MPJ motion due to variations in shoe sole flexibility. While these proximal adaptations may maintain gait efficiency, foot muscle strength could still be impacted. Footwear manufacturers should be aware of the evidence for the association between design decisions, product characteristics, and foot biomechanics. Further investigation is required to determine the effects of sole hardness and flexibility in younger children.

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A scoping review on methods for assessing product comfort: considerations for footwear comfort

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KEYWORDS footwear; review; comfort; insoles; Athletic footwear

Introduction

In footwear research, footwear comfort has become an increasingly popular topic. Commonly used assessment tools include the visual analogue scale, the Likert scale and self-reported ranking (Lindorfer et al., 2019). Data collection methods for footwear comfort often focus on participants' interactions with footwear, and tasks performed. However, existing literature on product comfort suggests that comfort is not only influenced by external physical factors. In a review on theoretical product comfort models by Vink and Hallbeck (2012), comfort has been defined as '*pleasant state or relaxed feeling of a human being in reaction to its environment*'. The review further explains that each individual experiences comfort differently based on various internal (e.g. sensation, emotions, expectations) and external (e.g. features of product, tasks performed, environment) factors. Perception of comfort is a complex subject, yet many commonly used assessment methods are often simplified and unable to encapsulate this complexity.

Purpose of the study

The purpose of this scoping review was to explore current methods in assessing product comfort. The considerations for footwear comfort will be explored in this presentation.

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