

THE EFFECT OF DIFFERENT MIDSOLE HARDNESS ON KINEMATIC AND KINETIC DATA DURING RUNNING INFLUENCED BY VARYING BODYWEIGHT

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INTRODUCTION

Millions of people are involved in running and jogging activities and they become more and more demanding concerning their running shoes. It is well known that runners desire different cushioning properties depending on their own preferences and varying running conditions (Kleindienst, 2003). It is also expected that the preferences depend on the runner's gender and anthropometrics. In terms of comfort, it would therefore make sense to invent a shoe that adapts its cushioning properties to different bodyweight as well as varying running speed and terrain.

However, it is not known whether adaptive cushioning can also contribute to the reduction of overuse injuries. The reported yearly incidence of running related injuries ranges between 37 and 56% (Van Mechelen, 1992). The knee has been shown to be a common site of injury for runners with Patellofemoral Pain Syndrome (PFPS) being the most common of the injuries to this joint. High abduction and external rotation moments in the knee joint are related to overuse injuries like PFPS (Stefanyshyn et al., 2001).

Therefore the purpose of this study was to investigate the effect of midsole hardness on kinematics and kinetics during running with reference to gender, bodyweight and running speed in order to clarify whether adaptive cushioning properties could reduce overuse injuries.

MATERIAL AND METHODS

Subjects were 14 male runners with a bodyweight of minimum 80kg (age: 37yr; ht: 184cm; mass 89kg; mileage: 44km/week) and 14 female runners with a bodyweight of maximum 55kg (age: 27yr; ht: 164cm; mass 53kg; mileage: 43km/week). According to a medical examination by an orthopedic surgeon, all subjects were injury free during the study. Three shoe types (adidas[®] Manhattan), differing exclusively in midsole hardness (40 Shore C, 55 Shore C and 70 Shore C) were used for the running trials, sizes varying from UK 4.5 – 12.5.

Kinematic data (200Hz) were collected using a 6-camera 3-dimensional Vicon System (Vicon, Oxford Metrics, Oxford, UK). Reflective markers were placed on the pelvis, upper leg, lower leg, rearfoot and forefoot (3 per segment). Kinetic data (1000Hz) were collected using a Kistler force plate (Kistler, Zurich, Switzerland). A lower body model, which was described earlier (Michel et al., 2004) was used to determine joint centers and angles between segments. Subjects ran across the force plate in the middle of a 25m runway at two different velocities ($3.0 \pm 0.2 \text{ms}^{-1}$, $4.5 \pm 0.2 \text{ms}^{-1}$, respectively). Kinematic and kinetic data were collected for 5 valid trials for each subject and condition. 3-dimensional knee joint moments were calculated during the stance phase using an inverse dynamics approach. Data was not normalized to bodyweight in order to evaluate absolute differences between different groups of runners. Selected values were determined from each curve and averaged for each condition and subject. Significant differences between shoe conditions were detected using non-parametrical tests ($p \leq 0.05$).

RESULTS AND DISCUSSION

Bodyweight and gender as well as running speed influence kinematic and kinetic data during running. Maximum horizontal and vertical ground reaction forces were significantly higher for male compared to female runners and increased significantly for faster running speed. Maximum knee joint moments were significantly higher for male compared to female athletes (Fig. 1-4) and increased significantly for faster running speed (Fig. 3&4).

Different midsole hardness did influence mean abduction moments (Figure 1&2) as well as mean external rotation moments (Fig. 3&4) in the knee joint. However, knee extension moments were not affected.

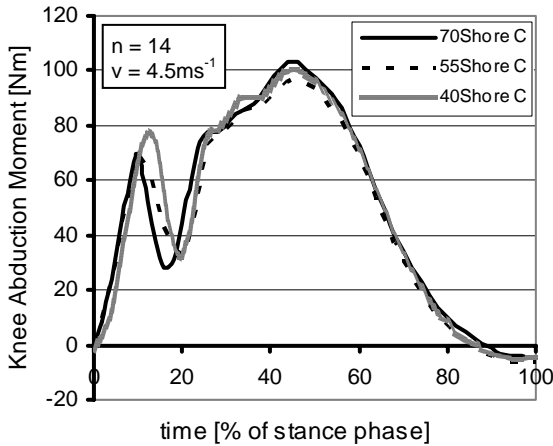


Fig. 1: Knee abduction moments (male)

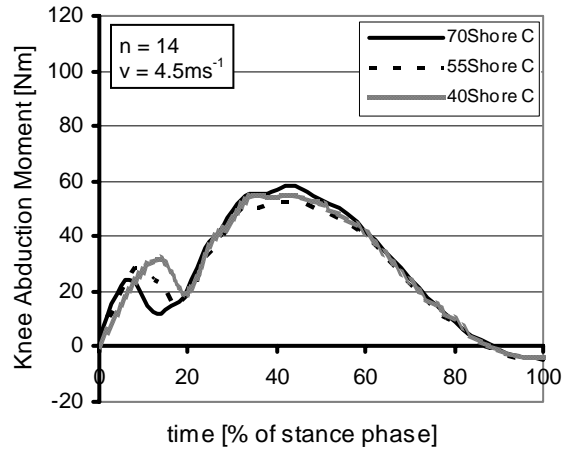


Fig. 2: Knee abduction moments (female)

The initial peak of the abduction moment was significantly higher for male runners for the soft shoe condition (Fig. 1). Although for female runners the soft shoe provokes the highest moment, the differences are much smaller and not significant (Fig. 2). This strong increase for the male runners might be due to a bottoming out effect of the soft shoe condition.

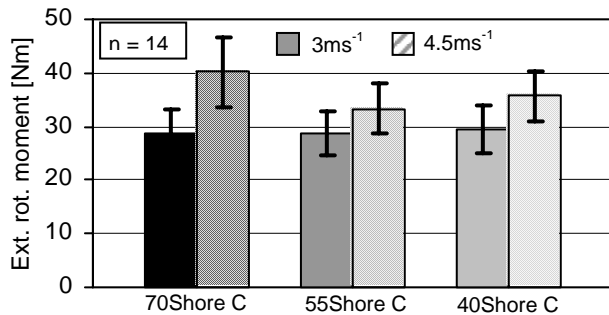


Fig. 3: Max. knee external rotation moments (male)

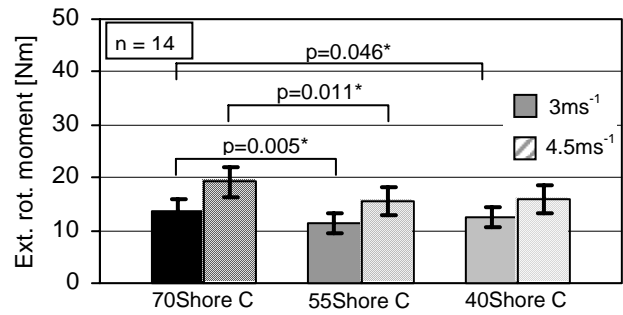


Fig. 4: Max. knee external rotation moments (female)

The maximum external rotation moment of female runners was significantly higher for the hard shoe than for the moderate and soft condition at both speeds (Fig. 4). For male runners there were no significant differences (Fig. 3). The different behavior of females regarding the hard shoe was also supported by significantly higher knee flexion angles for this condition compared to the moderate and soft shoe, which male runners did not show.

CONCLUSIONS

Based on the above mentioned results, it seems that very soft shoes are not appropriate for faster running speeds, especially not for heavier runners. Very hard midsoles are not appropriate for lightweight female runners. In order to provide optimal cushioning for every runner it makes sense to adjust the cushioning behavior of the shoes to different bodyweights, running styles and running speeds. As many runners change speed and terrain during one run, the adjustment has to be done in real time, during running.

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