Effects of Footwear Midsole Hardness on Females Lower Limb Kinetics and Kinematics During Cutting Manoeuvres

Cédric Morio*, Mohand Haddoum, Maxime Roux and Nils Guéguen
Oxylane Research, Movement Science Laboratory, Villeneuve d’Ascq, France

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1. Introduction
The anterior cruciate ligament (ACL) tear is a common sport injury, especially in team sports where cutting manoeuvres are overriding. Women were more likely to have an ACL injury (Quisquarter et al. 2013). Although a recent study by Nigg et al. (2012) investigated the influence of midsole hardness on running kinematics across different populations, very little was known about female athlete kinetics and kinematics with different types of footwear.

Regarding footwear effect on locomotion, several midsole parameters were studied (Nigg 2010). The influence of heel flare, thickness or hardness induced an increase ankle excursion during specific sports movement by increasing the foot-ground lever arm (Stacoff et al. 1996). Softer shoe was able to increase energy absorption whatever the ground stiffness or the running speed (Ly et al. 2010).

Thus, the objective of the present study was to investigate the influence of midsole hardness on the female lower limb kinematics and kinetics. The hypotheses were that harder shoes would induce more ankle 3D movements and softer shoes less ankle and/or knee net moments.

2. Methods
Nine females (166 ± 4 cm; 62.9 ± 9.8 kg) actively involved in regular team sports or fitness activities volunteered to participate in the study and gave their written informed consent.

Participants were asked to perform cutting manoeuvres go-and-return in both forward and lateral directions. Three different shoe conditions were studied varying the midsole hardness (soft, medium, hard). The shoe conditions were randomized and every movement in every footwear condition were tested at least five times.

Lower limbs 3D kinematics was recorded with a six cameras motion capture system (Qualisys) at 500 Hz. Ground reaction forces (Kistler) were synchronously recorded at 1000 Hz. The 3D lower limb model consisted in the left foot, leg, thigh segments and the pelvis. Data analyses (ankle, knee and hip joint angles and net moments) were then performed through Visual3D (C-Motion) software according to Wu et al. (2002). Joint angles and net moment amplitudes during ground contact were calculated as dependent variables.

Anova with repeated measures were performed separately for forward and lateral cutting with the midsole hardness as independent variable. If a main effect was observed, a Newmann-Keuls post-hoc test was applied. Regarding the low number of subjects (n = 9), effect trends were also investigated through Fisher comparison tests. For all statistics, level of significance was set at α = 0.05.

3. Results and Discussion
No significant difference was observed on ankle 3D motions in neither forward nor lateral cutting manoeuvres (Figure 1 and Figure 2). Reduced knee flexion/extension amplitudes were observed in both movement conditions (Figure 1 and Figure 2) while wearing the hardest shoes. This was due to a reduced knee extension during the pushing phase. Reduced flexion/extension net moment amplitude was observed on the ankle joint (Figure 1) for the softest midsole.

*Corresponding author. Email: cedric.morio@oxylane.com
Fisher tests showed that contact time tended to be shorter with the hardest midsole in both the forward (p = 0.04) and lateral (p = 0.06) cutting movements (Table 1).

Table 1: Mean and standard deviation of the contact time for the 3 shod conditions during the two cutting manoeuvres.

<table>
<thead>
<tr>
<th></th>
<th>Soft</th>
<th>Medium</th>
<th>Hard</th>
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<tbody>
<tr>
<td>Forward</td>
<td>463 ms</td>
<td>434 ms</td>
<td>421 ms</td>
</tr>
<tr>
<td>cutting</td>
<td>± 139</td>
<td>± 135</td>
<td>± 117</td>
</tr>
<tr>
<td>Lateral</td>
<td>491 ms</td>
<td>478 ms</td>
<td>463 ms</td>
</tr>
<tr>
<td>cutting</td>
<td>± 118</td>
<td>± 124</td>
<td>± 117</td>
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</table>

Regarding our first hypothesis the hardest midsole did not induce greater ankle angle amplitude compared to the softest shoe. The foam deformation during foot ground contact might not lead to foot-ground lever arm changes. Moreover the stiffness differences due to only midsole hardness were shown to be reduced at higher compression loadings (Morio et al 2009), like during sports movements.

Our second hypothesis was confirmed during forward cutting manoeuvres. Reduced ankle net moment amplitude with the softest shoes might be explained by greater energy absorption (Ly et al 2010). The lack of result during the lateral cutting manoeuvre might indicate a minor importance of midsole hardness on this type of movement.

The reduction of knee extension during push-off and the shorter contact time with the hard shoes in both forward and lateral cutting manoeuvres showed better energy recoil of the harder shoes. This increased efficiency could be confirmed with additional EMG measurements.

Although it was previously reported greater changes in frontal plane compared to sagittal during lateral cutting (Fleischmann et al 2010), the present results did not show any footwear effect in that plane neither in kinematic nor kinetic parameters.

4. Conclusions

To conclude, midsole hardness did not seem to influence knee net moment in female athletes. ACL injuries might thus not be prevented by hardness changes in footwear. Further investigations on EMG pattern as well as rotation manoeuvre are needed to confirm these initial results.

One interesting result, however, showed an ankle net moment reduction associated with a softer midsole material.

References


