DOES LOWER LIMB ALIGNMENT DETERMINE THE KINEMATIC RESPONSE TO VARIATIONS IN BOUNDARY CONDITIONS?

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INTRODUCTION
In the dynamic field of sports medicine, two facts that remain unchanged since the 1970’s are the increasing popularity of running for recreation and competition, and the incidence of running injuries at between 37 and 56% annually for the average recreational runner (van Mechelen, 1992). Sheehan, 1974 was among the first sports physicians to suggest that pronation may lead to running injuries, the mechanism later formalised by Subotnick, 1975 and James et al, 1978. Stacoff et al, 2000 using intracortical bone pins determined that there was no difference in the tibial and calcaneal skeletal movements with the use of sports shoes that varied in inherent motion control properties contrary to previous studies (Stacoff et al, 1991). We hypothesized that runners with uniform lower limb alignment would have a similar kinematic response to varying boundary conditions. The purpose of this study was therefore to determine the effect of anti-pronation shoes and neutral shoes on the kinematics of runners with neutral lower limb alignment.

METHODS
Fourteen (14) injury free male runners (27.0±4.3years, 74.0±10.2kg, 1.76±0.06m), undertook overground running at 2.3m/s in the barefoot [BF] and shod conditions (anti-pronation sports shoe [APS]; neutral sports shoe [NS]). A clinical biomechanical assessment (Dahle et al, 1991) determined that all but one subject had a neutral foot type. Right foot stance phase kinematic data were captured at 120Hz with a 6-camera video-based kinematic analysis system. Ankle eversion-inversion was determined as rotation of the leg segment about the long axis of the foot at initial and terminal contact. The peak ankle eversion angle was determined. The group mean and standard deviation were determined for each condition, tested with ANOVA, and significant differences between the conditions analyzed with the Schêffe post-hoc analysis, the significance level set at p<0.05.

RESULTS & DISCUSSION
The study revealed that the NS condition (-14.1±6.6⁰) permitted a significantly greater everted position (p<0.05) than the BF condition (-20.8±6.2⁰) at initial foot contact. The peak eversion angle achieved was significantly greater (p<0.05) in the shod conditions [APS (7.6±10.7⁰), NS (12.7±9.3⁰)] than the BF condition (-4.6±8.1). The ankle joint at terminal contact was significantly more everted in the shod state [APS (-17.0±5.8), NS (-15.1±4.7)] than the BF state (-21.2±7.3). These results contrast that reported by Stacoff et al, 2000, who did not find a difference in calcaneal and tibial skeletal kinematics between BF vs shod conditions. However, the results are similar to that of Stacoff et al, 2000, in that no significant difference in ankle joint kinematics was demonstrated between the two shod conditions. This suggests that the Helen Hayes hospital marker set used in the study may not be sensitive enough to detect subtle differences in ankle kinematics changes between the two shod conditions.
The inter-individual difference in the kinematic response to changing boundary conditions is evident in the graphs depicting the ankle eversion-inversion rotations during stance phase (Figure 1). Runners 4, 6, 7, 9, 10, 11, 12, 13, and 14 demonstrated a similar kinematic response to changing boundary conditions, and a graphical difference in shod vs BF conditions. Runners 1, 2, 3 and 8 had similar kinematic responses to the changing boundary conditions and did not have a clear graphical distinction between shod and barefoot conditions. Barefoot data for runner 5 were corrupted during collection and excluded from the analysis. Surprisingly, runner 14, who was identified clinically to have excessive pronation did not have an ankle eversion-inversion kinematic response different to that of the neutral subjects in the first group.

CONCLUSION

This study has shown that surface markers may overestimate lower limb kinematic responses to changing boundary conditions, as has been suggested by authors of intra-cortical bone pin studies. However, the Helen Hayes Hospital marker set is effective at demonstrating at least two groups of runners with similar kinematic responses with variations in the boundary conditions, despite similarities in lower limb alignment. We suggest that anatomical characteristics other than lower limb alignment be included into future kinematic studies to determine the inter-individual response to variations in boundary conditions.

REFERENCES


Table 1 Ankle joint eversion-inversion kinematic values [mean (SD) degrees]

<table>
<thead>
<tr>
<th>Ankle joint angle</th>
<th>Barefoot</th>
<th>Anti-pronation</th>
<th>Neutral</th>
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<tbody>
<tr>
<td>At initial contact</td>
<td>-20.8±6.2*</td>
<td>-17.7±8.5</td>
<td>-14.1±6.6</td>
</tr>
<tr>
<td>Peak eversion</td>
<td>-4.6±8.1**</td>
<td>7.6±10.7</td>
<td>12.7±9.3</td>
</tr>
<tr>
<td>At terminal contact</td>
<td>-21.2±7.3**</td>
<td>-17.0±5.8</td>
<td>-15.1±4.7</td>
</tr>
</tbody>
</table>

* BF < NS, p<0.05 ** BF < A and N, p<0.05

([-] Denotes an inverted and [+] an everted ankle position, respectively)

Figure 1. Representative ankle joint eversion-inversion graphs of barefoot vs anti-pronation, and neutral shoe conditions