

EFFECTS OF IMPEDED FOOT ARCH HEIGHT ON CALCANEAL EVERSION AND ANKLE JOINT FORCES DURING GAIT

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INTRODUCTION

Therapeutic footwear is prescribed to not only control excessive rearfoot motion by aligning tibia and calcaneus, but also retain the medial longitudinal arch (MLA) functions to appropriately attenuate shock and accommodate uneven surface while walking. Changes in the MLA height during midstance have been found to be positively correlated with calcaneal eversion [1]. Excessive calcaneal eversion could be successfully limited by therapeutic footwear [2]. However, small and unsystematic changes of the rearfoot motion [3] and inconsistent peak calcaneal eversion control [4] were found during running with inserted orthoses in shoes. These inconclusive findings may suggest constrained MLA height changes due to the inserted orthoses could affect the calcaneal motion during walking. Therefore, the purpose of this study was to determine effects of impeded MLA height on the calcaneal motion and on 3D ankle joint force (AJRF) in healthy young adults during walking.

METHODS

Fourteen adults (mean age: 25.3 ± 4.7 years, body mass: 71.3 ± 9.8 kg) were tested after being examined by a podiatrist who ruled out any foot-related pathologies. A six-camera motion analysis system (Motion Analysis Corp., Santa Rosa, CA) was used to collect eleven skin based reflective markers placed on left shank/foot during quiet stance and while walking with self selected pace in barefoot (BF) then two types customized arch supports: one deformable (AS1) and one rigid (AS2). Arch supports were directly attached to the plantar surface of the feet using double sided adhesive tapes. Heel cup of the arch support was removed to eliminate any effects on rearfoot motion. KinTrak 6.2 software (Motion Analysis Corp., Santa Rosa, CA) was used to analyze the motion data and 3D AJRF. The MLA height was defined as the perpendicular distance from the navicular marker to the line connected between distal calcaneal and 1st metatarsal head markers. The dynamic change of the MLA height was calculated as differences in heights between walking and standing for each testing condition (BF, AS1 & AS2, respectively). Subject means of MLA height changes were calculated over the stance period. The peak calcaneal eversion (CE) and peak AJRF across subjects were also calculated.

Planned contrasts with one way within-subjects ANOVA (SPSS 10.1) was performed to detect arch constrained effect (AS1 and AS2) on changes of the MLA height, peak CEV and peak AJRF, $p < .05$.

RESULTS AND DISCUSSION

Average walking speeds ($M = 1.31 \pm 0.02$ m/s) were found to be consistent across all subjects and among three testing conditions. Mean MLA height changes across stance periods in AS conditions (AS1 $M = 0.93 \pm 0.33$ mm; AS2 $M = 0.36 \pm 0.47$ mm) were found to be significantly less than that in BF condition ($M = 1.91 \pm 0.18$ mm). Significant differences in the peak CE were found between BF ($M = 1.51 \pm 1.93^\circ$) and AS2 condition (AS2 $M = 2.59 \pm 1.85^\circ$, $p = .03$). Significant arch support effects were found in vertical AJRF (*) at the 1st peak (p1↑) and trough (t1↓) as well as in the AP AJRF at trough 1 (t1↑). Impeded changes of arch height resulted in an increased peak calcaneal eversion and a corresponding increased vertical AJRF during early midstance (Figure 1a and 1b).

SUMMARY

When the MLA vertical motion was impeded, the increased calcaneal eversion might be a compromise for the lack of arch height changes, meanwhile, limiting the arch function in shock absorbing. When therapeutic footwear is designed to control rearfoot motion, its possible effects on the midfoot MLA motion should be considered.

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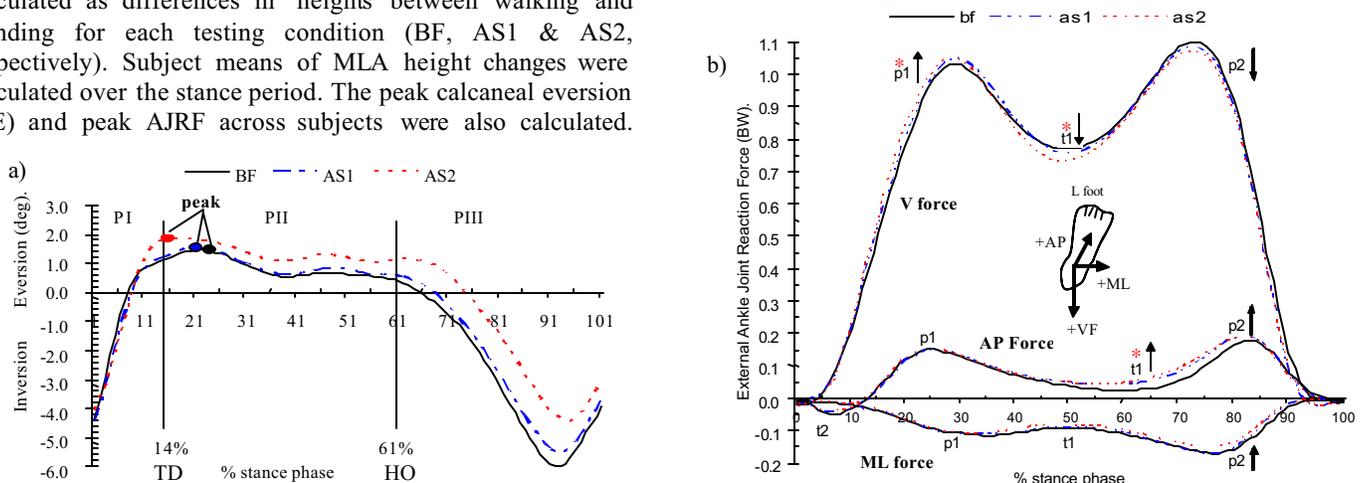


Figure 1. Subject means of a) Eversion/ Inversion change, b) 3D AJRF (Vertical/AP/ML w.r.t. left foot local coordinate system) in each testing condition (BF/AS1/AS2). TD (1st toe down), HO (heel off). * $p < .05$; ↑: AJRF increased with rigidity of the arch supports.