EFFECTS OF FOOT ARCH IMPEDANCE ON NAVICULAR DROP AND CALCANEAL EVERSION DURING WALKING

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INTRODUCTION

Excessive calcaneal eversion/ pronation have been linked to foot problems during walking and running. As calcaneal eversion occurs primarily through the midtarsal joints such as talonaviclar (Ouzounian, 1989), the midfoot navicular drop is found to positively correlate with calcaneal eversion during walking (Cornwall, 2002). The magnitude of navicular drop during standing has also been used as an indicator to predict excessive calcaneal eversion during walking (Muller, 1993).

A general goal for the use of foot orthoses or arch supports is to confine the foot in its neutral position and to reduce excessive rearfoot motion. However, contradictory findings have been reported. Increases in peak calcaneal eversion during mid-stance were observed while running with orthoses (Williams III, 2003). Furthermore, increases in eversion between calcaneus and talus were found in vitro while navicular height was impeded by an arch support with different loads (Kitaoka, 1997). Therefore, the purpose of this study was to examine and quantify the navicular arch height displacement and peak calcaneal eversion during level walking with and without arch height impedance.

METHODS

Three healthy male adults (mean age, 25.0 ±3.2 years) were recruited and tested after being examined by a local podiatrist and ruled out any foot-related pathologies. Nine 8-mm superficial skin markers were placed on the left lower limb: 4 on tibia, 4 on rear foot, and one on navicular tubercle. Motion data were collected using a six-camera ExpertVision^{TM} system (Motion Analysis Corp., Santa Rosa, CA) while quiet stance and during level walking with barefoot (BF) and with arch supports. KinTrak software (Motion Analysis Corp., Santa Rosa, CA) was used to analyze the motion data.

Two pairs of customized arch supports, one deformable (AS1) and one rigid (AS2), were prescribed to each subject. Heel cups of both supports were removed to eliminate any effects on rearfoot motion. Subjects first walked with barefoot at a self-selected speed, and then followed by AS1 and AS2 conditions. Supports were directly attached to the plantar surface of the feet and secured by double sided adhesive tapes

The navicular arch height (AH) displacement was defined as a range of vertical AH change between the highest and lowest positions of the navicular marker ($AH_{max} - AH_{min}$) during the mid-stance period of walking trials of each testing condition (BF, AS1 & AS2). The mid-stance was defined as the period between initial ground contact of the first metatarsal head and initial heel off. The peak calcaneal eversion was defined as a maximum angle occurring on frontal plane between the tibia and calcaneus. Joint coordinate systems were applied to calculate the eversion angle between the quiet standing and dynamic walking trial (Grood & Suntay, 1983). One-

way within-subjects ANOVA was conducted to detect effects of arch impedance on the range of AH displacement and peak calcaneal eversion.

RESULTS AND DISCUSSION

Neither average walking speeds nor mid-stance durations were significantly affected by the arch impedance (mean values: 1.38 ± 0.01 m/s and 42.9 ± 1.62 % of gait cycle, respectively).

Significant arch impedance effects on the range of the vertical AH displacement across subjects were found ($p < .02$, Fig 1) decreasing from the BF (2.98 ± 0.99 mm) to the AS1 (2.73 ± 0.85 mm), and to the AS2 (2.24 ± 0.71 mm) conditions. No significant arch impedance effects on the peak calcaneal eversion across subjects were detected ($p = .31$; Fig. 2). However, the peak eversion showed an increasing trend from the BF (1.93° ± 1.70°) to the AS1 (2.83° ± 1.19°), and to the AS2 (3.41° ± 1.40°) conditions.

Reductions in the range of vertical AH displacement with the use of arch supports demonstrated that the navicular drop was successfully impeded by the arch support. The tendency of increasing peak calcaneal eversion with impeded arch may imply compensation to the lack of the navicular drop in order to restore the arch height functions during barefoot walking.

SUMMARY

These preliminary findings suggested a greater calcaneal eversion might occur when the foot arch is impeded during the mid-stance of walking. As orthoses are often prescribed to correct excessive rearfoot motion, constraint on midfoot navicular drop needs to be considered.

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Fig 1. AH range (max- min)

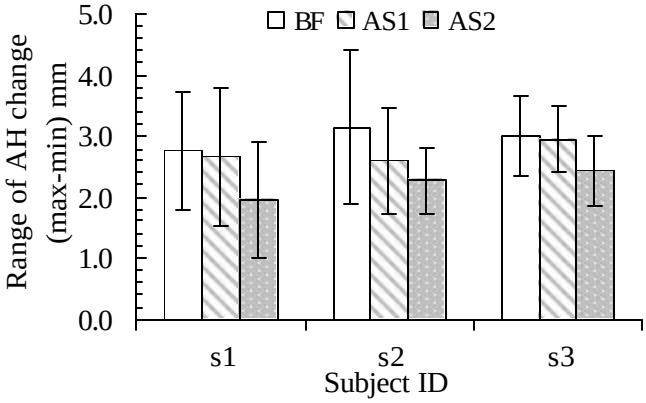

Fig 2. Peak calcaneal eversion