

Effects of Arch Support on Changes in Arch Height and Center of Pressure Under Different Foot Positions While Loading

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INTRODUCTION

Shoe support and orthotic research, design and development have focused on an attempt to improving/ correcting the movement of the foot/ankle complex and to maintain rearfoot movement/position in a neutral position (Clement et al., 1981). The support is designed to “fit” the structure of the arch (Subotnick, 1999). It is not presently clear how the shoe-arch support affects performance of the foot-arch since the foot-arch naturally undergoes structural changes during locomotion. Other researchers have questioned the function of the shoe-arch (Nigg et al., 1999). This study tends to fill the gap in understanding the mechanics of the arch in barefoot (BF) and when it is impeded by an arch support (AS). The purpose of the study was to investigate the effect of shoe-arch support on medial longitudinal arch performance during loaded conditions.

METHODS

A total of ten injury-free volunteers (7 males and 3 females) participated in the study (24 ±4.7 yr; height, 180.0 ± 8.5 cm; weight: 80.5±11.7 kg) excluding abnormal foot types. The left foot of each subject was tested under a load of 712 N. The load was applied to the leg while the subject sat on a chair with the left foot positioned on the force plate (AMTI) and the thigh parallel with the ground. A total of twelve (2) mm square reflective markers were used with

eight of the twelve markers placed on the medial longitudinal arch described by Phillips (1996). Eight markers (numbered t1 to t8) placed on the medial longitudinal arch then were sequentially lined up with the force plate’s center marker during each of the differing foot positions. Each subject was tested under eight conditions, with each condition consisting of position the foot in a new position relative to the force vector of the applied load. This was accomplished by lining up one of the medial longitudinal markers with the center of the force plate. For each condition, a different marker was lined up with the force plate center for a total of eight foot positions. These measurements simulate the positions of the foot (i.e., plantar flexion to dorsiflexion) during midstance. Each arch height change was measured from the marker on the navicular to the floor when the foot was positioned. The upper trunk and left thigh were immobilized by strapping them to the chair to prevent movement. Force data were collected at 1000 Hz for 5 seconds concurrent with a kinematic recording (30 Hz) of the foot arch. The kinematic data were manually digitalized by using the HU-M-AN (Human Movement ANalysis) software version 2.0. Mean arch height change and center of pressure (COP) shift in the medial-lateral (x) direction repeated measures for each foot position were calculated and means were compared to determine statistical significance.

RESULTS AND DISCUSSION

Figure 1 reports the group mean of the arch

height changes in the barefoot and arch support conditions across the eight foot positions (BF, 35.43 ± 6.39 mm; AS, 41.92 ± 5.76 mm). There was a significant increase in arch height in the arch supported condition higher than in the BF condition and a greater variability of AH in BF across the eight foot positions. Figure 2 shows the group means of the COPx (mm) [an indication of vertical ground reaction force (VGRF) in the medial lateral direction] changes in both barefoot (BF) and arch supported (AS) conditions. A greater variability of COPx shift in the BF than in the AS across the same eight foot positions was shown (BF: -1.9 ± 0.72 mm; AS: -2.1 ± 0.40 mm).

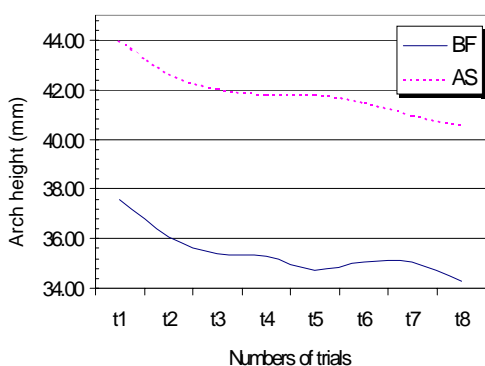


Figure 1. Arch height changes (mm)

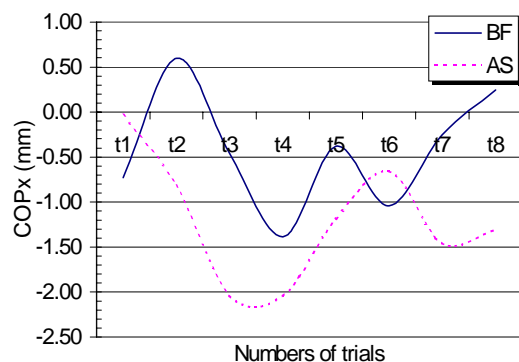


Figure 2. COPx (mm)

The arch height decreased as the foot was moved posteriorly relative to the line of application of the applied load. When the ankle was moved from a plantar flexed position to a dorsiflexed position, the arch height reduced. Since the result of the arch

height change shows a greater variability in the BF condition than in the AS condition, the AH change reflects greater foot adaptability in the BF condition than in the AS condition.

When the barefoot was loaded with weight, and the ankle joint was moved from a plantar flexed position to a dorsiflexed position, the COP along the x axis of the force plate changed more than when the arch supported foot was placed in the same positions. This greater variability of the COPx shift in the BF condition suggests the barefoot had a greater dynamic for change of the arch's distribution of force than in the AS condition. On the other hand, the impedance by the arch support influenced the force distribution resulting in less change of the COPx shift over the trials and tended to shift the COP even more in the medial direction which has greater negative values.

SUMMARY

When the arch support was used, it impeded the arch from achieving its fullest potential. The VGRF was relocated to act on the arch as demonstrated by the shifts of the COP in the x direction. In order to attempt to achieve the barefoot's changes in AH & COP, the data suggests the supported arch had to compensate for the lack of the AH changes by relocating the COP corresponding to the VGRF.

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