INFLUENCE OF MOTION CONTROL SHOES ON NORMAL AND OVERPRONATOR FOOT MOTION DURING RUNNING

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Introduction:
Some footwear manufacturers claim that particular shoes, which they market, control pronation. This is a particularly important claim to investigate as excessive pronation is associated with a variety of injuries, particularly when running (Clement et al., 1984, Bahlsen, 1988). Rearfoot control can be defined as the relative ability of a shoe to limit the amount and/or rate of subtalar joint pronation immediately following heel strike (Clarke et al. 1984). For shoes specifically designed to combat over-pronation several conclusions have been drawn. Nigg and co-workers (cited in Clarke et al. 1983) have shown that, with additional medial support, the average pronation in subjects with over-pronation problems was reduced to below that shown in symptom free subjects. Cavanagh et al (1981) have concluded that shoes with harder midsole materials, stiff heel counters and a wider heel base tend to control pronation the best. In terms of heel flare, Cavanagh (1981) determined that medial flare is beneficial in that it can reduce the amount of pronation. However, lateral flare is not beneficial as it can act as a lever arm, which may increase the angular velocity of the rearfoot thus increasing pronation. Stacoff et al (1991) showed that there was less rearfoot movement (ie less pronation) in the barefoot than the running shoes or running spikes condition. Thus there is some evidence to suggest that shoes can be manufactured which exert some control over rearfoot motion.

None of the above papers, however, measured actual rearfoot motion. Instead, shoe motion was measured and assumed to accurately represent rearfoot motion. Two research groups (Clarke et al., 1980; Nigg et al., 1981, both cited in Clarke et al., 1984) have conducted studies with small sample sizes using windows cut in the rear of the test shoes in order to compare the movement of the heel and the shoe. They showed that markers placed on the shoe move in a similar manner to those on the rear of the foot. However, the researchers themselves (Clarke et al., 1984) drew attention to two limitations to this method. Firstly, the shoe heel counter must fit the subject very well and, secondly, the offset between the midline of the calcaneus and the midline of the shoe is not accounted for. An additional and perhaps more important limitation to these two studies is that they were two-dimensional and thus were only able to measure the motion as a projection onto the frontal plane. A method for the in-shoe measurement of three dimensional rearfoot motion has been developed by Kinchington and Smith (1999) using a similar protocol as described below for this project. The method was shown to be valid with mean differences between the rearfoot and wand less than one degree.

The aim of this study was to investigate the influence of a pair of motion control shoes on the foot movement of excessive pronators and compare this to a control group using the protocol developed by Kinchington and Smith (1999).

Methods:
Ten Subjects (five control and five clinically diagnosed overpronators) underwent five running trials with and without footwear and after a period of familiarisation. Surface markers were placed on the lower right leg and foot, and a metal shim was attached to the calcaneus. A wand marker system consisting of three non-collinear markers was fixed to the shim by a slot and lock mechanism. In the shoe condition this wand was replaced through a single hole in the heel counter of the shoe. All subjects were fitted with the same model shoe designed for motion control. The three-dimensional position of these markers during stance phase of movement was captured using a seven-camera motion analysis system and segment angles were calculated using a joint co-ordinate system. Correction for standing eversion angle was used prior to calculation of the three-dimensional angles. Mean, maximum, minimum and range of all angles were computed in a spreadsheet. For these discrete measures, repeated measures analysis of variance was conducted with main effects and interactions reported and a significance level set at p<0.05
Results:
The wand marker system was found to be valid and reliable for measuring rearfoot movement and no trial effect was seen. A main effect of footwear was seen for dorsiflexion/plantarflexion in the rearfoot (Figure 1) and in the midfoot region (Figure 2).

![Graphs showing foot movement patterns](image)

**Figure 1** Mean curves for controls and pronators combined for plantarflexion/dorsiflexion (a), inversion/eversion (b) and adduction/abduction (c) compared between barefoot and in-shoe.

No significant differences were seen between the foot movement patterns of pronators when compared to the control group with the exception of minimum rearfoot inversion/eversion angles in which the pronators were more everted for both barefoot and shoe conditions especially at maximum eversion. The maximum eversion angle for pronators was significantly more negative than that for the control group (p < 0.05).

**Discussion:** In all conditions there was a significant difference in the movement of DFPF when in shoes compared to barefoot. The propulsion phase (between 75% and 100% of stance) was when this difference was most evident. The shoe severely limits the range of motion of the midfoot and compensates by causing the ankle joint (rearfoot) to have a greater range of motion in the shoe condition. No main effect of pronation in the rearfoot condition when in shoes may be explained by the highly variable individual response that all subjects experienced when wearing the footwear (Figure 4). The pronator with the highest barefoot range of motion maintained the same range in-shoe. One pronator had a highly exaggerated pronation in-shoe. The effect seen in minimum rearfoot inversion/eversion angle is attributed...
to a shift in the inversion/eversion curve because the pronated subjects are more everted initially. For all planes in-shoe rearfoot motion was more variable than barefoot rearfoot motion.

**Figure 4** Individual responses to the wearing of shoes for range of inversion eversion.

REFERENCES


