INFLUENCE OF ORTHOTIC DEVICES PRESCRIBED USING PRESSURE DATA ON LOWER EXTREMITY MOVEMENT AND PRESSURES BENEATH THE SHOE

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INTRODUCTION

In-shoe orthotic devices are typically prescribed using podiatric techniques, where it is assumed that the foot operates most efficiently about the subtalar neutral. A cast is made of the foot and is used to produce an orthotic device that is shaped to the static neutral foot structure of the individual. A degree of posting is typically applied to place the foot and leg in neutral alignment during weight-bearing. An alternative approach to the prescription of orthotic devices using plantar pressure data has recently been developed (RSscan D3D©, 2005). This approach uses the measurement of plantar pressures during barefoot running to determine the shape of the insert and the amount and location of added support. The influence of these devices on lower extremity biomechanics requires investigation, to determine whether the orthoses have the desired effect on movement and loading patterns. Thus the purpose of this study was to investigate the influence of orthotic devices prescribed using pressure data on lower extremity movement and loading patterns. Specifically, it was hypothesized that orthotic devices prescribed using this procedure would reduce peak eversion angle during running and would result in a reduced loading on the medial aspect of the shoe relative to the lateral aspect during early stance.

METHODS

Twenty-two runners experiencing recurring minor injury problems were recruited through local sports injury practitioners and running clubs. Each subject underwent an initial assessment involving the measurement of ten barefoot pressure time-histories for each foot during running at 3.83 $m.s^{-1}$ (±5%) over an RSscan pressure plate (500 Hz). These pressure data were used to produce orthoses through a modular system of orthotic prescription, where one of three orthotic shells differing in arch height is selected based on the dynamic arch index and the balance of pressures at different areas of the foot is used to determine whether additions are applied at selected foot areas (RSscan D3D©, 2005).

Each subject then attended the biomechanics laboratory for collection of movement and pressure plate data when running in a neutral test running shoe with and without the prescribed orthotic device. Ten running trials were performed under each of the conditions using a test running speed of 3.83 $m.s^{-1}$. Three-dimensional kinematic data were collected at 120 Hz using a Peak realtime system (Peak Technologies, USA). For each running trial, initial and peak angles were determined for rearfoot inversion-eversion, lower leg internal rotation, ankle dorsi-plantar flexion and knee flexion. In addition, the balance of pressure on the lateral to medial sides of the shoe was determined within the software by dividing the foot into areas of medial and lateral heel (HM, HL) and metatarsal areas (M1, M2, M3, M4, M5). Foot balance was defined as [(M1+M2+HM)-(M3+M4+M5+HL)] ÷ [average force] * 100, and the minimum value during early stance was used to indicate differences in balance during this phase. Study variables were compared for the two test conditions using paired t-tests ($p<0.05$).

RESULTS AND DISCUSSION

The addition of orthotic devices to a neutral shoe resulted in significant changes in both kinematic and pressure variables (Table 1). In support of the study hypothesis, there was a significant reduction in peak eversion ($p<0.05$). This was accompanied by a small reduction in peak lower leg internal rotation. The 2.2º reduction in peak eversion is of comparable magnitude to reductions previously observed with orthotic use (i.e. Mündermann et al., 2003). However, the ability of orthotic inserts to influence rearfoot movement has depended on the specific construction of the device, with factors such as posting, molding, rigidity and level of customization being influential (Eng and Pierrynowski, 1994; Williams et al., 2003; Nigg et al., 2003; Mündermann et al., 2003). The orthotic devices prescribed in the present study were customized to the individual athlete based on their pressure data during running. Through a selection of modular design features, the process of orthotic prescription was entirely objective. The resulting devices not only had a significant influence on rearfoot movement, but this effect was consistent across all but two study subjects.

The test orthoses in the present study also resulted in a significant increase in the initial inversion angle ($p<0.05$). This is suggested to be an adaptation to allow consistent total rearfoot movement during the period from initial ground contact to peak rearfoot eversion for both test conditions. The orthotic condition resulted in a significant increase in initial ankle dorsi-flexion and peak ankle dorsi-flexion, again resulting in similar ranges of motion for each condition. These results provide some support for suggestions that there is a preferred movement pattern regardless of footwear intervention (Stacoff et al., 2000). Knee flexion was not significantly influenced by wearing the orthotic ($p>0.05$). The foot balance data showed a significantly more negative value for the orthotic condition ($p<0.05$), supporting the hypothesis of a reduced pressure on the medial side of the shoe relative to the lateral aspect. Pressure data from beneath the shoe therefore show potential to indicate orthotic effects during running.

Table 1 – Group mean (±SD) kinematic variables and pressure data for neutral shoe with and without the test orthotic (* $p<0.05$)

	Initial rearfoot angle (°)	**Peak rearfoot angle (°)**	**Initial lower leg angle (°)**	**Peak lower leg angle (°)**	**Initial ankle angle (°)**	**Peak ankle angle (°)**	**Initial knee angle (°)**	**Peak knee angle (°)**	**Early foot balance**
Shoe	4.7 ± 5.4	-9.9 ± 4.5	2.9 ± 5.7	-5.3 ± 4.6	8.0 ± 4.8	21.2 ± 4.5	11.9 ± 6.2	41.3 ± 4.4	-37.7± 24.5
Orthotic	6.6 ± 5.4*	-7.7 ± 4.3*	3.4 ± 6.3	-4.8 ± 5.5	9.4 ± 5.3*	22.1 ± 5.1*	11.6 ± 6.3	41.1 ± 4.4	-49.7± 20.5*

CONCLUSIONS

The devices produced using the procedures of the present study have resulted in the production of shoe inserts that successfully limit peak eversion by encouraging the foot to operate in a more inverted orientation throughout the initial eversion phase of the running step. If a reduction in peak eversion is the intended outcome of an orthotic prescription, then the test devices were successful in achieving this through a prescription obtained using pressure data only.

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REFERENCES

Eng, J.J. and Pierrynowski, M.R. (1994). *Phys Ther* **74**, 836-844.

Mündermann, A., Nigg, B.M. et al. (2003). *Clinical Biomechanics* **18**, 254-262.

Nigg, N.G., Stergiou, P. et al. (2003). *Med Sci Sp Exerc* **35** , 314-319.

Rsscan.www.rsscan.com/files/manuals/Plate/scientific/footscan%207%20manual.x.pdf 02/09/05

Stacoff, A., Reinschmidt, C. et al. (2000). *Clinical Biomechanics* **15**, 54-64.

Williams, D.A., McClay Davis, I. et al. (2003). *Med Sci Sports Exerc* **35**, 2060-2068.