A METHOD FOR THE DESIGN OF HEEL CUSHIONING INSOLES

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INTRODUCTION

Shoe insoles with specialized heel components are often intended to supplement the inherent shock absorbency of the heel pad and the shoe during the early support phase of gait and/or to relieve focal heel pain. Little quantitative information is available to aid in the design of such devices and this study presents a method by which the heel cushioning element can be appropriately positioned to match the loading environment.

REVIEW

While a number of authors have assessed the mechanical properties of insole materials (Brodsky et al.,1988; Garcia et al.,1994; Sanfillipo et al.,1992, Sanders et al., 1998) few studies have been concerned with the efficacy and appropriate design of insole components to provide rearfoot cushioning (Gardner et al.,1988, Jones et al.,1999). Heel pain represents a significant proportion of orthopaedic complaints for which medical attention is sought (Lutter, 1986) and many over-the-counter devices are sold to provide relief. Although it is a complex and multifaceted syndrome, one design requirement for such devices is that the location of the cushioning material should match the regions of high pressure. The present study describes a method to facilitate this approach.

METHODS

Plantar pressures during walking at 1 (+ 0.05) m.s\(^{-1}\) were collected at 30 Hz using an optical pedobarograph (Baltimore Therapeutic). Seven right foot contacts in 6 young symptom free subjects (mean age 26.7 ± 5.5 yrs) with arch indices 0.21 < A.I. < .26 (Cavanagh and Rodgers, 1987) were collected. Prior to data collection, unobtrusive markers (11mm OD x 1.2mm thick washers) were securely fixed with adhesive tape to the plantar surface of the foot under the first and fifth metatarsal heads.

A footprint from each subject was recorded using ink and paper, and the foot position in relation to a commercially available insole component was determined. The footprints and insole outlines were digitized using NIH Image and the location of the markers on the footprint and the pressure distribution plot (apparent as a small low pressure region corresponding to the center of the washer) allowed registration of the footprint, the insole outline, and the pressure distribution. Using MATLAB 5.2, the various images were imported, filtered, aligned, scaled and then overlaid. Pressure distribution was plotted for each available frame in relation to the...
foot and insole geometry along the midline of the foot (midpoint of the heel to the second toe) based on a reference frame in units of % shoe length (%SL) with its origin at the most posterior point of the insole that was the appropriate size for each subject.

This approach is, of course, based on the assumption that the pressure distribution during barefoot walking on a rigid surface can be used as a first approximation of a template for modifications to be made inside a shoe.

RESULTS

The mean peak rearfoot pressure was $506 \pm 61$ kPa. The AP location of peak rearfoot pressure in relation to foot length (SL) was remarkably consistent between individuals and occurred at $10.3\% \pm 1.2\%$ SL. The anterior migration of the pressure distribution along midline of the foot can be seen in the typical plot shown in Fig 1. It is notable that the location of peak pressure moves initially forward and then dwells in a region of approximately 10 % SL for a considerable period of time. During this period, there is typically a broad plateau of high pressure which extends well beyond the distal margin of the cushioning element.

DISCUSSION

The insole examined in this study is typical of many commercially available devices that are intended to improve comfort and alleviate pain in the heel. While the present study does not address the issue of focal heel pain, the application of the proposed measurement technique does demonstrate that there are regions of the rearfoot that are subjected to relatively high pressures but that receive no additional "cushioning" from the insoles examined.

Figure 1. Successive pressure distributions for a typical subject along the midline of the foot at each 33 ms during heel contact. The peak pressure is shown as a small circle and the solid vertical line is the anterior extent of the cushioning element. The x axis is in units of SL.

REFERENCES

Lutter, L.D.

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