Pressure-relieving properties of various shoe inserts in older people with plantar heel pain

Daniel R. Bonanno, Karl B. Landorf, Hylton B. Menz

Department of Podiatry, Faculty of Health Sciences, La Trobe University, Bundoora, Vic 3086, Australia
Musculoskeletal Research Centre, Faculty of Health Sciences, La Trobe University, Bundoora, Vic 3086, Australia

ARTICLE INFO
Article history:
Received 10 June 2010
Received in revised form 2 December 2010
Accepted 9 December 2010

Keywords:
Plantar heel pain
Foot orthosis
Shoe inserts
Heel inserts
Plantar pressures

ABSTRACT
Plantar heel pain is one of the most common musculoskeletal conditions affecting the foot and it is commonly experienced by older adults. Contoured foot orthoses and some heel inserts have been found to be effective for plantar heel pain, however the mechanism by which they achieve their effects is largely unknown. The aim of this study was to investigate the effects of foot orthoses and heel inserts on plantar pressures in older adults with plantar heel pain. Thirty-six adults aged over 65 years with plantar heel pain participated in the study. Using the in-shoe Pedar system, plantar pressure data were recorded while participants walked along an 8 m walkway wearing a standardised shoe and 4 different shoe inserts. The shoe inserts consisted of a silicon heel cup, a soft foam heel pad, a heel lift and a prefabricated foot orthosis. Data were collected for the heel, midfoot and forefoot. Statistically significant attenuation of heel peak plantar pressure was provided by 3 of the 4 shoe inserts. The greatest reduction was achieved by the prefabricated foot orthosis, which provided a fivefold reduction compared to the next most effective insert. The contoured nature of the prefabricated foot orthosis allowed for an increase in midfoot contact area, resulting in a greater redistribution of force. The prefabricated foot orthosis was also the only shoe insert that did not increase forefoot pressure. The findings from this study indicate that of the shoe inserts tested, the contoured prefabricated foot orthosis is the most effective at reducing pressure under the heel in older people with heel pain.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

Plantar heel pain is one of the most common musculoskeletal conditions affecting the foot [1]. It is regularly experienced by running athletes [2] and people who are overweight [3], however it has also been reported to affect 4–17% of older people [4,5]. As the specific cause of pain is often difficult to determine clinically, the broad term plantar heel pain is regularly used [3,6]. There are many causes of pain in the plantar heel region, although plantar fasciitis is recognised as being the most common [6]. Among older people, heel pain can have a negative impact on foot-specific and general health-related quality of life [7], which includes functional limitation [8].

The aetiology of plantar heel pain remains unclear, but it is likely to be multifactorial with many associated risk factors having been identified, including increased age, obesity, increased hours of standing and some biomechanical or functional factors [1,9]. In addition, a strong association between plantar heel pain and calcaneal spurs has been identified [9,10]. This finding is supported by a radiographic study which reported that older people with calcaneal spurs were 5 times more likely to have a current or previous history of heel pain [11].

Shoe inserts have been found to be effective in the management of plantar heel pain [12–14]. The mechanism by which they achieve their effect is still largely unknown, although it may include a reduction in plantar pressure under the heel [15,16]. At present, only two studies have investigated the effects shoe inserts have on plantar pressure under the heel in people with a history of plantar heel pain, however one study measured plantar pressures while standing [15], while the other study only included participants who no longer experienced plantar heel pain [16]. In addition, neither study included participants over the age of 65 years. This may be of importance as it has been shown that ageing results in increased heel pad stiffness [17] and decreased energy dissipation [18]. Given that the biomechanics of the heel may differ between young and old people, this study aimed to investigate the pressure-relieving properties of a variety shoe inserts in older people with plantar heel pain.
2. Methods

2.1. Participants

The sample consisted of 36 participants, comprising 24 males (67%) and 12 females (33%). Participants were recruited via advertisements in local podiatry clinics, retirement villages and newspapers. Inclusion in the study was conditional on participants: (i) having symptoms consistent with plantar heel pain for a minimum of four weeks in one or both feet; (ii) being aged 65 years or older; (iii) being able to walk household distances without a walking aid; and (iv) having normal cognition, as determined by the Short Portable Mental Status Questionnaire [19]. The diagnosis of plantar heel pain was determined by: (i) heel pain being most noticeable in the morning or after rest but easing with mild activity; (ii) pain being generally worse with prolonged standing; and (iii) pain reproducible with palpation of the medial tuberosity of the calcaneus. Bilateral plantar heel pain was experienced by 14 participants (39%). The median duration of symptoms was 8 months (range 1–60 months). Participants were excluded from the study if they had a history of inflammatory arthritis, surgery to the heel, heel pain of unknown diagnosis, or were unable to speak English. The project was approved by the Institutional Ethics Committee and informed consent was obtained from all participants. The characteristics of the participants are shown in Table 1.

2.2. Interventions

All participants were tested wearing new shoe inserts and socks to minimise the effect of material fatique on the plantar pressure data. The cotton socks (Texas Peak Pty Ltd., Melbourne, Australia) and canvas athletic footwear (Dunlop Volley, Pacific Dunlop Ltd., Melbourne, Australia) were standardised to minimise their influence on pressures across participants. The style of footwear was selected as its lightweight construction and original flat insole surface was thought to have a minimal effect on the foot, the shoe inserts, and the in-shoe pressure mapping insoles.

The 5 conditions analysed were (Fig. 1):

(i) Shoe only (control condition).
(ii) Shoe + silicon heel cup (Silipos® Wonderspur, viscoelastic polymer).
(iii) Shoe + soft foam heel pad (PPTTM, 6 mm thick open-cell polyurethane).
(iv) Shoe + heel lift (Formthotics® heel lift, 6 mm thick polyethylene).
(v) Shoe + prefabricated foot orthosis (Formthotics®, 3/4 length dual-density polyethylene insole).

The silicon heel cup, along with other viscoelastic heel inserts, has been shown to reduce heel plantar pressures in asymptomatic young adults [20]. The heel lift and soft foam heel pad are both relatively inexpensive, and the material PPTTM [21] and elevation of the heel [22] have been shown to reduce heel plantar pressure. The prefabricated foot orthosis contours the heel and arch of the foot. Similar orthotic insoles, made by the same manufacturer, have been shown to be effective in providing short-term improvements in pain and function in people with plantar fasciitis [13]. Furthermore, contoured foot orthoses have been shown to decrease heel plantar pressure [23,24].

2.3. Randomisation

The 5 conditions were tested in random order to minimise potential sequencing effects.

2.4. Blinding

To minimise bias, participants were not aware of the variety of shoe inserts used in the study or which shoe insert was being investigated with each trial. The investigator was not blinded due to the difficulty in concealing the shoe insert used in each condition. Because the plantar pressure apparatus provides objective data, this was not viewed as a concern.

2.5. Pressure analysis equipment

Plantar pressures were measured with the in-shoe Pedar® system (Novel GmbH, Munich, Germany), a reliable, valid and accurate measure of in-shoe pressure.

There were a number of significant plantar pressure, force and contact area differences (Fig. 2) between the 5 conditions. As overall contact times did not differ across conditions it can be assumed that the participants walked at a consistent speed during the trials and therefore any differences in plantar pressures can be attributed to the conditions being analysed (Table 2).

3. Results

3.1. Plantar pressure changes

There were a number of significant plantar pressure, force and contact area differences (Fig. 2) between the 5 conditions. As overall contact times did not differ across conditions it can be assumed that the participants walked at a consistent speed during the trials and therefore any differences in plantar pressures can be attributed to the conditions being analysed (Table 2).

3.1.1. Heel

All shoe inserts had a statistically significant effect on either peak pressure or maximum force under the heel compared to the
shoe only condition (Table 3). Significant reductions in peak pressure were provided by the prefabricated foot orthosis (29%), soft foam heel pad (6%), and silicon heel cup (6%). The only shoe insert to provide a reduction in maximum force was the prefabricated foot orthosis (7%), while the heel lift was the only insert to significantly increase maximum force (6%). Comparison between the shoe inserts established that the prefabricated foot orthosis provided significantly lower peak pressure than all other inserts. Compared to the shoe only condition, the prefabricated foot orthosis was the only insert to significantly increase (5%) contact area in the heel. In contrast, the soft foam heel pad and silicon heel cup demonstrated a significant decrease in contact area (3% and 4%, respectively). The heel lift had no effect on contact area.

3.1.2. Midfoot

Compared to the shoe only condition, all shoe inserts had a significant effect on either maximum force or peak pressure under the midfoot (Table 3). Similar and significant reductions in peak pressure were provided by the silicon heel cup (24%), soft foam heel pad (22%), and heel lift (17%). In comparison, the prefabricated foot orthosis increased midfoot peak pressure (11%), although this increase was not significant compared to the shoe, but it was significantly different to the other shoe inserts.

The prefabricated foot orthosis was the only shoe insert to provide a significant increase in maximum force (66%) at the midfoot. In contrast, all other inserts significantly reduced maximum force (35–42%), with the silicon heel cup reducing maximum force significantly more than the soft foam heel pad.

All shoe inserts had a significant effect on midfoot contact area compared to the shoe only condition. The only insert to increase contact area was the prefabricated foot orthosis (42%), while all other shoe inserts provided significant and similar reductions in contact area (22–29%).

3.1.3. Forefoot

Compared to the shoe only condition, no shoe insert had an effect on maximum force (Table 3) and peak pressure were only affected by the heel lift and soft foam heel pad (6% and 7% increase, respectively). Comparison between the shoe inserts revealed that the prefabricated foot orthosis provided significantly lower forefoot peak pressure than all other shoe inserts. Finally, the heel lift produced a 4% reduction in contact area, while the prefabricated foot orthosis provided a 4% increase compared to the shoe alone.

4. Discussion

The attenuation of heel peak pressure provided by the prefabricated foot orthosis was approximately five-fold that of the next two most effective inserts – the soft foam heel pad and silicon heel cup. Interestingly, the soft foam heel pad and silicon heel cup both provided similar reductions in heel contact area, peak pressure and maximum force. Such a finding may be of financial importance as both heel inserts vary substantially in cost; with supply prices at the time of the study being approximately $29 (AUS) for the silicon heel cup and $6 (AUS) for the soft foam heel pad. This finding is consistent with previous research which has shown the cost of heel inserts is not indicative of their ability to provide immediate reductions in heel plantar pressure [20].

The materials and geometry of the shoe inserts were not standardised, and as such, several design features of the inserts may have influenced plantar pressures. The contoured shape of the prefabricated foot orthosis approximates the plantar contour of the foot, which appears to have a considerable effect on its ability to attenuate plantar pressures. Compared to the shoe only condition, it was the only insert to increase contact area under all 3 regions of the foot; with the midfoot increasing by at least 82% more than the other inserts. This enabled the prefabricated foot orthosis to redistribute force over a greater area compared to the heel inserts, thereby providing a greater reduction in heel and forefoot plantar pressure. These findings are consistent with previous research, which has shown insoles with a greater conformity to the foot are more effective at attenuating heel plantar pressure [22,24].

Although the heel inserts all differ in construction, they all slightly elevate the heel. Our data demonstrates that this is associated with a systematic increase in forefoot loading while also reducing contact area under the heel, midfoot and forefoot. The decreased contact area limits the inserts' ability to distribute force and this, coupled with the elevated heel height, may explain the increase in forefoot pressure. Such findings suggest caution is required when prescribing heel inserts, as the increase in forefoot

### Table 2

Mean (SD) contact time for each of the conditions (N = 36).

<table>
<thead>
<tr>
<th>Insert</th>
<th>Contact time (ms)</th>
<th>% Change</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoe only (control)</td>
<td>702.33 (83.89)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Silicon heel cup</td>
<td>701.29 (83.25)</td>
<td>−0.14%</td>
<td>1.000</td>
</tr>
<tr>
<td>Soft foam heel pad</td>
<td>703.75 (79.34)</td>
<td>+0.20%</td>
<td>1.000</td>
</tr>
<tr>
<td>Heel lift</td>
<td>712.80 (87.38)</td>
<td>+1.49%</td>
<td>1.000</td>
</tr>
<tr>
<td>Prefabricated foot orthosis</td>
<td>696.00 (78.78)</td>
<td>−0.90%</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**Fig. 2.** Percentage change of peak pressure, maximum force and contact area for the foot for each shoe insert compared to the shoe alone condition (N = 36). Significant (p < 0.05) changes marked with an asterisk (*).
plantar pressure may be of clinical importance and lead to symptoms in the forefoot.

The findings of this study may assist in explaining why contoured foot orthoses [12,13] and pressure-relieving shoe inserts [14] are beneficial in the management of plantar heel pain. Foot orthoses have often been used in the management of plantar heel pain primarily on the premise they minimise foot pronation and reduce plantar fascia strain [28,29]. However, the association between plantar heel pain and foot pronation is not fully established. Therefore, it would be beneficial if a clinical trial was conducted to explore: (i) how effective various shoe inserts are from a patient outcome perspective and (ii) whether reduction in plantar pressure under the heel is able to predict patient outcomes.

5. Conclusion

The results of this study suggest that prefabricated foot orthoses and some heel inserts provide immediate reduction in heel plantar pressure in older people with plantar heel pain while walking. Furthermore, the cost of a heel insert or orthosis was not found to be indicative of its ability to reduce heel plantar pressure. Importantly, the contoured foot orthosis used in this study provided a five-fold attenuation in plantar heel peak pressure compared to the shoe only (control) insert that contours the heel and arch of the foot is most appropriate when attempting to reduce heel plantar pressure in older people with plantar heel pain.

Conflicts of interest

The authors declare that there are no known conflicts of interest related to this project that could have influenced this manuscript.

Acknowledgements

The authors would like to thank: Briggate Medical Company Pty Ltd. (Melbourne, Australia) for providing the foot orthoses and heel inserts. D.R. Bonanno et al. / Gait & Posture 33 (2011) 385–389
inserts; and Texas Peak Pty Ltd. (Melbourne, Australia) for donating the socks used in this study. HBM is currently a National Health and Medical Research Council of Australia fellow (Clinical Career Development Award, ID: 433049).

References