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

Daniel R. Bonanno [a,b,*], Karl B. Landorf [a,b], Hylton B. Menz [b]

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

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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.

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.

* Corresponding author at: Department of Podiatry, Faculty of Health Sciences, La Trobe University, Bundoora, Vic 3086, Australia.
Tel.: +61 3 9479 5839; fax: +61 3 9479 5784.
E-mail address: d.bonanno@latrobe.edu.au (D.R. Bonanno).

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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 fatigue 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 (Silpos® Wonderspur, viscoelastic polymer).
(iii) Shoe + soft foam heel pad (PPT™, 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 PPT™ [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 [25,26]. The Pedar® insoles are approximately 2 mm thick and consist of 99 capacitive pressure sensors that are arranged in grid alignment. Plantar pressure data were sampled at a frequency of 50 Hz. All insoles were calibrated with the trublu® calibration device prior to the commencement of the study (Novel GmbH, Munich, Germany).

Table 1
Characteristics of the 36 study participants.

Characteristic	Mean	Standard deviation	Range
Age (years)	71	6.9	65–92
Height (m)	1.69	0.08	1.51–1.83
Body mass (kg)	81.4	13.1	54.0–103.9
Body mass index (kg/m^2)	28.7	4.8	20.8–40.3
Time on feet (h/day)	6.0	2.9	2.0–12.5

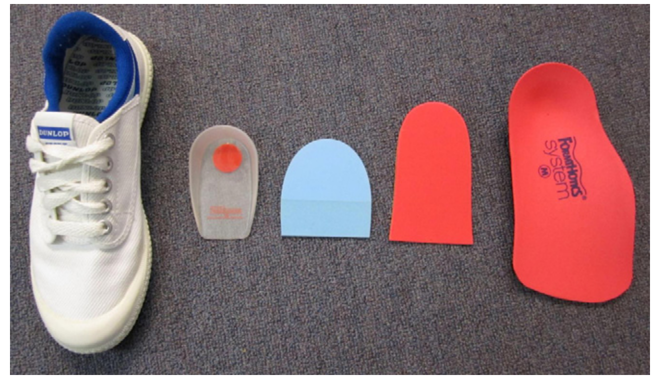

Fig. 1. The five experimental conditions. Left to right: (i) Dunlop Volley; (ii) silicon heel cup; (iii) soft foam heel pad; (iv) heel lift; (v) prefabricated foot orthosis.

2.6. Protocol

The Pedar® insole was placed on top of each shoe insert. Prior to the first walking trail of each condition, the pressure insoles were zeroed as described by the manufacturer's guidelines (Novel GmbH, Munich, Germany). After a familiarisation period of approximately 2 min, participants completed 4 walking trials for each condition. Participants were timed as they walked at a comfortable self-determined speed along an 8 m walkway. The mean walking speed was 4.4 (0.4) km/h (range 3.4–5.2 km/h). If a trial did not fall within 5% of the original walking time it was eliminated and repeated to minimise the effect of altered walking speed on plantar pressures [27]. To exclude the effect of acceleration and deceleration steps, only the middle 4 steps from each trial of the most painful foot were included for analysis. An average recording was determined from the 16 steps (4 steps from 4 trials) for each condition.

2.7. Outcome measures

The primary outcome measures were peak pressure, maximum force and contact area beneath the heel for each condition. Secondary outcome measures included peak pressure, maximum force and contact area beneath the midfoot and forefoot for each condition.

2.8. Statistical analysis

The plantar pressure data were entered into the Pedar® analysis program and a Novel percent mask was applied to each footprint. Percentage sized masks were applied to the heel (proximal 31% of foot length), midfoot (middle 19% of foot length), and forefoot (distal 50% of foot length) [24].

Data were analysed using the computer program Statistical Package for the Social Sciences (SPSS) Version 17.0 (SPSS Inc., Chicago, IL). The data were explored for normality and some data required log or inverse square root transformation prior to inferential analysis. A one-way repeated measures analysis of variance (ANOVA) with Bonferroni-adjusted post hoc tests was used to compare measurements between each of the conditions. Differences between the mean plantar pressures of each condition were considered significant if $p < 0.05$.

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

Table 2
Mean (SD) contact time for each of the conditions ($N = 36$).

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

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;

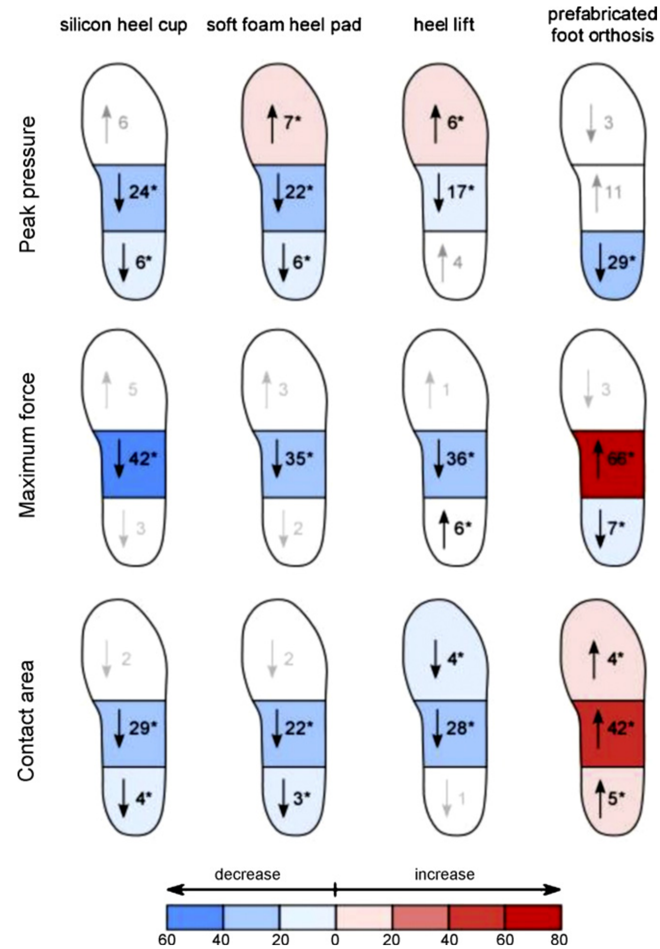

Fig. 2. Percentage change of peak pressure, maximum force and contact area for the foot for each shoe insert compared to the shoe alone condition ($N = 36$). Significant ($p < 0.05$) changes marked with an asterisk (*).

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 3
Mean values (SD) for the heel, midfoot and forefoot ($N = 36$).

Insert	Heel								
	Peak pressure (kPa)			Maximum force (%BW)			Contact area (cm^2)		
	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value
Shoe only (control)	251.5 (45.9)	n/a	n/a	73.3 (10.0)	n/a	n/a	45.7 (3.6)	n/a	n/a
Silicon heel cup	236.5 (38.6)	−6%*	0.002	70.9 (9.4)	−3%	0.092	44.1 (3.6)	−4%*	<0.001
Soft foam heel pad	236.7 (37.6)	−6%*	0.006	71.9 (9.4)	−2%	0.897	44.2 (3.8)	−3%*	<0.001
Heel lift	260.4 (35.6)	+4%	0.848	78.0 (9.2)	+6%*	<0.001	45.3 (3.7)	−1%	0.682
Prefabricated foot orthosis	178.0 (27.9)	−29%*	<0.001	68.0 (10.3)	−7%*	<0.001	47.9 (3.5)	+5%*	<0.001

Insert	Midfoot								
	Peak pressure (kPa)			Maximum force (%BW)			Contact area (cm^2)		
	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value
Shoe only (control)	87.4 (29.0)#	n/a	n/a	13.9 (6.2)	n/a	n/a	24.3 (7.0)	n/a	n/a
Silicon heel cup	66.7 (29.0)#	−24%*	<0.001	8.1 (5.4)	−42%*	<0.001	17.2 (7.5)	−29%*	<0.001
Soft foam heel pad	67.8 (27.9)#	−22%*	<0.001	9.0 (5.3)	−35%*	<0.001	19.0 (7.3)	−22%*	<0.001
Heel lift	73.0 (28.8)#	−17%*	<0.001	8.9 (5.4)	−36%*	<0.001	17.6 (7.1)	−28%*	<0.001
Prefabricated foot orthosis	97.4 (31.9)#	+11%	0.195	23.1 (6.4)	+66%*	<0.001	34.6 (2.8)	+42%*	<0.001

Insert	Forefoot								
	Peak pressure (kPa)			Maximum force (%BW)			Contact area (cm^2)		
	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value	Mean (SD)	% change	*p*-Value
Shoe only (control)	292.0 (67.3)	n/a	n/a	89.1 (14.7)#	n/a	n/a	73.1 (6.9)	n/a	n/a
Silicon heel cup	310.5 (75.7)	+6%	.085	93.6 (16.0)#	+5%	0.570	71.9 (7.5)	−2%	.766
Soft foam heel pad	311.3 (73.6)	+7%*	.001	91.4 (15.1)#	+3%	0.112	71.9 (7.4)	−2%	.267
Heel lift	310.8 (72.6)	+6%*	.003	90.5 (16.0)#	+1%	0.516	70.4 (7.4)	−4%*	.001
Prefabricated foot orthosis	283.6 (68.4)	−3%	1.00	86.7 (15.5)#	−3%	0.150	75.7 (6.8)	+4%*	.002

* Mean difference is significant at the 0.05 level (Bonferroni adjusted) compared to the shoe only (control).
\# Data transformed prior to determining significance.

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 uncertain [9] and the mechanisms by which foot orthoses work remain unclear [30]. The findings from this study are consistent with the theory that plantar heel pain in older people may result from increased vertical loading to the heel [11]. As such, plantar heel pain may be able to be effectively managed by reducing such loads. Interestingly, the prefabricated foot orthosis, which in this study provided the greatest reduction in heel plantar pressure, has been shown to be effective in reducing plantar heel pain [13].

The findings of this study need to be viewed in light of several limitations. First, the participants had a limited period to acclimatise to each of the conditions prior to data collection. A longer period of acclimatisation was considered, but due to the potential risk of aggravating the participants' symptoms, it was deemed inappropriate to do so from an ethical perspective. Second, the laboratory-based setting may have influenced the external validity of the study. Participants were required to wear standardised footwear that may not be representative of what they typically wear, and the insert being tested may also have responded differently in more supportive footwear. Third, the nature of using pressure-mapping insoles at the foot and shoe-insert interface may in itself influence plantar pressures, but as it is not possible to measure this potential influence it remains an inherent limitation of using pressure-mapping insoles. Fourth, the immediate effect heel inserts and foot orthoses have on plantar pressures were analysed in this study, therefore the findings may not reflect longer term changes such as degradation of the materials used to manufacture the shoe inserts and the participants acclimatising to them. Finally, we recognise that the association between vertical heel pressure and plantar heel pain has not been 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 next most effective heel insert. The contoured nature of the prefabricated foot orthosis allowed for an increase in heel and midfoot contact, which allowed for a greater redistribution of plantar loads. Therefore, it is recommended that a shoe 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.

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References

[1] Buchbinder R. Plantar fasciitis. N Engl J Med 2004;350(21):2159–66.
[2] Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 2002;36:95–101.
[3] Irving DB, Cook JL, Young M, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case–control study. BMC Musculoskelet Disord 2007;8(41).
[4] Hill CL, Gill TK, Menz HB, Taylor AW. Prevalence and correlates of foot pain in a population-based study: the North West Adelaide health study. J Foot Ankle Res 2008;1(2).
[5] Menz HB, Tiedemann A, Kwan MM, Plumb K, Lord SR. Foot pain in community-dwelling older people: an evaluation of the Manchester Foot Pain and Disability Index. Rheumatology 2006;45:863–7.
[6] Rome K. Etiologic and extrinsic risk factors associated with plantar heel pain during physical activity: a review. The Lower Extremity 1998;5(1):3–10.
[7] Irving DB, Cook JL, Young MA, Menz HB. Impact of chronic plantar heel pain on health-related quality of life. J Am Podiatr Med Assoc 2008;98(4):283–9.
[8] Badlissi F, Dunn JE, Link CL, Keysor JJ, McKinlay JB, Felson DT. Foot musculoskeletal disorders, pain, and foot-related functional limitation in older persons. J Am Geriatr Soc 2005;53(6):1029–33.
[9] Irving DB, Cook JL, Menz HB. Factors associated with chronic plantar heel pain: a systematic review. J Sci Med Sport 2006;9:11–22.
[10] McMillan AM, Landorf KB, Barrett JT, Menz HB, Bird AR. Diagnostic imaging for chronic plantar heel pain: a systematic review and meta-analysis. J Foot Ankle Res 2009;2(32).
[11] Menz HB, Zammit GV, Landorf KB, Munteanu SE. Plantar calcaneal spurs in older people: longitudinal traction or vertical compression? J Foot Ankle Res 2008;1(7).
[12] McPoil TG, Martin RL, Cornwall MW, Wukich DK, Irrgang JJ, Godges JJ. Heel pain-plantar fasciitis: clinical practice guidelines linked to the international classification of functioning, disability, and health from the orthopaedic section of the American physical therapy association. J Orthop Sports Phys Ther 2008;38(4):1–18.
[13] Landorf KB, Keenan AM, Herbert RD. Effectiveness of foot orthoses to treat plantar fasciitis: a randomized trial. Arch Intern Med 2006;166:1305–9.
[14] Pfeffer G, Bacchetti P, Deland J, Lewis A, Anderson R, Davis W, et al. Comparison of custom and prefabricated orthoses in the initial treatment of proximal plantar fasciitis. Foot Ankle Int 1999;20(4):214–21.
[15] Chia J, Suresh S, Kuah A, Ong J, Phua J, Seah A. Comparative trial of the foot pressure patterns between corrective orthotics, Formthotics, bone spur pads and flat insoles in patients with chronic plantar fasciitis. Ann Acad Med Singapore 2009;38(10):869–75.
[16] Hsi W, Lai J, Yang P. In-shoe pressure measurements with a viscoelastic heel orthosis. Arch Phys Med Rehabil 1999;80:805–10.
[17] Kinoshita H, Francis PR, Murase T, Kawai S, Ogawa T. The mechanical properties of the heel pad in elderly adults. Eur J Appl Physiol Occup Physiol 1996;73:404–9.
[18] Hsu TC, Wang CL, Tsai WC, Kuo JK, Tang FT. Comparison of the mechanical properties of the heel pad between young and elderly adults. Arch Phys Med Rehabil 1998;79:1101–4.
[19] Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. J Am Geriatr Soc 1975;23:433–41.
[20] Ramanathan AK, John MC, Arnold GP, Cochrane L, Abboud RJ. Off-the-shelf in-shoe heel inserts. Does cost matter? Br J Sports Med 2008;42(9):750–2.
[21] McPoil TG, Cornwall MW. Effect of insole material on force and plantar pressures during walking. J Am Podiatr Med Assoc 1992;82:412–6.
[22] Hong WH, Lee YH, Chen HC, Pei YC, Wu CY. Influence of heel height and shoe insert on comfort perception and biomechanical performance of young female adults during walking. Foot Ankle Int 2005;26(12):1042–8.
[23] Redmond AC, Landorf KB, Keenan AM. Contoured, prefabricated foot orthoses demonstrate comparable mechanical properties to contoured, customised foot orthoses: a plantar pressure study. J Foot Ankle Res 2009;2(20).
[24] Burns J, Crosbie J, Ouvrier R, Hunt A. Effective orthotic therapy for the painful cavus foot: a randomized controlled trial. J Am Podiatr Med Assoc 2006;96(3):205–11.
[25] Boyd LA, Bontrager EL, Mulroy SJ, Perry J. The reliability and validity of the novel Pedar® system of in-shoe pressure measurement during free ambulation. Gait Posture 1997;5(2):165.
[26] Murphy DF, Beynnon BD, Michelson JD, Vacek PM. Efficacy of plantar loading parameters during gait in terms of reliability, variability, effect of gender and relationship between contact area and plantar pressure. Foot Ankle Int 2005;26(2):171–9.
[27] Burnfield JM, Few CD, Mohamed OS, Perry J. The influence of walking speed and footwear on plantar pressures in older adults. Clin Biomech 2004;19(1):78–84.
[28] Kogler GF, Solomonidis SE, Paul JP. In vitro method for quantifying the effectiveness of the longitudinal arch support mechanism of a foot orthosis. Clin Biomech 1995;10(5):245–52.
[29] Kogler GF, Solomonidis SE, Paul JP. Biomechanics of longitudinal arch support mechanisms in foot orthoses and their effect on plantar aponeurosis strain. Clin Biomech 1996;11(5):243–52.
[30] Landorf KB, Keenan AM. Do foot orthoses prevent injury? In: McCauley D, Best T, editors. Evidence-based sports medicine. 2nd ed., Massachusetts: Blackwell Publishing; 2007.