# Coexistence of plantar calcaneal spurs and plantar fascial thickening in individuals with plantar heel pain

Hylton B. Menz,1,2🖂 Martin J. Thomas,1,3 Michelle Marshall,1 Trishna Rathod-Mistry,1 Alison Hall,1 Linda S. Chesterton1, George M. Peat1, Edward Roddy1,3

1Arthritis Research UK Primary Care Centre, Research Institute for Primary Care and Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG, United Kingdom

2School of Allied Health, College of Science, Health and Engineering, La Trobe University, Melbourne, Victoria 3086, Australia

3Haywood Academic Rheumatology Centre, Staffordshire and Stoke-on-Trent Partnership NHS Trust, Haywood Hospital, Burslem, Staffordshire, ST5 5BG, United Kingdom

🖂Corresponding author:

Prof Hylton B. Menz

School of Allied Health, College of Science, Health and Engineering

La Trobe University

Melbourne, Victoria 3086, Australia

Tel: +61 (3) 9479 5801

Fax: +61 (3) 9479 5415

email: h.menz@latrobe.edu.au

Short title: Associations of plantar heel pain

**Abstract**

**Objectives.** To examine associations between plantar calcaneal spurs, plantar fascia thickening and plantar heel pain (PHP), and to determine whether tenderness on palpation of the heel differentiates between these presentations.

**Methods.** Adults aged ≥50 years registered with four general practices were mailed a Health Survey. Responders reporting foot pain within the last 12 months underwent a detailed clinical assessment. PHP in the past month was documented using a foot manikin. Plantar calcaneal spurs were identified from weight-bearing lateral radiographs and plantar fascia thickening (defined as >4mm) from ultrasound. Tenderness on palpation of the plantar fascia insertion was documented. Associations between these factors and PHP were explored using generalised estimating equations.

**Results.** Clinical and radiographic data were available from 530 participants (296 women, mean [SD] age 64.9 [8.4] years), 117 (22.1%) of whom reported PHP. Plantar calcaneal spurs and plantar fascia thickening were identified in 281 (26.5%) and 501 (47.3%) feet, respectively, but frequently coexisted (n=217, 20.4%). Isolated plantar calcaneal spurs were rare (n=64, 6.0%). Participants with PHP were more likely to have a combination of these features compared to those without PHP (odds ratio 2.16, 95% confidence interval 1.24**–**3.77, *p*=0.007). Tenderness on palpation of the heel was not associated with plantar calcaneal spurs or plantar fascia thickening, either in isolation or in combination, in those with PHP.

**Conclusion.** Plantar calcaneal spurs and plantar fascial thickening are associated with PHP, but frequently coexist. Tenderness on palpation of the heel does not appear to differentiate between clinical presentations of PHP.

**Key words:** plantar fasciitis, heel spur syndrome, calcaneal spur

**Rheumatology key messages**

* Plantar calcaneal spurs and plantar fascial thickening frequently coexist in individuals with plantar heel pain
* Tenderness on palpation of the heel has limited value for clinical assessment
* Plantar heel pain is multifactorial and cannot be exclusively attributed to individual imaging findings

**Introduction**

Plantar heel pain is a common condition which affects approximately 10% of the general population [1-3] and is associated with activity limitation, depression and reduced health-related quality of life [4, 5]. In the USA, it has been estimated that management of plantar heel pain accounts for one million physician visits per year [6], at a total annual cost of US$284 million [7]. In the UK, the 12 month period prevalence of general practitioner consultation by individuals with plantar heel pain is 43% [8], and it has been estimated that 12% of all musculoskeletal foot and ankle consultations in primary care are related to heel pain [9].

Despite the high prevalence and burden of plantar heel pain, the underlying aetiology of the condition is not well understood. Several foot-level risk factors have been identified, including pronated foot type, limited ankle and first metatarsophalangeal joint dorsiflexion and reduced muscle strength [10-12], although the most consistently associated factor is an increased body mass index [13]. Imaging studies have revealed associations between plantar heel pain and the presence of plantar calcaneal spurs, thickening and hypoechogenicity of the plantar fascia, perifascial oedema and calcaneal bone marrow oedema [13-15], while histological investigations have noted plantar fascia degeneration, fragmentation, and calcaneal spur fracture [16, 17]. These findings suggest that plantar heel pain is a complex condition involving a range of osseous and soft tissue abnormalities, and is not simply an inflammatory condition affecting the plantar fascia in isolation [18].

In clinical practice, plantar heel pain is typically diagnosed based on clinical signs and symptoms, with point tenderness over the insertion of the plantar fascia into the medial

tubercle of the calcaneus being a characteristic feature [19]. Diagnostic imaging is not always necessary, although the most common approaches used are the identification of plantar calcaneal spurs using plain radiography, and detection of plantar fascial thickening using ultrasound; observations which have strong associations with plantar heel pain [13, 15]. However, the degree to which plantar calcaneal spurs and plantar fascial thickening may coexist has not been well established, nor has the value of palpation of the plantar fascial insertion in identifying these abnormalities. Understanding how these factors inter-relate would provide useful insights into the underlying cause of the condition and may influence treatment planning.

Therefore, the objectives of this study were to (i) examine associations between plantar calcaneal spurs, plantar fascia thickening and self-reported plantar heel pain in the past month, and (ii) determine whether tenderness on palpation of the heel differentiates between the presence of calcaneal spurs, plantar fascia thickening, or both these features combined. To do this we conducted a cross-sectional analysis of people aged 50 years and over who participated in a population-based observational cohort study [20].

**Methods**

**Study design**

This paper utilises baseline data from the Clinical Assessment Study of the Foot [20]. Adults aged 50 years and over registered with four general practices were invited to take part in the study, irrespective of consultation for foot pain or problems. Ethical approval was obtained from Coventry Research Ethics Committee (reference number: 10/H1210/5). Written informed consent was obtained from all participants.

**Health survey questionnaire**

All eligible participants were mailed a Health Survey questionnaire that gathered information on demographic and socio-economic characteristics (age, gender, education and occupation) and aspects of general health including the Short Form-12 (SF-12) [21] and the Hospital Anxiety and Depression Scale (HADS) [22]. Specific questions included the presence of pain in and around the foot in the past 12 months and the Manchester Foot Pain and Disability Index (MFPDI) [23]. Participants were asked to indicate the location of foot pain experienced in the right and left feet in the past month using a foot manikin (© The University of Manchester 2000. All rights reserved) [24], and those who shaded the region of the plantar heel were documented as having plantar heel pain in the selected foot [25]. Participants who reported pain in and around the foot in the past 12 months and provided written consent to further contact were invited to attend a research clinic where radiographs, ultrasound measurements and clinical assessments were undertaken.

**Radiographic assessment**

Weight bearing lateral radiographs were obtained from both feet according to a defined standardised protocol [26]. Participants were excluded from the current analyses if medical records (primary care and local hospital) or a clinical radiology report by a consultant musculoskeletal radiologist identified them as having inflammatory arthritis (non-specific inflammatory arthritis, rheumatoid arthritis, or psoriatic arthritis). Plantar calcaneal spurs were scored by a single reader (MM), blind to all other participant information, and documented as absent (score = 0), small (score = 1), moderate (score = 2) or severe (score = 3) using standard atlas images (Figure 1). Plantar calcaneal spurs were then dichotomised as being absent (score 0 or 1) or present (score 2 or 3). To establish inter-rater reliability, MM and HBM independently scored 120 lateral radiographs (60 right foot, 60 left foot). Inter-rater reliability was excellent (quadratic weighted kappa 0.82, 95% confidence interval [CI] 0.762**–**0.886, *p*<0.001, percentage agreement 94.4%).

**Ultrasound assessment**

The ultrasound examination was performed using a variable frequency 8-13 MHz linear transducer with a Logiq-e ultrasound system (GE Healthcare, Pollards Wood, UK) by one of three clinicians trained as research assessors. The three ultrasound assessors – a physiotherapist, radiographer and nurse – had successfully completed a Consortium for the Accreditation of Sonographic Education accredited, competency-assessed ultrasound training course to accurately measure the thickness of the plantar fascia using standard protocols (http://www.case-uk.org). Their clinical training and competency assessments were completed by a Consultant Musculoskeletal Sonographer (AH). Assessors were blind to the findings of the clinical assessment, radiography, postal questionnaires and medical records. The participant was positioned in a sitting position on a couch with their feet hanging over the end of the couch and ankles dorsiflexed to 90 degrees. Real-time sagittal (longitudinal) imaging of the plantar fascia was performed with the focus adjusted to the depth of the fascia for each participant. Plantar fascia thickness was measured where the plantar fascia crossed the anterior aspect of the inferior border of the calcaneus on the longitudinal view, but at its thickest point in the transverse plane [27]. See Figure 2. Three repeated measurements were obtained, and plantar fascia thickening was defined as >4mm for the highest of the measurements [14].

**Clinical assessment**

Participants underwent a standardised clinical interview and physical examination conducted by therapists blinded to the findings from ultrasound, radiography, postal questionnaires and medical records. In addition to anthropometric measurements (height and weight used to calculate body mass index), a detailed clinical assessment of the foot and ankle was undertaken to document tenderness to palpation of the heel, foot posture and range of motion. Tenderness on palpation of the heel (documented as present or absent) was performed with the participant in a supine position with the knee extended and ankle dorsiflexed. The assessor moved the first metatarsophalangeal joint into full dorsiflexion and then applied firm pressure with their thumb to the plantar-medial heel, approximating the insertion of the plantar fascia into the calcaneus. Foot posture was assessed with the participant standing in a relaxed bipedal position using Foot Posture Index (FPI), Arch Index (AI) and navicular height (NH) measurements. The FPI is a multidimensional visual observation tool consisting of 6 criteria scored on a 5-point scale (range, -2 to +2 [28]) and scores of the six criteria were converted to a single Rasch-transformed logit scale, with higher scores representing a more pronated (flatter) foot [29]. The AI was calculated from static carbon paper footprints as the ratio of area of the middle third of the footprint to the entire footprint area ignoring the toes. The flatter the foot, the higher the AI [30]. To determine NH, the most medial prominence of the navicular tuberosity was palpated and marked with a marking pen. A ruler was then used to measure the height of the navicular tuberosity from the ground, and this value divided by the total length of the foot. The lower the NH, the flatter the foot [31]. Each of these measures of foot posture have been shown to have good reliability and to reflect the underlying skeletal alignment of the medial longitudinal arch [31].

Range of motion was assessed at the 1st MTPJ, subtalar joint and ankle joint. 1st MTPJ dorsiflexion range of motion was measured using a goniometer as the maximum angle at which the hallux could not be passively moved into further extension in a non-weight bearing position [32]. Passive ankle/subtalar joint inversion and eversion were measured with the participant supine, using a flexible goniometer as described by Menadue *et al*.[33] Ankle joint dorsiflexion was measured using the weight bearing lunge test, with the knee flexed [34] and extended [35]. The reliability of each of these tests has been reported previously [32-36].

**Statistical analysis**

All analyses were conducted using SPSS Version 22 (IBM Corporation, Armonk, NY). Comparisons of person-level variables between participants with and without plantar heel pain in one or both feet were analysed using independent samples *t*-tests or chi-square tests as appropriate. Comparisons of foot-level variables according to the presence of plantar heel pain were undertaken using linear mixed models to account for the correlation between measurements obtained from the right and left feet. Associations between plantar calcaneal spurs, plantar fascia thickening, tenderness on palpation of the heel and plantar heel pain in the past month were explored using generalised estimating equations to account for the correlation between measurements obtained from the right and left feet. Body mass index was considered to be a confounding variable for the associations of plantar heel pain with plantar calcaneal spurs and plantar fascia thickening, and was adjusted for in the analysis. Odds ratios with 95% confidence intervals are presented and statistical significance was determined as *p*<0.05.

**Results**

**Study population**

As previously reported, a total of 5,109 completed Health Survey questionnaires were received (adjusted response 56%) [37]. Of these, 1,635 individuals who reported pain in and around the foot in the past 12 months and provided written consent to further contact were invited to the research assessment clinic and 560 attended. The median time between receiving the completed health survey and questionnaire and clinic attendance was 37 days (interquartile range 27 to 47 days). Individuals with inflammatory arthritis (n=24) were excluded, as were those with missing radiographs (n=3), ultrasound (n=2) or foot pain (n=1) data, leaving a total of 530 eligible participants for this analysis (296 women and 234 men, mean [SD] age 64.9 [8.4] years, mean [SD] body mass index 30.4 [5.7] kg/m2). Data for tenderness on palpation of the heel were missing for four feet (three right and one left).

**Characteristics of participants with plantar heel pain**

Of the 530 participants, 117 (22.1%) reported plantar heel pain in one or both feet in the past month. Of these, approximately half were unilateral (n=51, 43.6%) and half bilateral (n=66, 56.4%). Participants with plantar heel pain had a higher body mass index, reported worse scores on the SF-12 Physical, SF-12 Mental, HADS anxiety and HADS depression questionnaires, were more likely to report that their foot pain was disabling, reported worse scores on the MFPDI pain and function subscales, and feet with plantar heel pain had a higher AI (indicative of a flatter foot). There were no sex differences in the prevalence of plantar heel pain (Table 1).

**Prevalence of plantar calcaneal spurs and plantar fascia thickening**

At the person level, a plantar calcaneal spur in at least one foot was identified in 185 (35%) participants (48% unilateral, 52% bilateral), and plantar fascial thickening in at least one foot was identified in 317 (60%) participants (42% unilateral, 58% bilateral). At the foot level, plantar calcaneal spurs and plantar fascia thickening were identified in 281 (26.5%) and 501 (47.3%) feet, respectively. Sex was not associated with plantar calcaneal spurs (OR 1.04, 95% CI 0.74–1.47, *p*=0.816), however women were less likely to have plantar fascia thickening compared to men (OR 0.42, 95% CI 0.31-0.57, *p*<0.001). Plantar calcaneal spurs and plantar fascial thickening frequently coexisted, with isolated plantar calcaneal spurs being an uncommon presentation (Figure 3). Plantar calcaneal spurs were associated with plantar fascial thickening in feet with and without plantar heel pain (OR 3.86, 95% CI 2.22–6.69, *p*<0.001 and OR 4.35, 95% CI 3.10–6.10, *p*<0.001, respectively), and this association persisted after adjusting for body mass index (OR 3.78, 95% CI 2.11–6.81, *p*<0.001 and OR 3.75, 95% CI 2.63–5.35, *p*<0.001, respectively).

**Associations between plantar calcaneal spurs, plantar fascia thickening, and plantar heel pain**

Plantar heel pain in the past month was not significantly associated with plantar calcaneal spurs (OR 1.32, 95% CI 0.87–1.98, *p*=0.188), but was significantly associated with plantar fascia thickening (OR 1.55, 95% CI 1.09–2.18, *p*=0.013). The association between plantar heel pain and plantar fascial thickening was stronger in women (OR 1.70, 95% CI 1.01 – 2.85, *p*=0.046) than men (OR 1.33, 95% CI 0.84 – 2.08, *p*=0.224). After adjustment for body mass index, these associations were attenuated (OR 1.11, 95% CI 0.73–1.68, p=0.622 and OR 1.41, 95% CI 0.98–2.04, *p*=0.065, respectively). When combinations of these imaging findings were considered, plantar heel pain in the past month was associated with plantar fascial thickening in isolation and a combination of plantar fascial thickening and plantar calcaneal spurs, but not plantar calcaneal spurs in isolation (Table 2). Further examination of these associations using plantar calcaneal spur severity (i.e. the four categories of spurs shown in Figure 1) demonstrated: (i) an independent association between plantar fascial thickening and plantar heel pain in the absence of plantar calcaneal spurs (i.e. grade 0), and (ii) a strong association between grade 3 spurs in the presence of plantar fascial thickening and plantar heel pain (Supplementary file).

**Associations with tenderness on palpation of the heel**

Tenderness on palpation of the heel was evident in 177 (16.8%) feet and was associated with plantar heel pain in the past month (n=53 [29.0%] *versus* n=124 [14.2%]; OR 2.20, 95% CI 1.53–3.17, *p*<0.001). In feet with plantar heel pain, plantar fascial tenderness was not associated with the presence of plantar calcaneal spurs (OR 0.82, 95% CI 0.39–1.70, *p*=0.588) or plantar fascia thickening (OR 1.20, 95% CI 0.73–1.98, *p*=0.468). Similarly, there were no associations between tenderness on palpation of the heel when combinations of plantar calcaneal spurs and plantar fascial thickening were considered (Table 3).

**Discussion**

The objectives of this study were to examine associations between plantar calcaneal spurs, plantar fascia thickening and plantar heel pain in a population-based sample, and to determine whether tenderness on palpation of the heel differentiates between these presentations. We found that plantar calcaneal spurs and fascial thickening frequently coexisted, with isolated spurs being particularly uncommon. The presence of both of these imaging findings in combination were more strongly associated with plantar heel pain than either observation in isolation, in part due to the greater severity of spurs and thickening in those with both features combined. We also found that participants with plantar heel pain in the past month were more likely to report tenderness on palpation of the heel than those without plantar heel pain, although tenderness on palpation of the heel did not differentiate between the presence of plantar calcaneal spurs, fascial thickening, or both features combined. Taken together, these findings suggest that plantar heel pain is a complex, multifactorial condition that cannot be exclusively attributed to individual imaging findings, and that tenderness on palpation of the plantar heel has limited clinical assessment value.

The role of plantar calcaneal spurs in the pathogenesis of plantar heel pain has been debated for some time. First described in 1900, calcaneal spurs were initially considered to be causally related to heel symptoms (hence the term ‘heel spur syndrome’). It is now recognised that between 10 and 63% of asymptomatic individuals have calcaneal spurs [38]. In contrast to recent systematic reviews [13, 14], we did not find a significant association between plantar heel pain and the presence of plantar calcaneal spurs. There are three possible explanations for this discrepancy. Firstly, our sample were older (mean age 64.9 years) and had a relatively high body mass index (mean 30.4 kg/m2) compared to previous studies; factors that are strongly associated with plantar calcaneal spurs [38]. Secondly, participants without plantar heel pain were not true asymptomatic controls, as inclusion in the clinical assessment stage of the study required all participants to report pain in and around the foot in the past 12 months. Thirdly, plantar calcaneal spurs may remain long after the initial incident that caused them to develop, so the relatively recent time period for reporting plantar heel pain that we used (one month) may have missed participants who were previously symptomatic.

Thickening of the plantar fascia appears to be a characteristic feature of plantar heel pain, with a systematic review of 15 ultrasound studies concluding that symptomatic individuals were more than 100 times more likely to have plantar fascia thickness > 4 mm compared to controls [14]. We also found associations between plantar fascial thickening and plantar heel pain, both in isolation and in the presence of plantar calcaneal spurs, which were attenuated after adjusting for body mass index but remained significant. The underlying mechanism linking fascial thickening to heel symptoms is not well understood, but may involve myxoid degeneration [16] or neurovascular ingrowth associated with hyperaemia [39]. Plantar fascial thickening may be more strongly associated with plantar heel pain than plantar calcaneal spurs, as it may represent an active inflammatory process more directly linked to symptoms. Indeed, a reduction in thickness of the plantar fascia following treatment has been shown to be associated with the degree of symptomatic improvement [40, 41].

In contrast to previous studies which have examined either plantar calcaneal spurs or plantar fascia thickening in isolation, a novel aspect of our study was the ability to document these key imaging features of plantar heel pain concurrently. In those with plantar heel pain in the past month, plantar calcaneal spurs and fascial thickening frequently coexisted (30%), while plantar calcaneal spurs in the absence of fascial thickening were uncommon (4%). When the combinations of these features were examined for associations with plantar heel pain, the presence of isolated plantar calcaneal spurs was not significant, while isolated thickening and thickening in conjunction with plantar calcaneal spurs was significantly associated. These observations suggest that the association between plantar calcaneal spurs and plantar heel pain may be largely driven by their association with fascial thickening. Indeed, histological studies suggest that fascial thickening may precede the development of plantar calcaneal spurs, and that spur formation may be a protective mechanism to buttress the enthesis against further damage from compressive loads [42].

The secondary objective of our study was to examine the clinical assessment value of tenderness on palpation of the heel, a widely used test in clinical practice when assessing heel pain [19]. Because the test involves compressing the plantar fascia at its insertion in the medial tubercle of the calcaneus, it could theoretically assist in the identification of plantar calcaneal spurs and/or fascial thickening. However, although individuals with plantar heel pain were more likely to report tenderness on palpation, this test could not differentiate between the presence of plantar calcaneal spurs, fascial thickening, or combinations of these two features. As such, a positive test result can only be considered to be a non-specific confirmation of localised plantar heel pain, and is therefore of limited value regarding the presence or severity of the underlying plantar fascia and/or calcaneal spur pathology..

The key clinical implication of our study is that ultrasonography would appear to be a more informative imaging modality than radiographs in patients with plantar heel pain, as plantar fascial thickening identified with ultrasound is more strongly associated with symptoms, and reduction in thickness may be a marker of symptomatic improvement following treatment [40, 41]. In contrast, radiographs are only capable of identifying plantar calcaneal spurs, which are not associated with plantar heel pain in isolation, and their presence does not appear to influence treatment outcomes [43].

Strengths of our study include the population-based sample, the use of standardised imaging of both plantar calcaneal spurs and fascial thickening, blinding of the assessors, standardised training of ultrasound assessors, and review of ultrasound images by a consultant musculoskeletal sonographer (AH) to ensure measurement accuracy. However, several limitations of our study are worthy of acknowledgement. Firstly, the overall response to the postal health survey questionnaire from which the clinical sample was derived was lower than expected, although responders to the health survey questionnaire did not differ greatly from the mailed population [37]. Secondly, because pain in and around the foot in the past 12 months was an inclusion criterion for the clinical sample, participants without plantar heel pain were not asymptomatic controls, as they had pain elsewhere in the foot. Stronger associations between imaging findings, palpation and symptoms may have been observed if the controls were completely free of foot pain. Thirdly, the time-lag between reporting of plantar heel pain in the past month on the survey and the date of clinical examination may have resulted in misclassification due to either the onset or resolution of symptoms in some participants. Finally, diagnostic imaging was limited to plain film x-ray to detect spurs and ultrasound to measure plantar fascial thickness. Although these are the most commonly used imaging modalities for these observations, further insight may have been obtained by documenting plantar fascia echogenicity and neovascularity, or by utilising other techniques such as magnetic resonance imaging [44] and sonoelastography [45]. However, such techniques are likely to be too time-consuming or expensive for routine clinical use.

In summary, this study has demonstrated that plantar calcaneal spurs and plantar fascial thickening frequently coexist in individuals with plantar heel pain, that isolated plantar calcaneal spurs are rare, and that tenderness on palpation of the heel does not appear to differentiate between these features. These findings support the view that plantar heel pain is a complex, multifactorial condition involving multiple tissues. Future research using a wider array of imaging techniques may assist in identifying different subgroups of plantar heel pain and help identify the underlying cause of symptoms.

**Funding**

This work was supported by an Arthritis Research UK Programme Grant (18174) and service support through the West Midlands North CLRN. The study funders had no role in the study design; data collection, analysis, or interpretation; in the writing of the paper; or in the decision to submit the paper for publication.

**Acknowledgements**

HBM is currently a National Health and Medical Research Council of Australia Senior Research Fellow (ID: 1135995). MJT is currently supported by an Integrated Clinical Academic Programme Clinical Lectureship from the National Institute for Health Research (NIHR) and Health Education England (HEE) (ICA-CL-2016-02-014). The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the NIHR, HEE or the Department of Health. The authors would like to thank the administrative, health informatics and research nurse teams of Keele University’s Arthritis Research UK Primary Care Centre, the staff of the participating general practices and the Haywood Hospital, particularly Dr Jackie Saklatvala, Carole Jackson and the radiographers at the Department of Radiography. We would also like to acknowledge the contributions of Linda Hargreaves, Gillian Levey, Liz Mason, Dr Jennifer Pearson, Julie Taylor, Deborah D’Cruz and Dr Laurence Wood to data collection. We would like to thank Adam Garrow and the University of Manchester for permission to use the foot manikin (© The University of Manchester 2000. All rights reserved).

**Conflict of interest statement**

The authors have no completing interests to declare.

**References**

1 Dufour AB, Broe KE, Nguyen US, et al. Foot pain: is current or past shoewear a factor? Arthritis Rheum 2009;61:1352-8.

2 Hill CL, Gill T, 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.

3 Dunn JE, Link CL, Felson DT, Crincoli MG, Keysor JJ, McKinlay JB. Prevalence of foot and ankle conditions in a multiethnic community sample of older adults. Am J Epidemiol 2004;159:491-8.

4 Cotchett M, Munteanu SE, Landorf KB. Depression, Anxiety, and Stress in People With and Without Plantar Heel Pain. Foot Ankle Int 2016;37:816-21.

5 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;98:283-9.

6 Riddle DL, Schappert SM. Volume of ambulatory care visits and patterns of care for patients diagnosed with plantar fasciitis: a national study of medical doctors. Foot Ankle Int 2004;25:303-10.

7 Tong KB, Furia J. Economic burden of plantar fasciitis treatment in the United States. Am J Orthop 2010;39:227-31.

8 Roddy E, Case R, Thomas MJ, Menz HB, Rathod T, Marshall M. Population Prevalence and Associations of Plantar Heel Pain in Adults Aged 50 Years and Over: Cross-Sectional Findings from the Clinical Assessment Study of the Foot. Rheumatology 2015;54(Suppl\_1):i39-i40.

9 Menz HB, Jordan KP, Roddy E, Croft PR. Characteristics of primary care consultations for musculoskeletal foot and ankle problems in the UK. Rheumatology 2010;49:1391-8.

10 Irving DB, Cook JL, Young MA, 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.

11 Sullivan J, Burns J, Adams R, Pappas E, Crosbie J. Musculoskeletal and activity-related factors associated with plantar heel pain. Foot Ankle Int 2015;36:37-45.

12 Creighton D, Olson VL. Evaluation of range of motion of the first metatarsophalangeal joint in runners with plantar faciitis. J Orthop Sports Phys Ther 1987;8:357-61.

13 van Leeuwen KD, Rogers J, Winzenberg T, van Middelkoop M. Higher body mass index is associated with plantar fasciopathy/'plantar fasciitis': systematic review and meta-analysis of various clinical and imaging risk factors. Br J Sports Med 2016;50:972-81.

14 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.

15 Mohseni-Bandpei MA, Nakhaee M, Mousavi ME, Shakourirad A, Safari MR, Vahab Kashani R. Application of Ultrasound in the Assessment of Plantar Fascia in Patients With Plantar Fasciitis: A Systematic Review. Ultrasound Med Biol 2014;40:1737-54.

16 Lemont H, Ammirati KM, Usen N. Plantar fasciitis. A degenerative process (fasciosis) without inflammation. J Am Podiatr Med Assoc 2003;93:234-7.

17 Smith S, Tinley P, Gilheany M, Grills B, Kingsford A. The inferior calcaneal spur - anatomical and histological considerations. Foot 2007;17:25-31.

18 Riel H, Cotchett M, Delahunt E, et al. Is 'plantar heel pain' a more appropriate term than 'plantar fasciitis'? Time to move on. British journal of sports medicine 2017.

19 Thomas MJ, Menz HB, Mallen CD. Plantar heel pain. BMJ 2016;353:i2175.

20 Roddy E, Myers H, Thomas MJ, et al. The clinical assessment study of the foot (CASF): study procotol for a prospective observational study of foot pain and foot osteoarthritis in the general population. J Foot Ankle Res 2011;4:22.

21 Ware J, Jr., Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. Med Care 1996;34:220-33.

22 Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67:361-70.

23 Garrow AP, Papageorgiou AC, Silman AJ, Thomas E, Jayson MIV, Macfarlane GJ. Development and validation of a questionnaire to assess disabling foot pain. Pain 2000;85:107-13.

24 Garrow AP, Silman AJ, Macfarlane GJ. The Cheshire Foot Pain and Disability Survey: a population survey assessing prevalence and associations. Pain 2004;110:378-84.

25 Chatterton BD, Muller S, Thomas MJ, Menz HB, Rome K, Roddy E. Inter and intra-rater repeatability of the scoring of foot pain drawings. J Foot Ankle Res 2013;6:44.

26 Menz HB, Munteanu SE, Landorf KB, Zammit GV, Cicuttini FM. Radiographic classification of osteoarthritis in commonly affected joints of the foot. Osteoarthritis Cartilage 2007;15:1333-8.

27 Gibbon WW, Long G. Ultrasound of the plantar aponeurosis (fascia). Skeletal Radiol 1999;28:21-6.

28 Redmond AC, Crosbie J, Ouvrier RA. Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. Clin Biomech 2006;21:89-98.

29 Keenan AM, Redmond AC, Horton M, Conaghan PG, Tennant A. The Foot Posture Index: Rasch analysis of a novel, foot-specific outcome measure. Arch Phys Med Rehabil 2007;88:88-93.

30 Cavanagh PR, Rodgers MM. The arch index: a useful measure from footprints. J Biomech 1987;20:547-51.

31 Menz HB, Munteanu SE. Validity of 3 clinical techniques for the measurement of static foot posture in older people. J Orthop Sports Phys Ther 2005;35:479-86.

32 Hopson MM, McPoil TG, Cornwall MW. Motion of the first metatarsophalangeal joint. Reliability and validity of four measurement techniques. J Am Podiatr Med Assoc 1995;85:198-204.

33 Menadue C, Raymond J, Kilbreath SL, Refshauge KM, Adams R. Reliability of two goniometric methods of measuring active inversion and eversion range of motion at the ankle. BMC Musculoskel Disord 2006;7:60.

34 Bennell K, Talbot R, Wajsweiner H, Techovanich W, Kelly DH, Hall AJ. Intra-rater and Inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. Aust J Physiother 1998;44:175-9.

35 Munteanu SE, Strawhorn AB, Landorf KB, Bird AR, Murley GS. A weightbearing technique for the measurement of ankle joint dorsiflexion with the knee extended is reliable. J Sci Med Sport 2009;12:54-9.

36 Menz HB, Tiedemann A, Kwan MMS, Latt MD, Lord SR. Reliability of clinical tests of foot and ankle characteristics in older people. J Am Podiatr Med Assoc 2003;93:380-7.

37 Roddy E, Thomas MJ, Marshall M, et al. The population prevalence of symptomatic radiographic foot osteoarthritis in community-dwelling older adults: the Clinical Assessment Study of the Foot. Ann Rheum Dis 2015;74:156-63.

38 Kirkpatrick J, Yassaie O, Mirjalili SA. The plantar calcaneal spur: a review of anatomy, histology, etiology and key associations. J Anat 2017;230:743-51.

39 McMillan AM, Landorf KB, Gregg JM, De Luca J, Cotchett MP, Menz HB. Hyperemia in plantar fasciitis determined by power Doppler ultrasound. J Orthop Sports Phys Ther 2013;43:875-80.

40 Mahowald S, Legge BS, Grady JF. The correlation between plantar fascia thickness and symptoms of plantar fasciitis. J Am Podiatr Med Assoc 2011;101:385-9.

41 Fabrikant JM, Park TS. Plantar fasciitis (fasciosis) treatment outcome study: plantar fascia thickness measured by ultrasound and correlated with patient self-reported improvement. Foot 2011;21:79-83.

42 Kumai T, Benjamin M. Heel spur formation and the subcalcaneal enthesis of the plantar fascia. J Rheumatol 2002;29:1957-64.

43 Ahmad J, Karim A, Daniel JN. Relationship and Classification of Plantar Heel Spurs in Patients With Plantar Fasciitis. Foot Ankle Int 2016;37:994-1000.

44 Chang CD, Wu JS. MR Imaging Findings in Heel Pain. Magn Reson Imaging Clin N Am 2017;25:79-93.

45 Sconfienza LM, Silvestri E, Orlandi D, et al. Real-time sonoelastography of the plantar fascia: comparison between patients with plantar fasciitis and healthy control subjects. Radiology 2013;267:195-200.

**Figure captions**

**Figure 1.** Standardised images used to identify presence of plantar calcaneal spurs. Spurs were considered to be present of a score of 2 or above was documented.

**Figure 2.** Ultrasound measurement of plantar fascial thickness.

**Figure 3.** Stacked bar chart of imaging findings according to presence of plantar heel pain.

**Table captions**

**Table 1.** Characteristics of participants with and without plantar heel pain.

**Table 2.** Imaging findings in feet with and without plantar heel pain in the past month.

**Table 3.** Imaging findings in relation to tenderness to palpation in participants with plantar heel pain.