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IN-DEPTH REVIEW

Systematic review: plantar fasciitis and prolonged weight bearing

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Background Plantar fasciitis (PF) is one of the most common causes of foot pain. Work can involve factors that may predispose to foot pain.

Aims To systematically review the evidence of the association between weight bearing (walking or standing) and PF among workers.

Methods Literature search of relevant indexing databases from inception to May 2012, grey literature, websites of relevant organizations and reference lists for all identified articles. Two reviewers independently selected studies for full review, assessed methodological quality and graded evidence. Findings were summarized qualitatively.

Results Four studies were included; all were assessed as high or unclear risk of bias. Three studies were case–control studies; two used clinic populations and one used volunteers. The other study was cross-sectional involving the workforce of an assembly plant. A number of associations between PF and risk factors were identified including sex, obesity, foot biomechanics and job factors (e.g. job tenure). Two case–control studies and the cross-sectional study found an association with weight bearing, but the assessment of weight bearing varied (e.g. time on feet, time walking or standing). There was low-quality evidence to confirm a causal relationship (Royal College of General Practitioners (RCGP) * grade).

Conclusions This systematic review found low-quality evidence of an association between PF and weight-bearing tasks such as walking and standing on hard surfaces. The only occupations specifically identified as having higher risk were those associated with the engine assembly plant. Further research is required to fully determine the association between weight bearing and PF.

Key words Occupational disease; occupational epidemiology; musculoskeletal.

Introduction

Plantar fasciitis (PF; also called plantar fasciopathy) is one of the most common causes of foot pain [1]. The condition involves inflammation of the plantar fascia, which runs across the bottom of the foot and connects the calcaneus to the toes. It is usually triggered by, and worst with, the first few steps after awakening. It is also thought to be triggered by long periods of standing or getting up from a seated position after a long period of inactivity [2]. The condition is particularly common in runners [3], dancers and those who do orienteering [4]. It has also been suggested that those who spend most of their work hours walking or standing on hard surfaces are at risk of PF [5]. The condition may be a feature of ankylosing spondylitis, reactive arthritis and rheumatoid arthritis [6].

A number of factors have been suggested that may increase the risk of developing PF [1,6]. These include age, sex, weight, pregnancy, being flat-footed (pes planus), having a high arch (pes cavus) or having an abnormal pattern of walking. Shoe type is also thought to be important with loose, thin-soled shoes and shoes without enough arch support or flexible padding to absorb shock possibly increasing the risk of PF. Wearing high heels may result in shortening and contraction of the Achilles tendon, and this too is postulated to cause strain on the tissue around the heel.

A review published in 2000 examined whether work exposure was a risk factor for foot pain [7]. Based on the three studies that were included in the review, the author concluded that prolonged standing and walking were risk factors for developing foot pain including PF. However, the review was not a systematic review and it included foot conditions other than PF.

A systematic review published in 2006 examined the association between weight bearing and chronic plantar heel pain (CPHP) among workers [8]; it did not specifically focus on PF. This review included one case–control study (of PF) and two case series (one of painful heels and one of PF). The authors indicated that there was weak evidence of an association between CPHP and prolonged standing.

The objective of our systematic review was to examine the evidence of the association between weight bearing (walking or standing) and PF/plantar fasciopathy among adult workers. The specific research questions were as follows:

1. Is prolonged weight bearing a risk factor in the onset of PF/plantar fasciopathy among workers?
2. If prolonged weight bearing is a positive risk factor in the onset of PF/plantar fasciopathy among workers, what weight threshold or duration of weight bearing is associated with that risk?
3. Are there specific occupations associated with the risk of developing PF/plantar fasciopathy due to prolonged weight-bearing activities?

Methods

Through all stages of this work, we followed an *a priori* protocol that complied with standards for systematic reviews. A research librarian searched the following databases from inception to May 2012: MEDLINE®, MEDLINE® In-Process and Other Non-Indexed Citations, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, EMBASE and HealthStar all via Ovid; CINAHL Plus with Full Text, Academic Search Complete and SocINDEX all via EBSCO Host; ProQuest Dissertations International, BIOSIS Previews®, Science Citation Index Expanded®, Social Science Citation Index and Conference Proceedings Citation Index–Science all via Web of Science℠. No date, language or study design restrictions were applied. Search strategies with terms related to PF, a workplace setting and weight bearing were created in Medline (see Appendix, available as Supplementary data at *Occupational Medicine* Online) and then adapted for each additional electronic resource.

Conference proceedings (2009–11) of the following associations were hand searched: Epidemiology in Occupational Health; Nordic Ergonomics Society; Society of Occupational Medicine; American College of Occupational and Environmental Medicine; and the Canadian Association for Research on Work and Health. Reference lists of included studies and relevant reviews were searched to identify additional studies. We used Reference Manager© version 11.0 for Windows (2004–05 Thomson ResearchSoft) to manage search results.

Two reviewers independently screened all titles and abstracts. The full text was retrieved for any study that was considered potentially relevant by at least one reviewer. Two reviewers independently assessed each full-text article; disagreements were resolved through discussion and consensus. We included studies if they involved adult workers (≥18 years of age) with PF/plantar fasciopathy and included information about weight bearing (walking or standing). Only primary research in English language publications was included. There were no restrictions on study design.

For the assessment of quality, the risk of bias was assessed using guidelines proposed by Hayden *et al.* [9] and further developed by the National Institute for Health and Clinical Excellence [10]. The guidelines examine six potential areas of bias: study participation, study attrition, prognostic factor measurement, outcome measurement, measuring and accounting for confounding, and appropriateness of statistical analysis. Within each bias area, there are two or three signalling questions; response options are 'yes', 'no' and 'unclear'. We added specific questions for our *a priori* confounding variables (age, sex, certain types of exercise, faulty foot mechanics, obesity, improper shoes and medical conditions or comorbidities). Within each domain, an answer of 'no' corresponds to a high risk of bias, 'unclear' corresponds to a possible or unclear risk of bias and 'yes' corresponds to a low risk of bias.

Reviewers first assessed each signalling question, followed by a global assessment of each area of bias. Each domain was globally rated based on the lowest rating for any signalling question. For example, for study participation, if two of the signalling questions were rated 'yes' and one was rated 'no', then the overall bias rating for study participation was rated as 'no'. Two reviewers independently assessed risk of bias of the studies; disagreements were resolved by a third reviewer.

One reviewer extracted data using a standardized form, and a second reviewer verified the data for accuracy and completeness. Reviewers resolved discrepancies by consensus. We extracted study and participant characteristics (inclusion and exclusion criteria, type of work or work setting), information about PF (how diagnosed, duration), potential confounders (age, sex, body mass index [BMI] or obesity, nature and amount of exercise, foot mechanics, footwear, medical conditions or comorbidities) and information about weight bearing (standing or walking).

We summarized study findings in narrative form and a summary table. Meta-analyses were not conducted due to heterogeneity and inconsistent reporting across studies. The following criteria for causation identified by Bradford Hill were used to assess the strength of evidence for a causal relationship [11]: strength of the association, biological plausibility, consistency with other investigations, temporality (time sequence), dose–response relationship (biological gradient), specificity, coherence, experimental evidence and reasoning by analogy. In addition, the study design of the available studies, and a judgment of the overall quality and amount of evidence were considered.

Results

The search identified 9720 citations from electronic and hand searching (Figure 1). The full texts of 178 potentially relevant reports were evaluated for inclusion. Four studies [12–15] were ultimately included. One study [14] had two associated publications [16,17]. A total of 172 studies were excluded; a list of excluded studies is available from the authors. Table 1 presents a summary of the study characteristics and results.

Gill *et al.* [12] reported a case–control study investigating outcomes of non-surgical treatment for PF. A total of 411 patients with PF were compared with 400 controls randomly selected from orthopaedic patients without PF. Bivariate analyses by chi-square tests were performed on patient characteristics and showed significant associations between case–control status and weight, time spent on feet and type of floor walked on most of the time (Table 1). Although PF was common in the middle-aged groups, there was no difference in mean age between cases and controls.

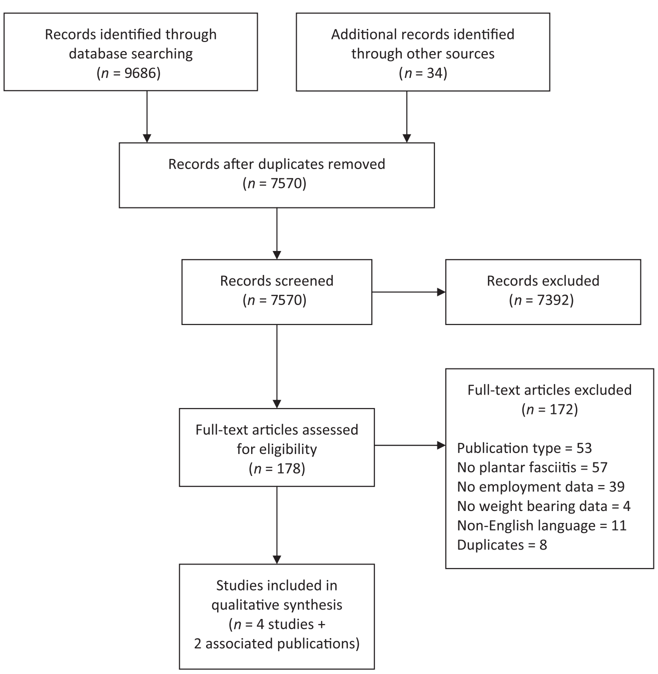

Figure 1. Flow diagram of study retrieval and selection.

Irving *et al.* [13] reported on CPHP in a matched case–control study (80 cases and 80 controls). Participants were volunteers who responded to newspaper advertisements. The authors used chronic heel pain as a surrogate for PF noting that 'CPHP' is often used interchangeably with PF; however, as plantar heel pain can be caused by conditions other than PF this case definition is likely sensitive but not specific [18,19]. Univariate comparisons showed an association between the cases and increased weight and BMI, a foot posture index, calf endurance (standing heel rise test), and range of ankle dorsiflexion. Multivariate analyses identified foot posture (pronated foot) and a BMI ≥30 to be significantly associated with CPHP (Table 1).

Riddle *et al.* [14] reported on a matched case–control study that compared 50 patients with unilateral PF who attended a physical therapy clinic with 100 controls from the community or the clinic. Patients with seronegative arthropathies were excluded. The authors observed that the risk of PF increased as BMI increased and as ankle dorsiflexion decreased. There was a positive association between PF and the participant reporting being on their feet for the majority of the workday (Table 1).

The final study was a cross-sectional study undertaken within an engine assembly plant [15]. Werner *et al.* [15] recruited 407 full-time employees (61% of eligible workers) including assembly line workers, skilled trades, drivers, machinists and administrative staff (Table 1). A symptom questionnaire supplemented by review of plant medical records and a focused physical examination were completed for all participants. To assess lower body posture/activity for assembly workers (*n* = 95), video analysis, pedometer analysis and interviews were conducted on 73 volunteers [20]. For non-assembly line workers, lower body posture was assessed by pedometer recordings and end-of-day interviews. Univariate analyses by *t*-tests and chi-square tests, and multivariate logistic regression were performed. For prevalent PF, the multivariate analysis identified the following risk factors: female sex, forefoot pronation, high metatarsal pressure, increased proportion of time standing on hard surfaces, increased proportion of time walking, increased entrance/exit from a truck (for truck and forklift drivers), job dissatisfaction and moderate job tenure. Rotation of shoes (defined as wearing at least two different sets of shoes each week) was found to be protective against the development of PF. In a multivariate model, 'new' PF was significantly associated with presence of forefoot pronation, proportion of time standing on hard surfaces, proportion of time walking, entrance/exit from a truck, shoe rotation, job dissatisfaction and moderate job tenure.

Assessment of methodological quality

Table 2 presents summary of the 'risk of bias' assessments. In all studies, the populations were suitably

Table 1. Patient and study characteristics of included studies of PF and prolonged weight bearing

Author, year, country, study design	Sample, source, age: mean (SD), sex: female	Foot mechanics, obesity, footwear, medical conditions	Definition of PF and description of weight bearing	Outcomes
Gill and Kiebzak [12], 1996, USA, case–control	411 cases/400 controls, clinic population, 47.5 years (12.5) cases/48.1 years (17.2) controls, 60% cases; 56% controls	Foot mechanics: NR; weight: 29% cases versus 23% controls ≥200 pounds; footwear: NR; medical conditions: NR	PF: clinical diagnosis; weight bearing: questionnaire: work habits regarding sitting and standing, type of floor encountered at work	Bivariate analysis: weight (>200 pounds): OR = 1.4 (95% CI 1.02, 1.91)[a]; majority of time on feet: OR = 1.45 (95% CI 1.1, 1.9)[a]; walks on hard floor most of time: OR = 1.58 (95% CI 1.2, 2.1)[a]; female sex: OR = 1.17 (95% CI 0.89, 1.55)
Irving *et al.* [13], 2007, Australia, matched case–control (age and sex)	80 cases/80 controls, volunteers from population, 52.3 year cases/51.9 year controls, 59% cases and controls	Foot posture index; ankle dorsiflexion ROM; BMI: 29.8 (SD 5.4) cases/27.5 (SD 4.9); footwear: NR; comorbidities: diabetes, heart or lung disease, osteoarthritis, hypertension, hormone replacement therapy, high cholesterol, thyroid disease; excluded: steroid injection/orthotic device/ conservative Tx in previous 8 weeks	PF: CPHP; Hx plantar heel tenderness and/or pain on rising in morning or after periods of rest; weight bearing: self-reported Occupational Rating Scale questionnaire: time spent sitting, standing/ walking, walking on uneven ground, squatting, climbing, lifting/ carrying, weight carried	Multivariate analysis: foot pronation: OR = 3.7 (95% CI 1.6, 8.7)[a]; BMI ≥30: OR = 2.9 (95% CI 1.4, 6.1)[a]; excessive ankle dorsiflexion: OR = 2.0 (95% CI 0.9, 4.4); no association with time spent standing, sitting, walking on uneven ground, squatting, climbing or lifting
Riddle *et al.* [14], 2003, USA, matched case–control (age and sex)	50 cases/100 controls, clinic population (cases and controls), church congregation (controls), 49 year (12) cases/50 year (12) 66% cases and controls	Goniometric measurement of passive ankle dorsiflexion; BMI ≥30 kg/m^2: 58% cases/17% controls, footwear: NR, excluded: systemic arthritic condition; tarsal tunnel syndrome; calcaneal stress fracture; bilateral PF	PF: unilateral PF; pain in area of insertion of plantar aponeurosis on medial tubercle of calcaneus; pain provoked with first few steps in morning and increased with weight bearing during day; weight bearing: self-report to question: do you spend the majority of your workday on your feet? (47% cases/24% controls)	Multivariate analysis: limited ankle dorsiflexion: OR = 23.3 (95% CI 4.3, 124.4)[a]; BMI ≥30: OR = 5.6 (95% CI 1.9, 16.6)[a]; on feet majority of workday: OR = 3.6 (95% CI 1.3, 10.1)[a]; 47% cases/24% controls; recreational jogger: OR = 2.8 (95% CI 0.4, 22.7)
Werner *et al.* [15], 2010, USA, cross-sectional	32 with PF, 375 without PF, assembly plant workforce, PF 48.6 year (9.5)/non-PF 48.4 year (10.3) PF 37%/ non-PF 22%	Focused physical examination: standing foot alignment, dynamic foot pressure (Tekscan Pressure Measurement System); observations of joint deformities; for those with localized symptoms: ROM restrictions, joint laxity, provocative diagnostic tests; BMI: 29.4 (5.3) kg/m^2; biomechanical evaluation of shoe; comorbidities: diabetes, rheumatoid arthritis, heel spur	PF: self-reported moderate or severe foot pain lasting >1 week or occurring ≥3 times in past year and tenderness to palpation at insertion of plantar fascia on calcaneus, new PF pain in foot related to palpation of plantar fascia at calcaneus without Hx of PF; weight bearing: (i) volunteer sample of assembly workers: video analysis of 200 randomly selected freeze-frames for each worker-job pairing (73 workers: 79 jobs). (ii) other workers (machining, skilled trades, administration, drivers): pedometer recordings and end-of-day interviews to document lower body activities	Prevalent PF (logistic regression): female sex: OR = 3.4 (95% CI 1.3, 8.8)[a]; shoe rotation: OR = 0.3 (95% CI 0.1, 0.7)[a]; forefoot pronation: OR = 4.2 (95% CI 1.7, 10.1)[a]; entrance/exit in truck (10% increase): OR = 1.2 (95% CI 1.1, 1.3)[a]; % time walking (10% increase): OR = 1.5 (95% CI 1.1, 2.1)[a]; % time standing on hard surface (10% increase): OR = 1.3 (95% CI 1.1, 1.6)[a]; high metatarsal pressure: OR = 2.7 (95% CI 1.1, 6.6)[a]; moderate job tenure (4–7 years): OR = 4.9 (95% CI 1.1, 21.8)[a]; age (increase in decade): OR = 1.2 (95% CI 0.6, 2.3); BMI: OR = 1.0 (95% CI 0.97, 1.10) New PF (logistic regression): forefoot pronation: OR = 5.4 (95% CI 1.9, 15.7)[a]; % time standing on hard surface (10% increase): OR = 3.9 (95% CI 1.4, 10.9)[a]; % time walking (10% increase): OR = 1.5 (95% CI 1.1, 1.2)[a]; moderate job tenure (4–7 year): OR = 8.3 (95% CI 1.05, 65.5)[a]; job dissatisfaction: OR = 1.3 (95% CI 1.05, 1.7)[a]; shoe rotation: OR = 0.3 (95% CI 0.11, 0.98)[a]; entrance/exit in truck (10% increase): OR = 1.2 (95% CI 1.02, 1.32)[a]; female sex: OR = 1.5 (95% CI 0.5, 4.5); age (increase in decade): OR = 1.6 (95% CI 0.7, 3.4); BMI: OR = 1.0 (95% CI 0.9, 1.1)

Hx, history; NR, not recorded; ROM, range of motion; SD, standard deviation; Tx, treatment.
[a]Statistically significant.

defined and described (Items 1a and b). It was unclear in any study whether the study population was entirely representative of the population of interest (Item 1c) as participants either represented patients in a specialist clinic, had foot pain rather than PF or worked in a specific workplace. The risk of bias for the domain of study participation was unclear. The risk of bias was considered to be low for study attrition. The completeness and adequacy of follow-up (Items 2a and b) were deemed low risk in three articles [13–15]. One study did not describe participant follow-up [12]. The prognostic factors constituting weight-bearing (Items 3a–c) and work-related duties (Items 4a–c) were generally not well addressed. One study [15] provided a clear definition of work-related duties; however, work activities were measured differently for assembly line and non-assembly line workers. No analysis to compare these methods was performed. In the remaining three studies, weight bearing

Table 2. Methodological quality or risk of bias

	Gill and Kiebzak [12]	Irving *et al.* [13]	Riddle *et al.* [14]	Werner *et al.* [15]
1. Study participation				
a. Source population clearly defined	Unclear	Low	Low	Low
b. Study population described	Low	Low	Low	Low
c. Study population representative of source population or population of interest	Unclear	Unclear	Unclear	Unclear
2. Study attrition				
a. Completeness of follow-up described	High	Low	Low	Low
b. Completeness of follow-up adequate	Unclear	Low	Low	Low
3. Prognostic factor (weight bearing)				
a. Prognostic factor defined	Low	Low	Unclear	Low
b. Measured appropriately	Unclear	Low	Unclear	Unclear
c. Extent of/reasons for missing data reported	High	Unclear	High	Unclear
4. Prognostic factor (work-related)				
a. Prognostic factor defined	High	High	High	Low
b. Measured appropriately	High	Low	High	Low
c. Extent of/reasons for missing data reported	High	Unclear	High	Low
5. Outcome measurement				
a. Outcome defined	Low	Low	Low	Low
b. Outcome measured appropriately	Low	Low	Low	Low
6. Confounders				
a. Age				
Measured appropriately	Low	Low	Low	Low
Accounted for	High	Low	Low	Low
b. Sex				
Measured appropriately	Low	Low	Low	Low
Accounted for	High	Low	Low	Low
c. Exercise				
Measured appropriately	High	High	Low	Low
Accounted for	High	High	Low	Low
d. Foot mechanics				
Measured appropriately	High	Low	High	Low
Accounted for	High	Low	High	Low
e. Obesity				
Measured appropriately	Low	Low	Low	Low
Accounted for	High	Low	Low	Low
f. Footwear				
Measured appropriately	High	High	High	Low
Accounted for	High	High	High	Low
g. Comorbidities				
Measured appropriately	High	Low	High	Low
Accounted for	High	Low	High	Low
7. Analysis				
Analysis described	Low	Low	Low	Low
Analysis appropriate	High	Unclear	Low	Low
Sufficient presentation of data	High	Low	Low	Low

High, high risk of bias; Low, low risk of bias; Unclear, possible or unclear risk of bias.

was assessed as unclear or high risk of bias, and work-related duties were poorly characterized. Overall, the risk of bias was considered to be high for both weight-bearing and work-related factors.

Outcome measurement (Items 5a and b) was adequately defined and measured in all studies. The risk of bias was low for this domain. Confounding (Items 6a–g) was poorly addressed. Based on our *a priori* criteria, we expected studies to consider age, sex, exercise, foot mechanics, obesity, footwear and medical comorbidities as potential confounders. Only one study reported and accounted for these covariates [15]. Of the remaining three studies, two [13,14] accounted for age, sex and obesity, and one each accounted for exercise [13] and foot mechanics [14]. Overall, the risk of bias was high for the domain of confounding. Statistical analysis was appropriately described in all the studies; however, for one matched case–control study [13], it was unclear if conditional logistic regression was used in the analyses. In summary, the overall risk of bias was considered to be high for this body of evidence.

Causal relationship

The strength of the study design was considered moderate for case–control studies but weak for cross-sectional studies [21]. Utilizing the Bradford Hill criteria, we were able to identify evidence of strength of association, consistency and dose–response. The studies lacked sufficient information to consider other relevant criteria for causation including: biological plausibility, temporality (time sequence), specificity, coherence, experimental evidence and reasoning by analogy (Table 3).

For the onset of PF, only one article [15] had an analysis of new cases. This showed evidence of an association between time standing at work and PF, with approximately a four-fold increase in risk for each 10% increase in time standing at work (odds ratio [OR] = 3.9, 95% confidence interval [CI] 1.4, 10.9). Further, there was a suggestion of a dose–response relationship with an increased likelihood of PF with a 10% increase in time walking (OR = 1.5; 95% CI 1.1, 1.2). However, this is from a single study with methodological limitations. The evidence is insufficient to confirm a causal relationship.

Discussion

We found moderate to weak evidence that weight-bearing tasks such as walking and standing on hard surfaces were a risk factor in the onset of PF among workers. There was insufficient evidence to state whether weight threshold and specific occupations were associated with risk of PF. Obesity, as measured by weight or BMI in the case–control studies, was associated with PF (moderate evidence of a causal association). The cross-sectional study did not find this association; however, the study population had a high BMI (mean 29 kg/m^2) and it is likely that the sample size was too small to find such an association. Although female sex was associated with prevalent PF in the cross-sectional study [15], this was not found in the one unmatched case–control study [12] (insufficient evidence). Similarly, there was insufficient evidence to confirm an association between age and PF.

Foot biomechanics were examined in three studies although the authors used different measures or assessments. Pronated foot posture, examined in two studies, was associated with PF [13,15]. The results were inconsistent for ankle dorsiflexion. One study found that greater dorsiflexion [13] was associated with CPHP, whereas the other reported that limited dorsiflexion [14] was associated with PF. The evidence for a causal association between foot biomechanics and PF is low.

The evidence from this review suggests low evidence of a causal association between prevalent PF and weight-bearing tasks such as walking and standing on hard surfaces (Royal College of General Practitioners * grade). The evidence is not completely consistent across the included studies.

The authors of the cross-sectional study highlighted that moderate job tenure was associated with PF but not longer-term employment [15]. These results do not support a dose–response relationship in relation to years of employment. The authors suggest that this was evidence of a 'healthy worker effect' with the implication that workers with foot problems had left the work site. There were no data on employees who left the assembly plant to support this assumption.

There is a body of literature on the association of PF and recreational running [3,4], military activities [22] and Irish dancing [23]. However, these populations were excluded from our review as we felt the results may not be generalizable to the general working population. One article in our review included recreational jogging as a risk factor, and it showed a non-significant elevated risk [14].

The primary studies in this review have several methodological limitations, which reduced our ability to reach conclusions on causation in relation to the workplace and weight bearing. The body of evidence was assessed as high risk of bias, although we acknowledge that this may be a limitation of reporting and not conduct of the studies. The methods of case and control selection and the overall response in the cross-sectional study bring into question whether the study populations are representative of the population of interest and, therefore, if the results can be generalized.

Weight bearing was assessed differently in the studies. All studies relied on self-reporting to assess weight bearing and may be subject to recall bias. The cross-sectional study used video analysis for a portion of assembly workers but used pedometers and interviews for others in their cohort. There was no comparison between the two methods [15].

Table 3. Quality of evidence for a causal association for PF

Risk factor	Study design[a] (studies; participants)	Risk of bias[b]	Consistency[c]	Dose–response[d]	Strength of association and precision[e] [study reference]	Quality of evidence
Prevalent PF						
Obesity (BMI ≥30 kg/m^2 or >200 pounds)	Case–control (3; cases = 541, controls = 580)	High	Yes for case–control	Yes [12,13]	OR = 1.4 (95% CI 1.0, 1.9) [12]	Moderate
	Cross-sectional (1; 407)	Unclear			OR = 2.9 (95% CI 1.4, 6.1 [13])	
					OR = 5.6 (95% CI 1.9, 16.6 [14])	
					OR = 1.0 (95% CI 0.9, 1.1 [15])	
Female sex	Case–control (1; cases = 411, controls = 400)	High	No	NA	OR = 1.2 (95% CI 0.9, 1.6) [12]	Insufficient
	Cross-sectional (1;407)	Unclear			OR = 3.4 (95% CI 1.3, 8.8) [15]	
Age	Cross-sectional (1; 407)	Unclear			OR = 1.2 (95% CI 0.6, 2.3) [15]	
Foot biomechanics	Case–control (2; cases = 130, controls = 180)	High	Yes	NA	Foot pronation: OR = 3.7 (95% CI 1.6, 8.7) [13]	Low
	Cross-sectional (1; 407)	Unclear			OR = 4.2 (95% CI 1.7, 10.1) [15]	
					Excessive dorsiflexion: OR = 2.0 (95% CI 0.9, 4.4) [13]	
					Limited dorsiflexion: OR = 23.3 (95% CI 4.3, 124.4) [14]	
					High metatarsal pressure: OR = 2.7 (95% CI 1.1, 6.6) [15]	
Weight bearing	Case–control (2; cases = 461, controls = 500)	High	Yes	Yes [12,14]	Time on feet: OR = 1.4 (95% CI 1.0, 1.9) [12]	Low
	Cross-sectional (1; 407)	Unclear			OR = 3.6 (95% CI 1.3, 10.1) [14]	
					% time walking: OR = 1.5 (95% CI 1.1, 1.2) [15]	
					Walks/stands on hard surface: OR = 1.6 (95% CI 1.2, 2.1) [12]	
					OR = 1.3 (95% CI 1.1, 1.6) [15]	
					Lower limb stress (Occupational Rating Scale): No association (data not provided) [13]	
Job factors	Cross-sectional (1; 407)	Unclear	NA	NA	Moderate job tenure: OR = 4.9 (95% CI 1.1, 21.8) [15]	Insufficient
New onset PF						
Obesity (BMI ≥30 kg/m^2)	Cross-sectional (1; 407)	Unclear	NA	No	OR = 1.0 (95% CI 0.9, 1.1)	Insufficient
Female sex	Cross-sectional (1; 407)	Unclear	NA	NA	OR = 1.5 (95% CI 0.5, 4.5) [15]	Insufficient
Age	Cross–sectional (1; 407)	Unclear	NA	NA	OR = 1.6 (95% CI 0.7, 3.4)	Insufficient

Table 3. (*Continued*)

Risk factor	Study design[a] (studies; participants)	Risk of bias[b]	Consistency[c]	Dose–response[d]	Strength of association and precision[e] [study reference]	Quality of evidence
Foot biomechanics	Cross-sectional (1; 407)	Unclear	NA		Foot pronation: OR = 5.4 (95% CI 1.9, 15.7) [15]	Insufficient
Weight bearing	Cross-sectional (1; 407)	Unclear	NA	Yes	Standing on hard surface (10% increase): OR = 3.9 (95% CI 1.4, 10.9) [15] % Time walking (10% increase): OR = 1.5 (95% CI 1.1, 1.2) [15]	Insufficient
Job factors	Cross-sectional (1; 407)	Unclear	NA	NA	Moderate job tenure: OR = 8.3 (95% CI 1.1, 65.5) [15] Job dissatisfaction: OR = 1.3 (95% CI 1.1, 1.7) [15]	Insufficient

[a]Study design (considers temporality): case–control = moderate; cross-sectional = high.
[b]Risk of bias: low, moderate and high risk of bias.
[c]Consistency: if there is more than one study, are estimates in the same direction.
[d]Dose response: evidence of increased risk of PF with an increase in risk factor.
[e]Strength of association and precision: magnitude of effect estimate and width of confidence interval.

There was inconsistency across studies on how PF was defined. It was based on a clinical assessment of (i) a clinic population in two studies [12,14], one of which excluded bilateral disease [14], (ii) a volunteer population with CPHP [13] and (iii) a definition of cases in a cross-sectional study [15] that was quite specific in terms of symptom duration or frequency. This latter definition may have resulted in a difference in subjects with the condition compared with a clinic population where the disease is more likely to be persistent. One case–control study [13] reported that those with the condition for >6 months accounted for 55% of cases, whereas the definition in the cross-sectional study was '… pain lasting more than 1 week or occurring at least 3 times in the past year'. In one study, 'new' PF was defined in workers with foot pain related to palpation of the plantar fascia at the calcaneus who did not report a history of PF in the medical history. This definition is different from that used in the other studies where pain on standing and walking on rising from rest was included.

In addition to the issues identified previously, there are limitations in systematic reviews in general. We addressed the issue of potential publication bias by conducting a comprehensive search of the published literature for potentially relevant studies, supplemented by hand searching for grey or unpublished literature. There is also a possibility of study selection bias. However, we employed at least two independent reviewers to identify potentially relevant studies and are confident that the studies that were excluded from this review were done so for consistent and appropriate reasons.

Further research is needed to address the questions raised in this systematic review. The strongest study design would be a longitudinal cohort study that includes all employees in a workplace or a number of workplaces where prolonged walking and standing on hard surfaces occurs. Future studies should take into account the methodological issues highlighted in the risk of bias assessment. In particular, the reliance on self-reported assessments of weight-bearing activities is problematic. Another option could involve data linkage of health and worker's compensation data to identify rates of physician-diagnosed 'new' PF in occupations with different levels of exposure to prolonged standing and walking. The relationship between family physician and specialist physician (rehabilitation medicine, orthopaedics and rheumatology) diagnosis from billing codes and occupation would also be of interest. This would require the creation of a job exposure matrix linking prolonged standing and walking to specific job titles.

The studies included in this review used a range of tools to assess weight-bearing activities (e.g. self-completed questionnaire, video analysis, pedometers). There may be merit in a further analysis of the cross-sectional study [15], specifically a sensitivity analysis for the assembly line workers with video analysis and the other work groups where the use of pedometers and end-of-day interviews was performed. Research comparing different methods of assessing work-related weight-bearing activity is needed in order to develop recommendations for 'best practice' in future research. Use of common measures across studies will facilitate future comparisons across studies and populations. The use of appropriate tools also may provide evidence on the 'dose' of weight bearing in order to inform prevention programs.

Finally, efforts are needed to improve the quality of reporting of observational studies that examine prognostic factors. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist [24] details 22 items that address the level of detail that should be specified within such studies including descriptions of participants, exposures, data sources and measurement, statistical methods and outcomes.

Despite exhaustive efforts to locate evidence of an association between PF and weight-bearing activities among adult workers, only a small number of studies met the inclusion criteria. All of the studies suffer from potential biases. Nonetheless, this summary represents the most current and comprehensive review on this topic. The conclusions reached by this systematic review should be considered in relation to the overall quality of the study designs used, study conduct and statistical analyses employed by the authors of the primary studies. Further research is required—both methodological and epidemiological—if the association between weight bearing and PF is to be fully determined and the occupational risk appropriately measured.

Key points

- This systematic review summarizes the available evidence regarding the association between plantar fasciitis and weight-bearing activities (standing and walking) among adult workers.
- Weak study designs (case–control and cross-sectional studies) and poor methodological quality limit the conclusions that can be made.
- The studies suggest low-quality evidence of a causal association between plantar fasciitis and prolonged weight-bearing tasks (Royal College of General Practitioners * grade).

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Conflicts of interest

None declared.

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A multidisciplinary clinic for occupational disease

The diagnosis and management of occupational diseases is complex and ideally requires expertise from several disciplines. There is little in the literature regarding clinical models for occupational disease practice aside from the German model for occupational skin disease. The Occupational Disease Specialty Program (ODSP) at St Michael's Hospital in Toronto, Canada, is a clinic dedicated to occupational disease.

The Ontario Workplace Safety and Insurance Board (WSIB) originally operated specialized clinics for workers with complex occupational injuries. In the 1990s, a review suggested the assessment and management of complex cases would be better served at academic hospitals where the worker would receive expert care and clinical education and research activities could be facilitated. This led to the development of the WSIB Specialty Clinic programme with the first speciality clinics focused on injuries starting in 1999. There is a contractual agreement between the WSIB and the hospital and referral to the clinics is by the WSIB. In the early 2000s, it was decided to establish a clinic focused on occupational diseases.

The ODSP was established in 2002. The goals of the ODSP are to provide services related to diagnosis, recommendations for treatment, determination of level of impairment and work restrictions. These are accomplished with a multidisciplinary team and integrated into teaching and research programmes. There are four clinical streams: skin, respiratory, hand–arm vibration syndrome and toxicology. Physician staffing is by occupational medicine specialists and subspecialists relevant to the stream (e.g. respirologist (respiratory physician), allergist, dermatologists). The programme includes support for specialized testing such as patch testing with workplace materials and specific inhalation challenge testing.

The ODSP has an occupational hygienist who assists both with the initial assessment by taking a detailed exposure history and gathering further exposure information as needed. In 2006, a formal return to work (RTW) component was added. This is led by a RTW coordinator, an occupational therapist, experienced in RTW for workers with work-related injuries. The RTW process is a collaborative one involving the RTW coordinator, the occupational hygienist and the physician. Communication amongst team members is facilitated as all are in the clinic together. In working together, the clinicians develop a better understanding of the others' particular skills and all acknowledge the benefit of the multidisciplinary team. The RTW coordinator serves as the main contact with the WSIB, the worker and the employer in the RTW process, thus streamlining and simplifying communication, a critical element in the RTW process.

The ODSP not only provides clinical service to the worker and assists the WSIB in dealing with complex claims but also provides excellent teaching and research opportunities. In addition to occupational medicine trainees, trainees in dermatology, respirology, allergy and clinical immunology and physiatry (rehabilitation medicine) rotate through the clinic, learning about occupational disease in their particular specialty and also the specialized testing. In addition, occupational hygiene and rehabilitation science students have work and research placements in the clinic. The ODSP also provides an excellent opportunity for clinical research.

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