Causation and risk factors of Plantar Fasciitis

Evidence-based review

April 2016

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Important note

- *The purpose of this report is to outline and interpret the best current evidence about risk factors and relative events that could lead to development of Plantar Fasciitis in order to facilitate decision making on future claims.*

- *It is not intended to replace clinical judgement or be used as a clinical protocol.*

- *A reasonable attempt has been made to find and review papers relevant to the focus of this report; however, it does not claim to be exhaustive.*

- *This document has been prepared by the staff of the Evidence Based Healthcare Team, ACC Research. The content does not necessarily represent the official view of ACC or represent ACC policy.*

- *This report is based upon information supplied up to April 2016.*

Revision History

Date	Version	Description	Author
16/09/2015			
28/09/2015	V1.2	MS Comments	Melissa Barry
19/11/2015	V2.0	Peer-review recommended amendments made	Melissa Barry
13/04/2016	V3.0	Further peer-review recommendations and extra papers added	Melissa Barry

1 Executive Summary

1.1 Background

Plantar fasciitis (PF) is a commonly reported cause of plantar heel pain[1-3]. The underlying descriptions of plantar fasciitis include: degeneration consisting of micro-tears occurring from repeated trauma of the plantar fascia at its insertion into the calcaneus (as in a tendinosis); collagen degeneration and fascial thickening[1, 4, 5]. The terms plantar fasciitis and chronic plantar heel pain are used interchangeably within the literature, although other plantar pain disorders can also be classed as chronic plantar heel pain (CPHP). A more detailed description of plantar fasciitis and the anatomy of the plantar fascia/aponeurosis can be found on the ACC's intranet on The Sauce within the Clinical Advisory Panel (CAP) summaries.

The purpose of this report is to determine what risk factors and/or events reported in the literature that lead to the development of plantar fasciitis. This may aid decision-making for claims for plantar fasciitis within ACC. The difference between this document and the previous literature reviews produced by CAP is this is an evidence-based review that critically appraises the peer-reviewed articles in the literature. It discusses the quality and strength of the evidence within the studies that have investigated the risk factors related to the occurrence of plantar fasciitis.

1.2 Methodology

A search was conducted by two researchers (of research up to February 2016) of medical databases (Ovid MEDLINE, Embase and Google Scholar). Included studies were: systematic reviews, as well as cohort studies, that were not included in the systematic reviews and were published after 2012. Excluded articles included literature reviews, expert opinion articles and case-series; studies that focused on treatment for plantar fasciitis and studies that did not differentiate plantar fasciitis from chronic plantar heel pain within their cohort. Included studies were appraised for quality using the Scottish Intercollegiate Guideline Network (SIGN) levels of evidence system and the methodology and findings of each study are summarised in evidence tables in the appendices.

1.3 Main findings

A total of one evidence-based guideline[6], three systematic reviews[7-9] and two observational cohort studies[10, 11] were included in the critical appraisal of the literature. The SRs were of moderate to high quality; however the primary studies that they reviewed were appraised as moderate to low quality due to study design and methodology. The other primary studies not included the SRs were also of low to moderate quality. Across the reviews and studies there was variation regarding the participant populations (eg. army personnel, runners, patients of an orthopaedic specialist), how plantar fasciitis was diagnosed and how risk factors were analysed (see Table 2 for more detail).

The main risk factors that came from these studies are summarised below in Table 1.

Table 1. Risk factors described for plantar fasciitis and summary of the quality of reported evidence

Factor	Main findings
Running activities	- A moderate quality SR[1] showed there was an increased prevalence and incidence of plantar fasciitis in running, or sports that included running activities (eg. soccer, running and dancing) (Epidemiological SR: Sobhani et al, 2013 reported in Martin et al, 2014) - A moderate quality SR showed incidence of plantar fasciitis to range from 4.5% to 10% across general running activities (Epidemiological SR: Lopes et al, 2012 reported in Martin et al, 2014) - Running in people with increased arch height. (Case-control, Ribeiro et al, 2011 reported

[1] *SR: Systematic review*

	in Martin et al, 2014) - Increased ground reaction forces, and a lower medial arch in female runners Pohl et al, 2009 as reported in Martin et al, 2014) - Running in spiked shoes, street running and in recreational joggers (Moderate quality prospective cohort study: DiCaprio, et al, 2010 as reported in Martin et al, 2014) - Recreational joggers (SR Waclawski et al, 2015) - Running more kilometres per week (SR: van Leeuwen et al, 2015)
Body Mass Index	- Significant associations found for plantar fasciitis in people who were overweight or obese compared to normal weight, (Guideline: Martin et al, 2014; SR: Waclawski, van Leeuwen; Primary studies: Owens et al, 2013; Klein et al, 2013) - Increased likelihood of PF if subjects were obese compared to overweight. (SR: Fransceschi et al, 2014)
Prolonged standing	- Low quality evidence from 2 case control and 1 cross-sectional study that showed an association between plantar fasciitis and walking or standing on hard surfaces for long periods of time (SR: Waclawski et al, 2015) - Occupations identified as high risk were those working in an engine assembly plant (SR: Waclawski et al, 2015) - Increased incidence found in both athletic and non-athletic populations who had increased occupational standing time, or spent majority of time on their feet (SR: van Leeuwen et al, 2015) - Shoe rotation (switching between pairs of shoes on alternate work days) was found to reduce the risk of plantar fasciitis (moderate quality prospective cohort study: Owens et al, 2013)
Employment sectors	Sectors that had a positive association with the occurrence of plantar fasciitis were reported in one prospective cohort study (moderate quality prospective cohort study; Owens et al, 2013): - Electronic equipment repair - Healthcare - Administration, functional support - Equipment repair - Craft work - Service and supply - *It should be noted that this study was conducted in an active army population and that the components of these jobs that may contribute to occurrence of plantar fasciitis were not discussed.*
Foot biomechanics	There was high variability in how the foot postures, anatomical features and measurements of the arches were analysed across studies. Positive association with plantar fasciitis occurring was found for: - Forefoot pronation (SR: Waclawski et la, 2015, Franscheschi et al, 2014) - Excessive or limited ankle dorsiflexion (from two different primary studies, both reported in SR: Waclawski et al, 2015) - Cavus arch posture (SR: van Leeuwen et al, 2015) - Varus knee alignment (SR: van Leeuwen et al, 2015) - Decreased straight leg elevation and contractures of the hamstrings (SR: van Leeuwen et al, 2015)
Other factors	- **Increased plantar fascia thickness:** Shown in pooled imaging analysis of ultrasound and MRI measurements (SR: van Leeuwen et al, 2015) - **Increased heelpad thickness**: Seen in both weightbearing and non-weightbearing SR: (van Leeuwen et al, 2015) - **Calcaneal spurs:** increased association of occurrence of spurs in people with PF (SR: van Leeuwen et al, 2015) - **History of tendinopathy or fracture** (moderate quality prospective cohort study: Owens et al, 2013)

1.4 Conclusion

The literature that reports on factors contributing to the causation of plantar fasciitis can provide some evidence however there are limitations due to study design. The evidence found was mostly from lower quality studies which were varied on how they diagnosed plantar fasciits, and how they defined and measured risk factors. It should also be noted that a number of reports used cross-sectional and epidemiological study designs which although can report on increased association and prevalence of plantar fasciitis, they cannot confirm causation.

There are also other caveats to be considered when using this information. Studies that focused on specific populations (eg. runners, military populations, workers in a manufacturing plant) could be less applicable to the general population. This should be taken into consideration when using this data as an information source.

The most consistent finding across the reviews and studies was that the occurrence of plantar fasciitis is higher in people who have a high BMI (>25kg/m^2). Another finding was that the occurrence of the symptoms of plantar fasciitis may be higher with walking/standing workers, however due to the underlying study designs that reported this data, it was difficult to determine if the symptoms of plantar fasciitis were actually caused by the standing/walking components of that job.

Associations for plantar fasciitis and other factors (different foot biomechanics, gender, and specific employment sectors) were less consistent. Although one study discussed the occurrence of plantar fasciitis with injury, little evidence is published, as injury was usually an exclusion factor for participants in primary studies.

Overall it is unlikely that a person will have a single risk factor that leads them to developing plantar fasciitis. The causation of plantar fasciitis is likely due to multiple factors which are reflected in the variable nature of the literature.

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2 Background

2.1 Description of plantar fasciitis

Plantar fasciitis is a commonly reported cause of plantar heel pain[1-3]. The underlying descriptions of plantar fasciitis can be confusing and descriptions include: degeneration consisting of micro-tears occurring from repeated trauma of the plantar fascia at its insertion into the calcaneus (as in a tendinosis); collagen degeneration and fascial thickening[1, 4, 5]. Although it has been described as an inflammation, it is considered more of a degenerative disorder[1-3]. It presents as a sharp, non-radiating pain on the medial part of the calcaneous that occurs with standing in the morning, and by painful palpation of the medial anterior calcaneous, or dorsiflexion of the foot while extending the toes[1, 3, 5]. There are a number of treatment options ranging from: orthotics, night splints and taping, stretching techniques, extracorporeal shock wave therapy, cortisone injections and surgery to just leaving the problem to resolve by itself as some patients recover spontaneously[4, 12]. However as it is a degenerative disorder and there are other causes of heel pain, plantar fasciitis may be diagnosed as some other disorder.

A more detailed description of plantar fasciitis and the anatomy of the plantar fascia/aponeurosis can be found on the ACC's intranet on The Sauce within the Clinical Advisory Panel (CAP) summaries. The CAP summary for plantar fasciitis was completed in 2010 and is a literature review that discusses the presentation, anatomy and risk factors associated with plantar fasciitis. The difference between this document and the previous literature reviews produced by CAP is this document critically appraises the peer-reviewed articles in the literature and discusses the quality of the studies that have investigated the risk factors related to the occurrence of plantar fasciitis.

2.1.1 Differential Diagnoses

The differential diagnosis of plantar fasciitis include other types of heel pain that it could be mistaken for[4, 12]. These include fat pad contusions, calcaneal stress fractures, tarsal tunnel syndrome and plantar fascia rupture[4, 12]. The history of the individual's pain and presentation can assist diagnosis as plantar fasciitis is predominantly described as a gradual onset disorder, not acutely arising from an event like a trauma[2, 3]. The figure below (Figure 1) outlines some basic differential diagnoses for different types of heel pain.

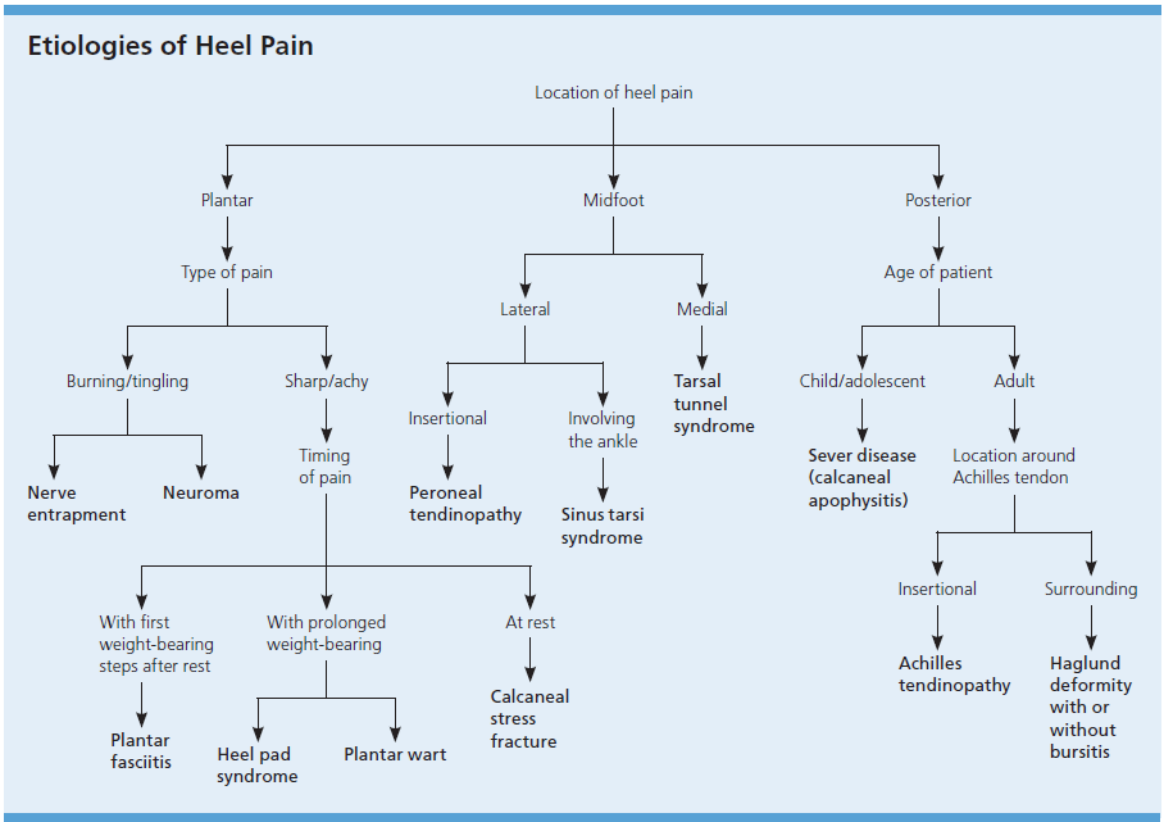

Figure 1. Differential diagnoses and aetiologies of heel pain[3]

2.1.2 *Reported risk factors for plantar fasciitis*

The causes of plantar fasciitis are thought to be multifactorial and a combination of patient related and physical risk factors have been reported. Risk factors for plantar fasciitis can be categorised as patient-related or physically-related [5, 12, 13]. An evidence-based review on the workplace factors associated with plantar fasciitis by ACC[13] showed positive associations of patient-related factors (age, gender, high body mass index: BMI) with plantar fasciitis. In contrast, evidence for the physical risk factors from work activity (e.g. standing on hard surfaces) was conflicting with some evidence from moderate to low quality studies showing an association, whereas others showed no association. The evidence for patient-related factors like diabetes and foot biomechanics is also conflicting[13].

2.1.3 *Purpose of this report*

The purpose of this report is to provide an evidence-based review of the risk associated with the occurrence of plantar fasciitis. This may aid decision-making for claims for plantar fasciitis within ACC.

2.2 Plantar fasciitis claims within ACC

2.2.1 *Analysis of current claims*

A general analysis of ACC claims for plantar fasciitis was extracted from InFact (internal ACC interface to access the ACC data warehouses) on the 2 July 2015. Both the read codes, ICD-9 and ICD-10 codes for plantar fasciitis were used to extract claims data deemed relevant for this report.

An overview of claims data from 2010 – 2015 (by financial year) are outlined in Table 2 below. As it shows there have been a total of 34,138 claims for Plantar Fasciitis over five years, however only 1,705 (5%) of these were accepted. The most predominant primary diagnosis is coded as “Gradual Process”, however a very low percentage of claims were paid for soft tissue sprains or strains, as well as contusions.

Table 2. Overview of claim numbers for Plantar Fasciitis

	Quantity Count N	Claims Paid Count N (% of quantity count)	Cost per claim ($ average)	Cost Ex GST ($)
All Claims	34,138	1,701 (5%)	$304	$602,628
Primary diagnosis				
Contusion (intact skin, including crushing)	18	5 (28%)	$327	$1.637
Sprain or Strain (ICD-9)	132	8 (6%)	$990	$6,285
Gradual Process	33,994	1,704(5%)	$333	$562,272

The graphs below (Figure 2) show the number of claims that have come through for plantar fasciitis since 2009 (Figure 2a) and the number of plantar fasciitis claims that have been paid (Figure 2b). There was a decrease in claims lodged for plantar fasciitis between 2010 and 2013 but these started to increase again in 2014 to 2015. It appears that after a decrease between 2009 to 2010 the number of claims paid for has fluctuated between 200 – 300 each year which indicates only a small percentage (6% in 2015) of plantar fasciitis claims that are being paid/accepted in ACC.

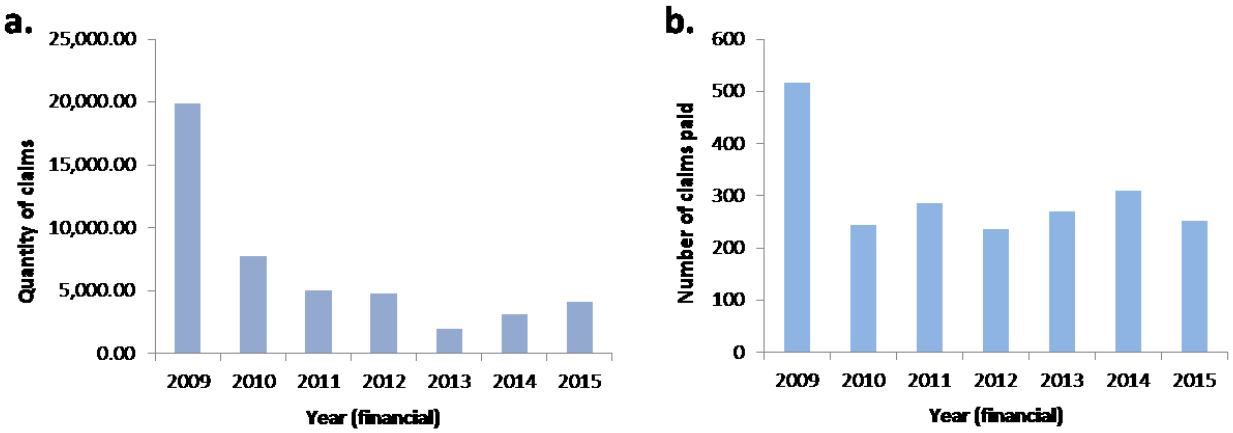

Figure 2. Number of existing claims (a), and claims that have been paid (b) for plantar fasciitis (2009 - 2015)

2.2.2 Services Groups claims linked to plantar fasciitis

From data pulled from InFact (internal ACC electronic interface to ACC claims data warehouses) in September 2015 when plantar fasciitis was used as a read code description it was found that claims for plantar fasciitis were made under primary diagnoses of Gradual processes (local inflammation), Soft tissue injury (crushing, contusion), and strain. The services that had be claimed and paid for by ACC include a wide range of groups from Allied Health, disputes and reviews to vocational rehabilitation (full list can be found in the Appendices at the end of this document).

The highest cost reported under plantar fasciitis was for specialist medical services ($240,781 in total, 54.7% or n = 1,243 of these claims were accepted). Other high cost and/or volume groups were: physiotherapy ($171,310: 14.5% or n = 703 of these claims accepted) and general practice ($115,612: 56.4% or n = 1,882 claims accepted). These numbers show that large numbers of claims for a wide range of services in relation to plantar fasciitis are made, but for most services the majority is not paid, depending on what the services are. More detail can be found within the table drawn from InFact which is provided within Appendix 1 at the end of this document.

2.3 Objective of this report

The objective of this evidence-based review is to provide the ACC32 team with an overview of the causation of plantar fasciitis from an evidence based perspective. To achieve this objective this evidence-based healthcare (EBH) report will attempt to:

- Identify best available evidence using standard research methods (described in methods section below) and grade articles found in peer-reviewed medical journals, guided by the Scottish Intercollegiate Guideline Network (SIGN) criteria (section 3.3 below);
- summarise the best available evidence into a comprehensive report for the ACC32 team;
- provide a brief summary of differential diagnoses for heel pain; and
- clearly outline the caveats within the included evidence that need to be taken into consideration by the ACC32 team when using this report as a guide for decisions about plantar fasciitis.

3 Methods

3.1 Search Strategy

A search was conducted by two EBH researchers (up to 5 April 2016) within the following databases:

- Ovid MEDLINE <1946 to Present>,
- Google Scholar
- Embase

A brief summary of the search terms included are: risk factors, plantar fasciitis, plantar fasciotomy and other associated MeSH terms. Detailed search strings used within the Ovid databases on Medline can be found in the appendices at the end of this document.

3.2 Inclusion and Exclusion Criteria

3.2.1 Inclusion Criteria

- *Study design*: Systematic reviews and evidence based guidelines, primary studies not included in secondary literature (including prospective and retrospective observational studies, cross-sectional studies, case control published from 2003 – February 2016) published after 2012
- *Types of participant:* People diagnosed with plantar fasciitis
- *Types of comparison:* People without plantar fasciitis
- *Types of outcome measures:* Pain on palpation of fascia insertion to medial tubercle of the calcaneus, administrative data (BMI, Age, Gender) goniometric measures, clinical examination, participant history

3.2.2 Exclusion Criteria

- *Study design:* Case series and grey (non-peer reviewed) literature, literature reviews, expert opinion
- Articles that did not provide a description of diagnosis of the plantar heel pain
- Articles that only described chronic plantar heel pain and did not classify plantar fasciitis
- Studies that only reported treatment outcomes
- Animal or laboratory study
- Non-English studies

3.3 Level of Evidence

Studies meeting the criteria for inclusion in this report were assessed for their methodological quality using the Scottish Intercollegiate Guideline Network (SIGN) level of evidence system[2] (See table below). Evidence tables with the details of the critique for each paper are provided for in Appendix 3 at the end of this report.

Levels of evidence	
1++	High quality meta analyses, systematic reviews of randomised controlled trials (RCTs), or RCTs with a very low risk of bias
1+	Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1-	Meta analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort studies High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

[2] *Scottish Intercollegiate Guidelines Network http://www.sign.ac.uk/*

4 Results

4.1 Study Overview

A total of one evidence-based guideline, three systematic reviews and two primary studies were found that met the inclusion criteria for this review. The guideline and systematic reviews were graded as good to moderate quality reviews of low quality primary studies. The primary studies were graded as low to moderate quality. Participants that were included across the studies were from a range of different cohorts that included army personnel, patients of orthopedic specialists, and automotive plant employees. The tables (Tables 3 to 5) provide a brief outline of the main findings and participants included within the articles. More detail about these articles is presented in Appendix 3.

The main findings show that plantar fasciitis was positively associated with high BMI and running activities. Other risk factors found were related to gender and specific job categories. A brief description of each of the types of articles and evidence are presented below. This is followed by sections that will group together the results of findings for each risk factor.

4.1.1 Evidence-based guideline

One evidence-based guideline was found that investigated plantar fasciitis. The guideline did critique treatment areas for PF as well as risk-factors, however only the risk-factor results are included for this review. Appendix 3 outlines the studies and systematic reviews included in the guideline.

This guideline also included two systematic reviews of epidemiological studies [14, 15]. This is important to note as epidemiological studies cannot provide causal information to identify the risk factors of PF, but rather information on the activities that are associated with PF.

Table 3. Evidence-based guideline

Guideline	Focus	Included primary and secondary studies	Summary of recommendations	Recommendation	Level of evidence (LOE)
Martin et al, 2014 [6]	Evidence-based guideline for plantar fasciitis – Revision of the 2008 guideline	Systematic Reviews: n = 3 Primary studies: n = 4	**Level II and III evidence found for Running as a risk factor** for PF. Variables included Street running, spiked shoes, cavus foot and hind-foot varus; increase in ground reaction forces, and biomechanical issues. **Level III evidence found for BMI as a risk factor:** Strong association in non-athletic population **Level III for assembly line workers:** Case control study of factory workers. Shoe rotation found to decrease risk of PF **Level IV evidence for biomechanics:** Some association found for high foot arches, decreased ankle dorsiflexion, hamstring tightness, leg-length discrepancy **Level IV evidence for intrinsic muscle strength:** These may be associated with the development of heel pain / plantar fasciitis	**Grade B**: *(based on LOE from included primary studies)* Clinicians should consider limited ankle dorsiflexion range of motion and a high body mass index in nonathletic populations as factors predisposing patients to the development of hell pain / plantar fasciitis.	**1+**

4.1.2 Systematic Reviews

A total of three systematic reviews have been included in this report. These reviews have been critiqued as moderate to good quality reviews of low quality primary articles. Primary studies included within the reviews were largely case control and cross-sectional studies. A table of primary studies included within these reviews can be found in Appendix 3 at the end of this report which shows there is some overlap between primary studies used between the systematic reviews and the guideline. One SR[7] had a much larger number of included primary studies which is likely due to the aim of the review (ie. it included multiple factors associated with PF rather than just one or two as did the other SRs) and also included Dutch, German as well as English studies.

Table 4. Overview of systematic reviews included in this report

Systematic Review	Focus	Included primary studies	Findings	Conclusions	LOE
Waclawski et al, 2015[8]	Review evidence for association between weight-bearing (walking or standing) and PF among workers	Case-controls: 3 Cross-sectional: 1	Associations between PF and risk-factors including sex, obesity, foot biomechanics and job factors. Association between weightbearing and PF: 2 case control and cross sectional study (however assessment of weightbearing varied.	Low-quality evidence of an association between PF and weight-bearing tasks such as walking and standing on hard surfaces. Only occupations specifically identified as having higher risk were those associated with the engine assembly plant.	**1+**
van Leeuwen et al, 2015[7]	Review all factors associated with PF	N = 51 papers Prospective cohort: 1 Case-control: 46 Cross-sectional: 4	Significant risk factors determined from prospective cohort for PF included: Varus knee alignment, cavus arch posture, spiked athletic shoes, number of kilometres run, years of activity. Positive associations (not causation) with PF found for: BMI, decreased hamstring flexibility, thickened plantar fascia, some foot postures, greater heel pad thickness and calcaneal spurs.	Consistent clinical association between higher BMI and plantar fasciopathy. Association may differ between athletic and non-athletic subgroups. There is consistent evidence to support bone a range of bone and soft tissue abnormalities, but there is a lack of evidence for clinical and mechanical measures of foot and ankle function	**1+**
Franceschi et al, 2014[9]	To examine whether obesity is a risk factor for onset of some musculoskeletal disorders, including plantar fasciitis	For Plantar fasciitis only *(excluding papers that only describe CPHP)* Case control: 2 Cross-sectional: 1	Women with body weight of more than 60kg were at risk of PF Increased likelihood of PF if subjects overweight, and Obesity could be an independent risk factor for plantar fasciitis	Association between obesity and plantar fasciopathies seems strong, in which the increased weight creates an increased load for the tendons, stressing these structures	**1-**

4.1.3 Primary studies

Two primary studies not included in the guideline or systematic reviews were found. Both were longitudinal observational studies of administrative data and were of moderate to low LOE.

Table 5. Overview of primary studies included in this report

Reference	Study design	Participants	Plantar fasciitis diagnosis	Main findings	Level of evidence
Owens et al, 2013[11]	Prospective cohort	N = 80,106 active duty army personnel	Determined from ICD code in data obtained	Positive significant associations with plantar fasciitis was found for:	Moderate: 2+

		Enrolled over 3 waves (2001, 2004, 2007) Followed up for 1 year	from the: - Millennium Cohort Study - Defence manpower data centre - Electronic records from military health service data repository	- Recent deployment - Gender - High BMI - Specific job categories - Patients with history of tendinopathy or fracture	
Klein et al, 2013[10]	Retrospective cohort	N = 182 (124 female) N = 39 had bilateral symptoms	ICD-9 code, and description of primary diagnosis Acute: <6months Chronic: >6 months	No difference between chronic and acute PF groups No comparisons made for non PF groups	Low: 2-

4.2 Main findings from the evidence-based guideline

The factors associated with plantar fasciitis came from a mixture of systematic reviews, observational studies and epidemiological studies. The lower levels of evidence (III and IV outlined in Table 6 below) came from lower study designs (cross-sectional and case control) that can show an increase of occurrence of PF in a specific population, but this does not determine that PF was caused by this particular factor. The non-epidemiological systematic review[16] covered a similar cohort of papers to van Leeuwan et al, 2015 (see Appendix 3 for primary study lists).

Table 6. Factors associated with occurrence of plantar fasciitis

Evidence level	Description of recommendation
II – Running	Risk factor for PF (taken from two SRs of epidemiological data). Street running, spiked shoes, cavus foot, and hind-foot varus related to onset of plantar fasciitis in a group of runners
III-Running	Increased arch height, greater rates of increase in vertical ground reaction forces and a lower medial longitudinal arch found in female runners with a history of plantar fasciitis.
III – BMI	One SR found a strong association between greater BMI and chronic plantar heel pain in a non-athletic population, two other studies found it to be a risk factor for developing PF. One of these studies did not find a difference in BMI between whose with an acute or chronic condition
III-Assembly line workers	In this case control study, risk factors for plantar fasciitis included time spent standing on hard surface, time walking, number of times jumping in and out of vehicles and 4 – 7 years of factory work. Shoe rotation found to reduce risk of PF
IV-Biomechanics	High-arch foot type and decreased ankle dorsiflexion range of motion. Positive association between hamstring tightness, leg-length discrepancy (with pain in the longer limb) and PF
IV-intrinsic muscle strength	May be associated with development of heel pain / plantar fasciitis.

4.3 Factor 1: High BMI – Overweight and obesity

Three systematic reviews and two primary studies reported increased occurrence of plantar fasciitis with high BMI. The systematic reviews reported largely the same primary studies. The odds of PF occurring were higher with a higher BMI as shown in both the SRs and Owens et al, 2013. No difference was seen between acute or chronic PF and BMI[10].

Table 7. Studies reporting occurrence of plantar fasciitis in people with high BMI

Reference	BMI classifications	Main findings *(OR, (95% CI))*
Waclawski et al, 2015[8]	>200 pounds BMI≥30 vs BMI ≤ 25	OR: 1.4 (1.02 – 1.91) (Gill et al, 1996) OR 2.9 (1.4 – 6.1) (Irving et al, 2007) OR 5.6 (2.9 – 16.6 (Riddle et al, 2003)
Franscheschi et al, 2014[9]	BMI≥30 vs BMI ≤ 25 BMI >25	OR 5.6 (2.9 – 16.6) (Riddle et al, 2003) Increased incidence leading to CPHP, but not significant (Irving et al, 2007)
van Leeuwen et al, 2015[7]	BMI >27 Significantly higher BMI	Pooled OR: OR 3.7 (2.9 – 5.6) (Prichasuk et al, 1994, Sconfienza e tal, 2013) Pooled mean difference (MD): 2.3 kg/m^2 (95%CI 1.3 – 3.2)
Owens et al, 2013[11]	Normal weight: 18.5-24.9kg/m^2 Over weight: 25.0 – 29.9kg/m^2 Obese: ≥ 30kg/m^2	*Significant positive associations with:* - Over weight: 1.62 (1.42 – 1.86) - Obesity: 1.95 (1.61 – 2.36)
Klein et al, 2013[10]	Average BMI all participants Acute PF BMI (n = 92) Chronic PF BMI (n = 90	29.1 (6.2) Mean (SD) 28.9 (6.2) 29.3 (6.2)

4.4 Factor 2: Running

Running was reported in two of the systematic reviews. Results came from two different primary studies. These studies showed that there was an increase in odds of PF occurring in recreational joggers and with running more kilometers per week. However findings showed that occurrence of PF was inconsistent for athletes vs non-athletes within these measures.

Table 8. Studies reporting association between running and plantar fasciitis

Reference	Running activity	Main findings *(OR, (95% CI))*
Waclawski et al, 2015[8]	Recreational joggers	OR 2.8 (95% CI 0.4 – 22.7) (Riddle et al, 2003)
van Leeuwen et al, 2015[7]	Running more kms per week	MD 20.00 (12.12 – 27.88) (DiCaprio et al, 2010) Findings between studies were inconsistent for athletes vs non-athletes

4.5 Factor 3: Standing for prolonged periods

Two SRs reporting different sources showed increased odds of PF occurring with prolonged standing, walking on hard surfaces, or participants spending a majority of their time on their feet. Increased odds were found in all populations: assembly plant workers as well as clinic populations and non-athletic or athletic cohorts.

Table 9. Studies reporting association between standing for long periods and plantar fasciitis

Reference	Cohort	Measure	Main findings *(OR, (95% CI))*
Waclawski et al, 2015[8]	Clinic population	Walks on hard floor most of time	OR 1.58 (1.2 – 2.1) (Gill et al, 1996)
	Clinic population	On feet most of work day	OR 3.6 (1.3 – 10.1) (Riddle et al, 2003)
	Assembly plant workers	Time standing on hard surface	Prevalent PF (10%increase) (Werner et al, 2010) OR: 1.5 (1.1 – 2.1) New PF (10% increase) OR: 3.9 (1.4 – 10.9)
van Leeuwen et al, 2015[7]	Athletic and non-athletic populations	Increased occupational standing time on hard surfaces	OR 1.3 (1.1 – 1.6) (Werner et al, 2010)
		Spent majority of time on feet	OR: 3.6 (1.3 – 10.1) (Riddle et al, 2003)

4.6 Factor 4: Biomechanics and foot posture

The most consistent foot posture associated with increased odds of PF was increased foot pronation identified from three separate primary studies. Conflicting evidence was found with both excessive and limited dorsiflexion being associated with PF. Some association was seen with regards to arch posture and varus knee alignment.

Table 10. Biomechanics and posture reported in different studies

Reference	Movement or foot posture	Main findings *(OR, (95% CI))*
Waclawski et al, 2015[8]	Increased foot pronation	OR 3.7 (1.6 – 8.7) (Irving et al, 2007)
	Excessive ankle dorsiflextion	OR 2.0 (0.9 – 4.4) (Irving et al, 2007)
	Limited dorsiflextion	OR 23.3 (4.3 – 134.4) (Riddle et al, 2003)
	Forefoot pronation	Prevalent PF: OR 4.2 (1.7 – 10.1) (Werner et al, 2010) New PF: OR 5.4 (1.9 – 15.7) (Werner et al, 2010)
Franscheschi et al, 2014[9]	Foot pronation	Independent and modifiable risk factor for chronic plantar heel pain (Frey and Zamora et al, 2007)
van Leeuwen et al, 2015[7]	Varus knee alignment	OR 5.63 (2.01 – 15.72)
	Cavus arch posture	OR 5.52 (2.12 – 14.33)
	Decreased straight leg elevation	Decreased straight leg elevation and contractures of the hamstrings were found in people with PF. In non-athletic groups a positive association was found for a more pronated foot posture, lower sagittal arch angle change between weight bearing and non-weight bearing.

4.7 Employment sector

Some specific employment sectors were also associated with the occurrence of plantar fasciitis as seen below in Table 8. However it should be noted that these factors were looked at within a specific population from one primary study that was performed in an active army population, and that examples of similar jobs outside of the army

environment have not been found for this report. The data in this study was taken from administrative data and did not report what aspect of these occupations may have led to development of PF.

Table 11. Job factors associated with plantar fasciitis

Reference	Main findings *(OR, (95% CI))*
Owens et al, 2013[11]	**Electronic equipment repair:** 1.56 (1.24 – 1.97) **Healthcare:** 1.55 (1.24 – 1.94) **Administration, functional support**: 1.30(1.06-1.61) **Equipment repair:** (1.26 (1.01-1.58) **Craft work:** 1.48 (1.10 – 2.18) **Service and Supply:** 1.36 (1.07 – 1.73)

4.8 Other factors

Other factors that were identified in individual primary studies included previous injury and were predominantly from cross-sectional and case-matched studies. These are factors associated with PF rather than causation. The ORs for shoe rotation (rotating between different pairs of shoes during the week) and females (>60) are both lower than 1 indicating that these factors may be preventative against occurrence of PF. Although high odds of PF were found for participants with a history of tendinopathy or fracture, it is unclear if other confounding variables (eg. age, BMI, job activity) were included in the OR calculation.

Table 12. Studies reporting association between previous injury and plantar fasciitis

Reference	Factor (Primary study)	Main findings *(OR, (95% CI))*
Waclawski et al, 2015[8]	Shoe rotation (Werner et al, 2010)	Prevalent PF: OR 0.3 (0.1 – 0.7) New PF: OR 0.3(0.11 – 0.98)
Franscheschi et al, 2014[9]	Females (>60kg) with PF (Taunton et al, 2002)	OR 0.378 (0.203 – 0.706)
van Leeuwen et al, 2015[7]	Imaging: Measured with ultrasound, magnetic resonance imaging (MRI)	Found increased plantar fascia thickness in participants with PF Pooled MD 2.32mm (95%CI1.86 – 2.79) ; n = 21 studies
	Heelpad thickness:	Both loaded and loaded heel pad thickness was greater in PF compared to controls.
	Calcaneal spurs	Examined in 11 studies (6 matched for confounders age and gender). CS more common in PF compared to controls Metabolic bone activity around calcaneus higher in PF (n = 2 studies) Larger effect sizes in older compared to younger participants.
Owens et al, 2013[11]	Participants with a history of tendinopathy or fracture	OR 4.79 (4.25 – 5.41)

5 Discussion

5.1 Nature and quality of the evidence

The articles included in this report were both secondary and primary research. The secondary research consisted of moderate to high quality systematic reviews and a guideline that critiqued low to moderate quality primary data. The lower quality evidence was due to study design, the cohorts included within studies (eg. restricted populations or analyses of administrative data). The guideline and systematic reviews did overlap in the primary studies that were included (see Appendix 3) and altogether covered a total of 60 primary articles that covered either causative risk factors (from prospective or retrospective observational studies); or factors associated with plantar fasciitis (epidemiological studies, cross-sectional studies and case-matched studies). The two additional primary studies that were published after the systematic reviews were a retrospective analysis of a clinical population (Klein et al, 2013) and a prospective observational study of an administrative dataset (Owens et al, 2013).

It should be noted that for research questions such as the risk factors associated with plantar fasciitis that higher quality study designs like randomised control trials are inappropriate and that the literature presented here is the best available evidence that can be sourced from the peer-reviewed academic literature for this sort of research question.

The diagnosis of plantar fasciitis was similar between studies (see Table 2). Studies that retrospectively investigated administrative data and medical charts[10, 11] used ICD-9 specifications. Studies that diagnosed plantar fasciitis via clinical examination were examined by physiotherapists, or orthopaedic foot specialists although some articles did not provide this information[17]. A large body of the literature for plantar fasciitis was excluded as it focused on treatment, or due to being literature reviews or opinion pieces.

5.2 Limitations of studies

There were a number of limitations within the available evidence that are related to the differences between studies, and study selection. These were different participant cohorts (e.g. army personnel, recreational runners, athletic vs non-athletic individuals, clinic vs non-clinic populations), and differences in how factors were measured (e.g. different foot biomechanics, or different groupings of BMI), due to the particular focus or objective of the study or review. This can make it difficult to obtain a consensus from the information for a particular factor.

Factors identified from studies that used administrative data or epidemiological data, or studies that do not follow participants over a period of time (like in prospective or retrospective observational studies) cannot provide information about causation. However these studies can provide relevant information related to factors that have been associated with plantar fasciitis and identify potential opportunities for future causative studies.

5.3 Comparisons with what is previously reported for risk factors of plantar fasciitis

The main findings of this report are in agreement with what has been reported in literature reviews about the risk factors that are thought to contribute to the causation of plantar fasciitis [1, 4, 5, 18]. Obesity, standing for prolonged periods on hard surfaces and specific foot biomechanics have all been linked to the development of plantar fasciitis, the difference with this review is that the evidence has been critically appraised and reports the increased or decreased odds of plantar fasciitis occurring with each factor.

6 Conclusion

This report indicates that the occurrence of plantar fasciitis is higher in people who have higher BMI and have increased time on their feet on hard surfaces. There is also some evidence that it may have higher occurrence in people with certain foot biomechanics and postures, hamstring tightness and that the use of foot orthotics may be preventative. The results of this review are largely in agreement with what is already conventionally known about PF.

6.1 Evidence statement

The available evidence on the risk factors that contribute to the causation of plantar fasciitis is of low to moderate quality, mainly due to study design. It should be noted that for research questions that investigate causative factors, the type of studies that can ethically explore these studies will be restricted to observational study designs. Very little data was found regarding injury leading to the occurrence of PF.

Cross-sectional, case-matched and epidemiological study designs may help outline increased odds of PF in particular populations, but this does not provide evidence with regards to causality and if these elements are a risk factor. However this evidence has been included in this review as it provides useful information for clinical advisors to use when making decisions on claims.

To determine clearly what the risk factors are for plantar fasciitis in order to help understand the underlying causation more high quality prospective and retrospective cohort studies are needed. With regards to ACC, more studies on the relationship between injury and occurrence of plantar fasciitis is required to inform decision makers within the organisation better when assessing requests regarding this disorder.

7 References

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8 Appendices

8.1 Appendix 1: Services claimed for within ACC for plantar fasciitis

Read Code Desc	Primary Diagnosis Group	Primary Diagnosis	Service Group	Qty Count	Claims Paid Count	Cost Ex GST
Plantar fasciitis	Gradual onset	Gradual Process - Local Inflam.	Accident and Medical Clinic Services	523.85	252	$21,972
			Activity Programmes	496.52	16	$21,494
			Allied Health	1,579.05	438	$51,728
			Dental	68.83	245	$10,965
			Disputes and Reviews	74.00	18	$15,035
			Elective Surgery	194.60	19	$97,513
			Emergency Transport	625.07	2	$1,310
			General Practice	3,336.22	1,882	$115,612
			Hearing Loss Services	38.25	5	$148
			Home and Community Support Services	1,078.07	12	$7,057
			Impairment assessments	59.50	18	$4,031
			Mental Health and related services	54.82	5	$6,798
			Non-Contracted Purchasing	2,384.99	42	$11,377
			Not Applicable	0.00	3	$694
			Nursing	33.00	16	$741
			Orthotics	296.00	139	$71,045
			Other	50,519.00	57	$23,429
			Other social rehabilitation services	6.00	2	$18,886
			Pain Management Services	489.27	25	$49,508
			Pharmaceuticals	56.00	24	$1,696
			Physiotherapy	4,842.18	703	$171,310
			Procurement	89.00	26	$7,964
			Radiology	1,042.00	551	$136,923
			Social Rehabilitation Assessments	747.31	16	$9,695
			Specialist Medical Services	2,271.53	1,243	$240,781
			Training for Independence	977.95	3	$5,276
			Transport for Independence	5.00	1	$15,973
			Treatment Injury Advisory Services	17.50	2	$2,898
			Undefined	1,098.25	130	$13,180
			Vocational Assessment Services	2,587.98	56	$56,118
			Vocational Rehabilitation Services	9,890.31	66	$146,246
	Soft tissue injury	Contusion(intact Skin)inc Crushing	Orthotics	17.00	1	$2,167
			Specialist Medical Services	1.00	1	$148

		Soft Tissue Inj (contu,str,spr,int	General Practice	6.00	1	$182
			Orthotics	3.00	2	$1,124
			Radiology	1.00	1	$48
			Specialist Medical Services	1.00	1	$130
		Sprain Or Strain	Radiology	1.00	1	$53
			Undefined	1.00	1	$93

8.2 Appendix 2: Search Strategy

8.2.1 *Plantar fasciitis, Medline*

1. Fasciitis, Plantar/et, ge [Etiology, Genetics]
2. Fasciitis, Plantar/ and (causation or etiolog$ or aetiolog$ or et.fs.).af.
3. diagnosis, differential/
4. Fasciitis, Plantar/ and 3
5. Fasciitis, Plantar/ and risk factor$.sh,ti.
6. 1 or 2 or 4 or 5
7. limit 6 to (english language and humans and yr="2000 -Current")

8.2.2 *Plantar fasciitis, Embase*

1. exp plantar fasciitis/et [Etiology]
2. exp plantar fasciitis/ and (causation or etiolog$ or aetiolog$ or et.fs.).af.
3. exp differential diagnosis/
4. exp plantar fasciitis/ and 3
5. exp *risk factor/
6. exp plantar fasciitis/ and 4
7. exp plantar fasciitis/ and risk factor$.sh,ti.
8. 1 or 2 or 4 or 6 or 7
9. limit 8 to (human and english language and yr="2000 -Current")

8.3 Appendix 3 – Lists of primary studies included in secondary studies

Table 13. Primary studies included within secondary articles

Review	Included studies																						
	Butterworth et al, 2012	Sobhani et al, 2013	Lopex et al, 2012	Gill et al, 1996	Irving et al, 2007	Riddle et al, 2003	Werner et al, 2010	Prichasuk et al, 1994	Ozdemir et al, 2005	Rano et al, 2001	Wearing et al, 2004	Rome et al, 2002	Rome et al, 2001	Sadad-Ali et al, 1998	Wenzel et al, 2009	Frey et al, 2007	Janchal et al, 2010	Taunton et al, 2002	DiCaprio et al, 2010	Tenforde et al, 2013	Ribeiro et al, 2011	Pohl et al, 2009	Klein et a;, 2012
Martin et al, 2014 *(Evidence-based Guideline)*	●	●	●		●																●	●	●
Systematic reviews																							
Waclawski et al, 2015				●	●	●	●																
Butterworth et al, 2012					●	●		●	●	●	●	●	●	●	●	●	●						
Franscheschi et al, 2014					●	●										●		●					
van Leeuwen et al, 2015					●	●	●	●	●	●	●	●	●	●			●		●		●		

Review	Included studies																						
	Mahmood et al, 2010	Labovitz et al, 2011	Sahin et al, 2010	Patel et al, 2011	Abdel-Wahab, 2008	Akfirat, 2003	Allen, 2003	Alvarez, 2000	Berkowitz, 1991	Bolivar, 2013	Bigrave, 1998	Carinal, 1996	Cetin, 2001	Chen 2013	Chundru, 2008	Creighton, 1987	Fabrikant, 2011	Genc, 2005	Gibbon, 1999	Harty, 2005	Johal, 2012	Kamel, 2000	Karabay, 2007
Martin et al, 2014 *(Evidence-based Guideline)*	●	●	●	●																			
Systematic reviews																							
Wearing et al, 2015																							
Butterworth et al, 2012																							
Franscheschi et al, 2014																							
van Leeuwen et al, 2015			●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Review	Kibler, 1991	McMillan, 2013	Messier, 1988	Osborne, 2006	Oztuna, 2002	Sabir, 2005	Sconfienza, 2013	Tsai, 2000	Turgut, 1999	Vohra, 2002	Wainwright, 1995	Wall, 1993	Walther, 2004	Wearing, 2007	Wearing, 2010	Williams, 1987	Wu, 2011
Martin et al, 2014 *(Evidence-based Guideline)*																	
Systematic reviews																	
Wearing et al, 2015																	
Butterworth et al, 2012																	
Franscheschi et al, 2014																	
van Leeuwen et al, 2015	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Table 14. Epidemiological studies included in two separate SRs

Systematic review	Included studies																					
	Pileggi et al, 2010	Jakobsen et al, 1994	Lysholm and Wiklander, 1987	McKean et al, 2006	Jacobs and Berson, 1986	Scheer and Murray et al, 2011	Fallon, 1996	Hutson, 1984	Rovere et al, 1983	Linde, 1986	Beukeboom et al, 2000	Knobloch et al, 2008	Cloke et al, 2009	Alonso et al, 2010	Walls et al, 2010	Dubravcic-Simuniak et al, 2006	Kuhne et al, 2004	Migliorini, 1991
Lopes et al, 2012	●	●	●	●	●	●	●	●										
Sobhani et al, 2013			●		●				●	●	●	●	●	●	●	●	●	●

8.4 Appendix 4 - Evidence tables

8.5 Evidence-based guideline

<table>
<tr><th>Study</th><th>Methodology</th><th>Outcomes & results</th><th colspan="2">Paper grading[3]</th><th>ACC reviewer comments & evidence level</th></tr>
<tr>
<td rowspan="11">Martin et al, 2014

Journal of Orthopaedic and Sports Physical Therapy, 44 (11), A1 – A23

Study design:

Evidence based Guideline – Revision of the 2008 guideline

Purpose (for risk factors only)

Funding

Not stated</td>
<td rowspan="11">Results for risk-factors only are presented

N = 11

3 were Systematic Reviews, n = 8 were primary studies

Inclusion criteria

Systematic reviews, meta-analyses, experimental and quasi-experimental , cohort, case-series, and cross-sectional studies

Exclusion criteria

Non-systematic review articles and reports, and articles reporting on: <16 years; heel pain primarily related to conditions other than plantar fasciitis; topics outside the scope of physiotherapist practice (eg. ordering MRIs, Extracorporeal shockwave therapy, diagnostic ultrasound)

Databases

An extensive MeSH and Keyword search strategy, and hand search of references from relevant papers was conducted for between 2007 and December 2012

MEDLINE; Cochrane Library; ProQuest Nursing and Allied Health Source;</td>
<td rowspan="11">Summary of recommendations taken from critical appraisal of the literature

This document was an update of the 2008 guideline where the recommendation was:

Grade B: Clinicians should consider limited ankle dorsiflexion range of motion and a high body mass index in nonathletic populations as factors predisposing patients to the development of heel pain / plantar fasciitis.

Update of findings:

<table>
<tr><th>Evidence level</th><th>Description of recommendation</th></tr>
<tr><td>II – Running</td><td>Risk factor for PF (taken from two SRs of epidemiological data). Street running, spiked shoes, cavus foot, and hind-foot varus related to onset of plantar fasciitis in a group of runners</td></tr>
<tr><td>III-Running</td><td>Increased arch height, greater rates of increase in vertical ground reaction forces and a lower medial longitudinal arch found in female runners with a history of plantar fasciitis.</td></tr>
<tr><td>III – BMI</td><td>An SR found a strong association between greater BMI and chronic plantar heel pain in a non-athletic population, two other studies found it to be a risk factor for developing PF. One of these studies did not find a difference in BMI between whose with an acute or chronic condition</td></tr>
</table>
</td>
<td>Clearly defined research question?</td><td>Y</td>
<td rowspan="11">SIGN evidence level

1+

ACC Reviewer comments:

Good quality, high quality relevant guideline.

Guideline is of literature up to 2012, and presents relative evidence by study type.

Evidence tables available on Orthopaedic Section of the (American Physical Therapy Association) APTA site.</td>
</tr>
<tr><td>Two people selected studies and extract data</td><td>Y</td></tr>
<tr><td>Comprehensive literature search carried out</td><td>Y</td></tr>
<tr><td>Authors clearly state how limited review by publication type</td><td>Y</td></tr>
<tr><td>Included and excluded studies listed</td><td>N</td></tr>
<tr><td>Characteristics of included studies are provided</td><td>Y</td></tr>
<tr><td>Scientific quality of included studies assessed and documented</td><td>Y</td></tr>
<tr><td>Likelihood of publication bias assessed</td><td>Y</td></tr>
<tr><td>Conflicts of interest declared</td><td>N</td></tr>
<tr><td>Are results of study directly applicable to patient group targeted by guideline?</td><td>Y</td></tr>
<tr><td>Evidence from other sources used to demonstrate method of</td><td>Y</td></tr>
</table>

[3] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

	CINAHL; PEDro **<u>Article grading</u>** Graded from criteria adapted from the Centre for Evidence-based medicine (CEBM) for diagnostic, prospective and therapeutic studies. In 3 teams of 2 each reviewer independently assigned a level of evidence and evaluated the quality of each article using a critical appraisal tool.	**III-Assembly line workers**: In this case control study, risk factors for plantar fasciitis included time spent standing on hard surface, time walking, number of times jumping in and out of vehicles and 4 – 7 years of factory work. Shoe rotation found to reduce risk of PF **IV-Biomechanics**: High-arch foot type and decreased ankle dorsiflexion range of motion. Positive association between hamstring tightness, leg-length discrepancy (with pain in the longer limb) and PF **IV-intrinsic muscle strength**: May be associated with development of heel pain / plantar fasciitis. **Author conclusions** <u>*Grade B recommendation*</u>: (Moderate evidence - a preponderance of level II studies supporting the recommendation) Clinicians should assess the presence of limited ankle dorsiflexion range of motion, high body mass index in nonathletic individuals, *running and work-related, weight-bearing activities – particularly under conditions with poor shock absorption* – as risk factors for the development of heel pain / plantar fasciitis.	outcome assessment is valid and reliable		
			Exposure level measured more than once		
			Main confounders identified and taken into account	N	
			Confidence intervals provided	N	
			Are results directly applicable to ACC claims for PF?	Y	

8.6 Systematic reviews

Study	Methodology	Outcomes & results	Paper grading[4]		ACC reviewer comments & evidence level
Waclawski et al, 2015 *Occupational Medicine, 65, pg 97 - 106* **Study design:** Systematic Review **Research question** To systematically review the evidence of the association between weight-bearing (walking or standing) and PF among workers **Funding** Worksafe BC (RS2011 – SR01)	**Number of studies:** N = 4 total 3 were case-control studies (two with clinic populations, 1 with volunteers): Gill et al, 1996 Irving et al, 2007 Riddle et al, 2003 1 was a cross-sectional study of a workforce in an assembly plant: Werner et al, 2010 **Inclusion criteria** Adult workers (> 18 years) with PF/Plantar fasciopathy and included information about weight bearing. Only primary research in English language publications was included. No restrictions on study design or date. **Bias** Examined for 6 potential areas of bias: study participation, study attrition, prognostic factor measurement, outcome measurement, measuring and accounting for confounding and appropriateness of statistical analysis **Confounding variables analysed for** Age, sex, certain types of exercise, faulty	**Results** Included n = 4 studies, discussed in narrative form **Gill et al, 1996. OR (95% CI), Bivariate analysis** Cohort: Clinic population (n = 411, and 400 controls). 47.5 years mean for cases Weigh >200 pounds: OR 1.4 (1.02, 1.91) Majority time on feet: OR 1.45 (1.1, 1.9) Walks on hard floor most of time: OR1.58 (1.2, 2.1) Female: OR 1.17 (0.89, 1.55) **Irving et al, 2007, multivariate analysis** Cohort: Volunteer population (80 cases, 80 controls), 52.3 years cases/51.9yrs controls Foot pronation: OR 3.7 (1.6, 8.7) BMI ≥ 30: OR 2.9 (1.4, 6.1) Excessive ankle dorsiflexion: OR 2.0 (0.9, 4.4) No association with time spent standing, sitting, walking on uneven ground, squatting, climbing or lifting **Riddle et al, 2003, multivariate analysis** Cohort: Clinic population, 50 cases / 100 controls, 49yr, 50yr Limited dorsiflexion: OR 23.3 (4.3, 134.4) BMI ≥ 30: OR 5.6 (1.9, 16.6) On feet majority of work day: 3.6 (1.3, 10.1) Recreational joggers (47% or cases, 24% controls): OR 2.8 (0.4, 22.7)	Clearly defined research question?	Y	**SIGN evidence level** **1-** *high quality analysis of low – moderate studies* **Reviewer comments:** Good quality pragmatic assessment of moderate to low quality studies (low quality data was why this SR is graded 1-). Review authors identified potential confounders (studies not including information on age, sex obesity and foot mechanics) that could affect overall results.
			Two people selected studies and extract data	Y	
			Comprehensive literature search carried out	Y	
			Authors clearly state how limited review by publication type	Y	
			Included and excluded studies listed	N	
			Characteristics of included studies are provided	Y	
			Scientific quality of included studies assessed and documented	y	
			Likelihood of publication bias assessed	Y	
			Conflicts of interest declared	y	
			Are results of study directly applicable to patient group targeted by guideline?	y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	

[4] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

	foot mechanics, obesity, improper shoes and medical conditions or cormorbidities **Comprehensive Literature search:** Databases from inception to May 2012: MEDLINE, MEDLINE In-Process, Cochrane Central Register / Database of SRs, EMBASE and HealthStar, CINAHL, Plus, Academic Search Complete, SocINDEX, ProQuest dissertations. **Assessment of methodological quality:** Risk of bias was assessed using guidelines proposed by Hayden et al 2006 (*Annals of Internal Medicine, 144, 427-437)*, and developed by the NIH and Clinical Excellence. It examined six potential areas of bias: study participation, study attrition, measuring and accounting for confounding, and appropriateness of statistical analysis. **Data extraction:** Extracted by one reviewer using a standardised form, this was peer-reviewed by another review for accuracy and completeness. Data extracted: - Participant characteristics - How PF diagnosed, duration - Potential confounders (age, sex, BMI, # exercise, foot mechanics, footwear, other medical conditions or comorbidities) - Weight-bearing information	**Werner et al, 2010 Logistic regression** Cohort: Assembly plant workforce, 32 cases, 375 control, PF 48.6yrs ***Prevalent PF*** *Female*: OR 3.4 (1.3, 8.8) *Shoe rotation:* OR 0.3 (0.1, 0.7) *Forefoot pronation:* OR 4.2 (1.7, 10.1) *Entrance/exit in truck*: OR1.2 (1.1, 1.3) *Time walking (10% increase):* OR 1.5 (1.1, 2.1) *Time standing on hard surface* (10% incr): OR 1.3 (1.1, 1.6) *High metatarsal pressure:* OR 2.7 (1.1, 6.6) *Job tenure (4 – 7 yrs),* OR 4.9 (1.1, 21.8) *Age (incr in decade:* OR 1.2 (0.6, 2.3) *BMI:* OR 1.0 (0.97, 1.10) ***New PF*** *Female*: OR 1.5 (0.5, 4.5) *Shoe rotation:* OR 0.3 (0.11, 0.98) *Forefoot pronation:* OR 5.4 (1.9, 15.7) *Entrance/exit in truck*: OR 1.2 (1.02, 1.32) *Time walking (10% increase):* OR 1.5 (1.1, 1.2) *Time standing on hard surface* (10% incr): OR 3.9 (1.4, 10.9) *Job tenure (4 – 7 yrs):*OR 8.3 (1.05, 65.5) *Age (incr in decade:* OR 1.6 (0.7, 3.4) *BMI:* OR 1.0 (0.9, 1.1) *Job dissatisfaction:* OR 1.3 (1.05, 1.7) **Summary for causal association for PF:** *Prevalent PF* Obesity: moderate quality of evidence Female: insufficient evidence Age: Unclear Foot biomechanics: Low Weight bearing: Low Job factors: insufficient *New PF* Insufficient quality of evidence for obesity, female, and age	Exposure level measured more than once	CS	
				Y	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for PF?	Y	

		Author conclusions Low quality evidence of an association between PF and weight-bearing tasks such as walking and standing on hard surfaces. The occupations identified as higher risk were those associated with the engine assembly plant. The weak study designs and poor methodological quality limit the conclusions that can be made.			

Study	Methodology	Outcomes & results	Paper grading[5]		ACC reviewer comments & evidence level
Franscheschi et al, 2014 *International Journal of Endocrinology, Article ID: 670262* **Study design:** Systematic Review **Research question** *To review the literature to clarify whether obesity is a risk factor for the onset of tendonopathy*.	***Results for Chronic Plantar fascia Heel Pain discussed only*** **Number of studies for CPHP**: N = 15, Of these N = 4 for a diagnosis of plantar fasciitis **Inclusion criteria** Clinical studies investigating association between obesity and one or more types of tendinopathy being investigated for study. No restrictions on study design, or publication date. English, Spanish, French and Italian articles accepted subject to author skill. Obesity defined by: BMI (Using WHO criteria), waist circumference or waist-to-	**Results** N = 4 for CPHP N = 2 were frequency matched case controls N = 1 was retrospective case-control N = 1 was Cross-sectional in design Riddle et al, 2003 50 PF patients matched with 100 controls. *Associations with PF:* Participants with BMI >30: OR 5.6 (1.9 – 16.6) than those with BMI ≤ 25 Taunton et al, 2002	Clearly defined research question?	Y	**SIGN evidence level** **1-** **ACC Reviewer comments:** Studies were graded based on study design, but no statements were made regarding the quality of individual studies, potential biases within these studies, otherwise this is a well-structured review.
			Two people selected studies and extract data	Y	
			Comprehensive literature search carried out	Y	
			Authors clearly state how limited review by publication type	Y	
			Included and excluded studies listed	N	
			Characteristics of included studies are provided	Y	
			Scientific quality of included studies assessed and documented	N	

[5] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

Funding Not stated, although authors declared no conflicts of interest.	hip ratio. **<u>Exclusion criteria</u>** Biomechanical studies, case reports, literature reviews, technical notes and instructional courses were excluded. Subjects <18 years. **<u>Databases</u>** MeSH and Keyword search strategy, and hand search of references from relevant papers PubMed, EMBASE, The Cochrane Library **<u>Data extraction</u>** Demographic data, diagnosis design, objective means and findings for statistical association between weight and tendinopathy were independently extracted by all investigators.	Running related injuries. Reported females (>60kg) associated with PF: OR 0.378 (0.203 – 0.706) <u>Frey and Zamora et al, 2007</u> 80 patients vs 80 controls Obesity and foot pronation as independent and modifiable risk factors for CPHP However unable to distinguish causality. Ie was PF from decrease in activity leading to obesity and thus PF, OR was obesity pre-existing leading to PF? <u>Irving et al, 2007</u> Increased incidence of BMI>25 leading to CPHP, however not significant **Author conclusions** The best available evidence indicates obesity as a risk factor for tendinopathy, in particular plantar fasciopathy in which the increased weight creates an increased load for the tendons, stressing these structures. Further studies are needed to establish the real strength of the association for each type of tendinopathy as the design of published studies do not allow identification of a precise cause-effect relationship and specific role of obesity independent of other conditions.	Likelihood of publication bias assessed	c/s	Primary aim is to assess for association of obesity with PF which could lie outside of the scope for ACC claims. Confounders like metabolic issues, exercise etc not taken into account
			Conflicts of interest declared	Y	
			Are results of study directly applicable to patient group targeted by guideline?	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	c/s	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for PF?	c/s	

Study	Methodology	Outcomes & results	Paper grading[6]		ACC reviewer comments & evidence level
van Leeuwen et al, 2015 *British Journal of Sports Medicine, O, pg 1 - 12* Study design: Systematic Review with meta-analyses Purpose To systematically review all factors associated with PF, as described in prospective, case-control and cross-sectional studies Funding Dutch Arthritis Foundation	Included studies N = 51 primary studies 1 prospective, 46 case-control and 4 cross-sectional Studies up to June 2014 included Inclusion criteria Prospective, case-control and cross-sectional studies in English, German and Dutch. *As case-control and cross sectional studies do not provide information regarding causality they were analysed separately from the prospective study that can determine causality associated with PF* No limitation on age, gender and setting. PF description had to include: Heel pain, tenderness/pain at rest during exercise of palpation in inferior heel or insertion of plantar fascia on calcaneus. Pain in first few steps in the morning. All synonyms for plantar fasciopathy Exclusion criteria Heel pain other than plantar aspect of heel, other foot pathologies, or studies that included participants with systemic diseases. Conference abstracts, outcome not PF, no control group. Databases	**Main findings** Risk factors associated with PF: This was taken from one prospective cohort study (DiCaprio et al, 2010) given a lower percentage (44 out of 100%) based on their assessment criteria. Study found six variables significantly associated with higher risk of PF: Varus knee alignment: OR 5.63 (95% CI 2.01 – 15.72) Spiked athletic shoes: OR 5.49 (1.71 – 17.64) Cavus arch posture: OR 5.52 (2.12 – 14.33) Greater number of days practice per week: OR 2.59 (1.68 – 3.99) Greater number of years of activity: MD 3.30 (1.01 – 5.59) Running more kms per week (MD 20.00 (12.12 – 27.88). Factors associated with PF *(nb. This is not causation)*: BMI: A positive association between PF and significantly higher BMI: pooled MD 2.3kg/m^2 (95%CI 1.3 – 3.2) n = 21 studies BMI>27: Pooled OR: 3.7 (95% CI 2.9 – 5.6) n = 2 studies Flexibility Two studies showed less flexibility (contractures of hamstrings, or smaller straight leg elevation) in people with PF	Clearly defined research question?	Y	SIGN evidence level 1+ ACC Reviewer comments: High quality SR and meta-analysis of primary studies. Other SRs have been referenced, but are not included in the analyses. Risk factors come from only one Prospective cohort study that has been included in other SRs and in the guideline. *Other factors associated with PF do not determine causality and so cannot be used as risk factors.*

[6] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

	PubJed(MEDLINE), EMBASE, Web of Science (WoS), MEDLINE (OVID) and the Cochrane Central Register up to 4 June 2014 <u>Article grading</u> Graded from criteria created based on those reported in the Dutch Cochrane centre, van Rijn et al, and Lankhorst et al. Nine criteria were determined as positive, negative or unclear. Criteria included study population, study design. Assessment of determinant and outcome and analysis and data presentation.	Variable results for ankle ROM from six different studies. Some studies show decreased dorsiflexion, others found no difference in a non-athletic population. First MTP ROM: out of three studies, only one reported a significantly smaller ROM in the PF group. <u>Posture and alignment</u> In non-athletic groups a positive association was found for a more pronated foot posture, lower sagittal plane calcaneal pits on x-ray and reduced sagittal arch angle change between weight bearing and non-weight bearing. <u>Imaging</u> N = 21 studies described an association between plantar fascia thickness and PF, nine of these matched for confounders (age, gender and body weight). Measured with MRI, US and x-ray. Pooled data from all imaging techniques showed: PF on average had a thicker plantar fascia to controls: Average 2.32mm (95% CI 1.86 – 2.79). There was variability in these measures based on how thickness was measured by heel, or by participant. <u>Heel pad</u> N = 9 studies. Pooled data showed that loaded and unloaded thickness was greater in PF vs controls <u>Calcaneus</u> Spurs examined in 11 studies, six of these matched for age and gender. CS significantly more common in patients with PF than controls. Metabolic bone activity higher in patient with PF than controls (n = 2 studies). Larger effect size seen for older compared to younger participants. <u>Activity levels</u> Standing time (n = 4 studies) Increased occupational standing time on hard surfaces: OR1.3 (95%CI 1.1 – 1.6)			

		Spent majority of workday on feet OR 3.6 (1.3 – 10.1) Mixed findings for recreational and competitive athletic activity. <u>Footwear</u> Shoe rotation negatively associated with PF (OR 0.3, (95% CI 0.1 – 0.7). <u>Author conclusions</u> Consistent clinical association between higher BMI and plantar fasciopathy. Association may differ between athletic and non-athletic subgroups. There is consistent evidence to support bone a range of bone and soft tissue abnormalities, but there is a lack of evidence for clinical and mechanical measures of foot and ankle function. Funnel plots for BMI and PFT but not calcaneal spur are suggestive of publication bias. However effect sizes are similar			

8.7 Observational Cohort Studies

Study	Methodology	Outcomes & results	Paper grading[7]		ACC reviewer comments & evidence level
Owens et al, 2013[11] Orthopaedic Journal of Sports Medicine, 1(1), 1 – 8	**Participants** 80,106 active duty army personnel were enrolled over three waves (2001, 2004, 2007) that recently deployed to operations. They were	1228 participants had plantar fasciitis within 1 year of baseline Recent deployment significantly associated with higher odds of PF (OR 1.27; 95 CI 1.04 – 1.56)	Appropriate and focused question?	Y	**Appears that PF is significantly related to military deployment. One finding relevant to the ACC cohort is that there was a high association of**
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	NA	

[7] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

Study design: Prospective cohort using data from the Millennium Cohort Study **Research question:** To identify risk factors for the development of lower extremity tendinopathy and plantar fasciitis in US military personnel **Funding** Not stated	followed for 1 year Demographic, military health, lifestyle and behavioural info, BMI and alcohol consumption were collected using the Millennium Cohort Questionnaire. DOB, gender, race, education military occupation and other admin were collected by the Defense Manpower Data Centre Electronic medical record data were obtained from Military Health Service Data Repository. **Diagnosis** Determined by ICD codes	*Also:* **Gender**: Female OR 1.85 95%CI 1.62 – 2.12 **Obese individuals:**1.95 (1.61 – 2.36) **Overweight:** 1.62 (1.42 – 1.86) *Specific job categories:* **Electronic equipment repair:** 1.56 (1.24 – 1.97) **Healthcare:** 1.55 (1.24 – 1.94) **Admin, functional support**: 1.30(1.06-1.61) **Equipment repair:** (1.26 (1.01-1.58) **Craft work:** 1.48 (1.10 – 2.18) **Service and Supply:** 1.36 (1.07 – 1.73) **Participants with a history of tendinopathy or fracture:** 4.79 (4.25 – 5.41) Sensitivity analyses (where prior injury removed from models) were consistent with main model. **Author conclusion** Lower extremity tendinopathies and plantar fasciitis are common among military service members, and this study identified several modifiable risk factors for their occurrence. These potential risk factors could serve as the focus for future preventive and intervention studies	Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	NA	**PF in participants with a history of tendinopathy or fracture, however the details of previous injuries were not included so details of this association are not known.** **Limitations to this study are that the PF diagnosed was related to deployment, as there was no observed association, just linking of data. Analyses were restricted to those that were severe enough to warrant medical treatment, so may be underestimating the real effect.** **Results are not statistically adjusted for multiple comparisons** **Level of evidence: 2+**
			% of individuals or clusters recruited dropped out	NA	
			Comparison made between full participants and those lost to follow-up	NA	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	NA	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	CS	
			Exposure level measured more than once	CS	
			Main confounders identified and taken into account	Y	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for PF?	Y	

Study	Methodology	Outcomes & results	Paper grading[8]		ACC reviewer comments & evidence level
Klein et al, 2013 [1010] Foot and Ankle International, 33(9), 693 – 698 **Study design:** Retrospective observational analysis **Research question:** To explore the relationship between duration of symptoms in plantar fasciitis patients and demographic factors, intensity and location of pain, extent of previous treatment and self-reported pain and function **Funding** None stated	N=182 (36 excluded) patient seen by orthopaedic foot and ankle surgeons between July 2008 and October 2010 N= 124 female, 58 male N=39 had bilateral symptoms *Diagnosis:* ICD-9 code, primary diagnosis included Acute: Symptoms <6 months Chronic: Symptoms >6 months *Exclusion criteria* Diagnosis not PF from chart, pain not primary condition for clinic visit, had plantar fascia rupture diagnosis, neurogenic cause of heel pain Clinical variables extracted from chart. VAS scores collected upon initial visit as was functional performance score (FAAM)	There were no differences in demographics between the chronic and acute PF groups. People with chronic symptoms are more likely to seek multiple providers for treatment **Author conclusion:** PF symptoms extend beyond 6 months patients do not experience increasing pain intensity or functional limitation. No specific risk factors have been identified to indicate a risk of developing chronic symptoms.	Appropriate and focused question?	Y	**Retrospective analyses of chronic vs acute plantar fasciitis taken from a cohort of patients identified as having PF through ICD-9 codes.** **No association calculations made** **No statistical comparisons made between PF and non-PF** **This study shows demographically there is little difference between chronic and acute PF, however no comparisons are made with non-PF participants.** **Data all extracted from patient charts collected retrospectively** **Grade:2-**
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	Y	
			% of individuals or clusters recruited dropped out	NA	
			Comparison made between full participants and those lost to follow-up	NA	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	Y	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	CS	
			Main confounders identified and taken into account	Y	

[8] Y = yes, N = no, NA = not applicable, ? = can't say (information is missing or unclear)

Table 1: Patient Demographics

	Total (n = 182)	Acute (<6 months) (n = 92)	Chronic (≥6 months) (n = 90)
		Mean (SD)	
Age	48.9 (12.0)	49.1 (11.9)	48.7 (12.1)
BMI (8 missing)	29.1 (6.2)	28.9 (6.2)	29.3 (6.2)
Duration of symptoms (months)	14.1 (23.1)	3.1 (1.8)	25.7 (28.8)
		N (%)	
Gender			
Female	124 (68.1%)	57 (61.3%)	67 (75.3%)
Male	58 (31.9%)	36 (38.7%)	22 (24.7%)
Unilateral symptoms			
Right	66 (36.3%)	43 (46.2%)	23 (25.8%)
Left	77 (42.3%)	38 (40.9%)	39 (43.8%)
Bilateral symptoms	39 (21.4%)	12 (12.9%)	27 (30.3%)
Comorbidities			
Diabetes mellitus	13 (7.1%)	6 (6.5%)	7 (7.9%)
Heart disease	12 (6.6%)	5 (5.4%)	7 (7.9%)
Inflammatory arthropathy	5 (2.7%)	1 (1.1%)	4 (4.5%)
Tobacco use current (4 missing)	10 (5.5 %)	7 (7.8%)	3 (3.4%)
Tobacco use ever (4 missing)	51 (28.0%)	32 (34.4%)	19 (21.3%)

Confidence intervals provided	N	
Are results directly applicable to ACC claims for PF?	CS	