Causation and risk factors of Achilles Tendinopathy

Evidence-based review

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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 Achilles tendinopathy 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 June 2015.*

Revision History

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Abbreviations

ACC	Accident Compensation Corporation
AT	Achilles tendinopathy
BMI	Body Mass Index
CTS	Carpal tunnel syndrome
DF	Dorsiflexion
HRT	Hormone replacement therapy
NWB	Non-weight bearing
OR	Odds ratio
RCD	Rotator Cuff Disease
ROM	Range of motion
SD	Standard deviation
SMD	Standardised mean difference
WHR	Waist to hip ratio
WC	Waist circumference

1 Executive Summary

1.1 Background

Achilles tendinopathy is commonly referred to as an overuse injury to the tendon which includes symptoms of pain and swelling in and around the Achilles tendon, and limitation in function. Patients may report intermittent pain at the beginning and end of exercising, or after a long period of sitting or sleeping and as the condition progresses pain may continue for the duration of exercising and interfere with activities of daily living. A large cross-sectional study of patients enrolled in Dutch GP practices[5] reported an overall incidence of midportion Achilles tendinopathy of 1.85 per thousand registered patients. The incidence rate for adults aged 21 – 60 years was 2.35 per 1000 patients.

The aetiology and risk factors for Achilles tendinopathy remain uncertain[4]. The ACC32 team requested an evidence-based report summarizing the best available research around risk factors for Achilles tendinopathy. This report summarises and critiques the quality of the evidence for risk factors for Achilles tendinopathy, and will be used to develop resources for medical advisors within ACC to support decision-making for cases of Achilles tendinopathy.

1.2 Methodology

A systematic search was conducted of Ovid Medline, Embase and Google Scholar by two EBH researchers up to 25 May 2015. Systematic reviews, prospective and retrospective cohort studies, case-control studies and cross-sectional studies which investigated risk factors for Achilles tendinopathy were included. Studies which investigated risk factors for Achilles tendon ruptures were excluded. 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 were summarized in evidence tables.

1.3 Main results

Four systematic reviews and ten additional primary studies were included in the current report. Studies were of low to moderate quality and systematic reviews were limited by a lack of high quality primary research, the two main themes being obesity and lower limb biomechanical factors. Studies examining biomechanical features of Achilles tendinopathy varied widely in the risk factors they examined and the way they were measured. There was a consistent relationship between increased body mass index (BMI) and Achilles tendinopathy, with a BMI of 25 or more associated with a moderately increased risk of developing Achilles tendinopathy. There was some evidence that a previous diagnosis of tendinopathy or fracture was associated with an increased risk of Achilles tendinopathy but more studies are needed to confirm this relationship. Other risk factors such as previous injury, age, gender and work characteristics have had less focus.

The main risk factors and quality of evidence are summarised in the table below.

Risk factors described for Achilles tendinopathy and summary of the quality of reported evidence

Risk Factor	Main findings
Previous injury	- A large prospective cohort study reported significantly increased odds of developing Achilles tendinopathy in people who had a previous tendinopathy or fracture diagnosis (OR 3.87, 95% CI 3.16 – 4.75) (Owens et al 2013) - A lower quality study of patient records reported increased odds of Achilles tendinopathy in people with a history of rotator cuff disease (Titchener et al 2014). A case-control study found no significant association between injury history and Achilles tendinopathy (Taunton et al 2002). - Most of the primary studies excluded participants who had a previous history of Achilles tendinopathy or Achilles tendon rupture
Body Mass Index	- Significant associations found for Achilles tendinopathy in people who were overweight or obese compared to normal weight, (SR: Fransceschi et al, 2014; Primary studies: Owens et al, 2013) - Significant associations between Achilles tendinopathy and measures of adiposity (BMI, waist to hip ratio, waist circumference, adipose tissue volumes) . (SR: Gaida et al 2009)

	- Greater likelihood of Achilles tendinopathy in people who are overweight (BMI>25) and obese (BMI>30) (SR: Fransceschi et al, 2014; Primary studies: Owens et al, 2013)
Age	- Mixed findings. Some evidence of an increased risk of Achilles tendinopathy in people older than 30 years from one large prospective cohort study (Owens et al 2013), but two other primary studies reported no association with age (Longo et al 2006; Van Ginckel et al 2009)
Gender	- Included studies reported no significant difference in risk of Achilles tendinopathy for men and women (Primary studies: Owens et al 2013; Longo et al 2006) - Most of the included studies were unable to examine gender as a risk factor because of their study design
Employment sectors	One large, prospective cohort study set in a military cohort reported no significant association between specific roles and Achilles tendinopathy (moderate quality; Owens et al, 2013). Examined roles included: - Electronic equipment repair - Communications/Intelligence - Healthcare - Administration, functional support - Technical and allied specialists - Equipment repair - Craft work - Service and supply
Lower limb biomechanics	There was high variability in how foot dynamics and range of motion were assessed across different studies. - Two moderate quality systematic reviews reported very limited evidence that some biomechanical factors are associated with Achilles tendinopathy (SR: Dowling et al 2014; Munteanu and Barton 2011) - One low quality primary study reported a significantly greater likelihood of developing Achilles tendinopathy in novice runners whose gait showed more laterally-directed force and decreased displacement of the centre of force (van Ginckel et al 2009) - One low quality cohort study reported reduced ankle plantar flexor strength in military cadets who developed Achilles tendinopathy (Mahieu et al 2011) - One low quality cohort study reported a significant association between Achilles tendinopathy and decreased peak ankle dorsiflexion (Rabin et al 2014) - One low quality study reported a significant association between Achilles tendinopathy and decreased knee flexion (Azevedo et al 2009)

1.4   Conclusions

Overall the current report lends support to the body of evidence that the development of Achilles tendinopathy is multifactorial and may involve a variety of intrinsic and extrinsic factors. The evidence indicates that the occurrence of Achilles tendinopathy is higher in people who are overweight or obese and that there is some indication the relationship may be causal. There is also some evidence that biomechanical factors, such as decreased knee range of motion, decreased ankle dorsiflexion range of motion and a more laterally directed force distribution under the forefoot are related to the development of Achilles tendinopathy. There is some evidence that a previous diagnosis of tendinopathy or fracture is associated with a higher likelihood of having Achilles tendinopathy but further studies are needed to confirm this finding.

The main limitations of the evidence base are a lack of high quality studies and a focus on highly selected populations, for example, professional athletes, patients receiving treatment for Achilles tendon problems, military personnel, which limit the applicability of findings to the general population. There was little consistency in the biomechanical variables assessed or how data was gathered, contributing to an overall lack of consistency in findings.

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2   Background

2.1   Description of Achilles tendinopathy

The Achilles tendon connects muscles of the lower leg – the soleus, plantaris and gastrocnemius – to the heel bone (calcaneus). It is the thickest and strongest tendon in the human body[11] and is able to tolerate high tensional forces.

Achilles tendinopathy describes a pathological change to the tendon and includes symptoms of pain and swelling in and around the Achilles tendon, and limitation in function. It is sometimes referred to as a tendonitis (implying the presence of inflammation) or tendinosis (implying the presence of degeneration).   However, histological and imaging studies have shown that the presence of degeneration or inflammation is not necessarily associated with clinical symptoms, leading to the more widely accepted current terminology of Achilles tendinopathy[17].

Achilles tendinopathy is commonly classified as being either noninsertional or insertional[31,32].   Noninsertional tendinopathy, also known as midportion tendinopathy, occurs 2 - 6cm above the insertion of the tendon to the calcaneus, and accounts for 55-66% of Achilles disorders[31]. Insertional tendinopathy occurs at the point where the tendon inserts to the calcaneus.

2.2   Clinical presentation and diagnosis

Achilles tendinopathy commonly presents as a clinical triad of pain, limitation in activities, and focal swelling[4,17]. Patients may report intermittent pain at the beginning and end of exercising, or after a long period of sitting or sleeping. As the condition progresses, pain may continue for the duration of exercising and interfere with activities of daily living[17].

A diagnosis of Achilles tendinopathy usually involves an assessment of the history of the current condition and clinical examination. Symptoms may include:

- Gradual progressive pain over the posterior lower leg
- Early morning pain and stiffness or after prolonged immobility
- History of swelling over the Achilles tendon area at the midportion of the tendon
- Tenderness to palpation, for non-insertional tendinopathy 2-6cm above the tendon insertion, and for insertional tendinopathy at the point of insertion with the calcaneus
- Tendon swollen and oedematous
- Tender, nodular swelling present in chronic cases and is believed to signify tendinosis
- Movement of the nodular area with plantar dorsiflexion (positive shift test)

2.3   Epidemiology

A large cross-sectional study of patients enrolled in Dutch GP practices[5] reported an overall incidence of midportion Achilles tendinopathy of 1.85 per thousand registered patients. The incidence rate for adults aged 21 – 60 years was 2.35 per 1000 patients, with a mean age at diagnosis of 43.4 years (range 7 – 85 years). The incidence rate amongst athletes is reported to be much higher, especially for sports involving actions with high tendon loading such as running and jumping. Studies focusing on athletes, mainly long-distance runners, have reported annual incidence rates of 7-9%, with a lifetime risk of approximately 50%[9,11]. In the Dutch study however, only 35% of cases were associated with a sporting activity, however this was based on patient report[5].

The international literature suggests there has been an increase in Achilles tendon injuries in the past two decades[11,17]. A local study confirmed an increase in the incidence of Achilles tendon ruptures in New Zealand between 1998 and 2003, rising from 4.7/100000 to 10.3/100000[26] but comparable data regarding Achilles tendinopathy rates in New Zealand have not been published to date.

2.4 Mechanism of injury

The mechanism by which tendinopathy develops is not fully known but it is commonly described as the result of a failed healing response[4,27], where the tendon's normal repair process is disrupted. The two underlying physiological processes thought to contribute to this response are the biomechanical, where repetitive loading causes microtrauma that disrupts the arrangement of collagen fibres[12,27]; and biochemical where chemical signals for pain signaling and vessel formation are changed [27,29].

Biomechanical changes underlying tendinopathy occur when the tendon repairs itself in a haphazard way[4,17]. In a healthy tendon collagen fibers, which give the tendon tensile strength, are arranged in densely-packed, parallel bundles. In tendinopathy the collagen fibers appear disorganized and lose their parallel structure[12,27]. This causes a weakness in the tendon's structure, decreasing its ability to cope with further loads.

Biochemical changes involve changes in biochemical signaling which effect pain signaling and neovascularization, the formation of new blood vessels into the injured area of the tendon, leading to further weakness and pain[1,4]. Interestingly the areas of the tendon that have a poorer vascular supply are thought to be more vulnerable to further injury and disorganized healing. The significance of this during the healing response in the Achilles tendon is not fully known, but it is used as a hypothesis to explain why particular parts of the Achilles (i.e. midportion) are more vulnerable to injury[22].

2.5 Intrinsic/extrinsic risk factors

The origin of Achilles tendinopathy is seen as multifactorial, and is postulated to be the result of a combination of extrinsic (outside the body) and intrinsic (within the body) factors[17]. Proposed intrinsic risk factors include biomechanical features, such as excessive pronation of the foot, limited range of motion of the ankle joint, lower limb malalignment, and systemic diseases such as diabetes mellitus and inflammatory joint diseases[11]. The condition is also reported to be associated with age and is more likely to occur in males[11]. In recent years researchers have been working to identify genes which may be associated with a greater susceptibility to developing chronic Achilles tendinopathy[30].

Extrinsic factors include some medications, such as fluoroquinolone antibiotics and estrogen hormone therapy, excessive loading and characteristics of training. Many training factors have been proposed as causative, such as running for too long at too great an intensity, training on hard, slippery or uneven surfaces, running in sand, too much uphill or downhill work and inappropriate footwear[17]. However, these risk factors have been mainly generated from cross-sectional studies or case series and are thus not a robust source of evidence, nor are they able to determine causation[11].

In runners and other athletes the incidence is elevated with studies reporting 7-9% of runners have Achilles tendinopathy, with a lifetime cumulative incidence of 24%[2,19]. Participation in sports activities has also been posited as contributing to the development of Achilles tendinopathy, particularly running, jumping, middle and long-distance running, orienteering, track and field, tennis, badminton, volleyball and soccer[11]. However, it also occurs in the general population among people with low mechanical loading and a recent, large epidemiological study reported only 35% of identified cases were associated with a sporting activity[5].

2.6 Objective of this report

The main purpose of this evidence-based review is to provide the ACC32 team with an overview of the evidence regarding risk factors for Achilles tendinopathy. The report focuses on intrinsic and extrinsic factors which may be relevant to a claim for injury cover by ACC. The associations between Achilles tendinopathy and diabetes mellitus, fluoroquinolone antibiotics, hormone therapy or genetic characteristics are not included in the scope of the current report. This report includes a critique of the quality of included studies which differentiates it from previous ACC reviews on Achilles tendinopathy.

To this end, this report utilizes EBH tools and methodologies to:

- identify best available evidence using standard EBH research methods (described in methods section below) and appraise articles found in peer-reviewed medical journals, guided by the Scottish Intercollegiate Guideline Network (SIGN) criteria (section 3.3 below),
- clearly outline the quality and consistency of evidence for and against the most commonly considered risk factors for Achilles tendinopathy, 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 Achilles tendinopathy.

3   Methods

3.1   Search Strategy

A search was conducted by two EBH researchers within ACC Research using the following databases up to 25 May 2015

- Ovid MEDLINE In-Process & Other Non-Indexed Citations
- Ovid MEDLINE <1946 to Present>,
- Google scholar

Full search strategies are presented in Appendix A.

3.2   Inclusion and Exclusion Criteria

3.2.1   Inclusion Criteria

- *Study design*: Systematic reviews, prospective and retrospective cohort studies, cross-sectional studies, case control published from January 2000 – May 2015
- *Types of participant:* People diagnosed with Achilles tendinopathy
- *Types of comparison:* People without Achilles tendinopathy
- *Types of outcome measures:* Rates of Achilles tendinopathy in those exposed to risk factors and those not. Risk factors including BMI and other measures of overweight, biomechanical data, training characteristics, previous injury, gender and age.

3.2.2   Exclusion Criteria

- Case series and grey (non-peer reviewed) literature, literature review
- Articles that did not provide a description of the method of diagnosis of Achilles tendinopathy
- Studies that did not investigate one or more risk factors for Achilles tendinopathy, including studies only reporting treatment or epidemiology
- Studies where it was not possible to extract the findings for Achilles tendinopathy e.g. in studies of risk factors for many types of tendinopathy
- Studies examining risk factors for rupture of the Achilles tendon
- Animal or laboratory study
- Non-English studies

Primary studies which were included in one of the systematic reviews of BMI or biomechanical factors were only appraised for quality in the current review if they also reported data for another risk factor, e.g. age, gender, previous injury. This was done to avoid over-reporting the data for BMI and biomechanical factors.

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 (See table 1 below). Evidence tables summarising the methodology and findings of each included study and a brief outline of any limitations are presented in Appendix B.

Table 1. Levels of evidence based on the Scottish Intercollegiate Guideline Network (SIGN) level of evidence system

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
	High quality systematic reviews of case-control or cohort studies
2++	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

4   Results

4.1   Study Overview

Four systematic reviews and nine additional primary studies met the inclusion criteria for this report.   Two systematic reviews focused on BMI as a risk factor for Achilles tendinopathy[7,8] and two focused on biomechanical factors[6,19].   Additional primary studies appraised in the current report were either not included in any of the systematic reviews, or were included but also reported data for risk factors other than BMI or biomechanical factors.   The articles were graded as having low to moderate quality of evidence, and participants were from a range of different cohorts that included military personnel, patients of orthopedic specialists, and novice and professional athletes. Tables 2 and 3 below provide a brief outline of the main findings and participants for included primary and secondary studies.   The evidence provided by these articles was graded as moderate to low based on study design and potential biases within the articles (see evidence tables in Appendix B for more details).

The main findings show that Achilles tendinopathy was positively associated with high BMI, age, previous injury and a variety of biomechanical factors.

Table 2. Overview of primary studies of Achilles tendinopathy included in report

Reference	Study design	Participants	Achilles tendinopathy diagnosis	Main findings	Level of evidence
Owens et al, 2013[20]	Prospective cohort	N = 80,106 active duty army personnel Enrolled over 3 waves (2001, 2004, 2007) Followed up for 1 year	N = 450 cases Determined from ICD code in data obtained from the: - Millennium Cohort Study - Defence manpower data centre - Electronic records from military health service data repository	Positive significant associations with Achilles tendinopathy were found for: - Recent deployment - Age (linear relationship) - High BMI - Prior tendinopathy or fracture - Moderate (7-13 drinks) weekly alcohol intake - Specific job categories	Moderate: 2+
Mahieu et al, 2011[16]	Prospective cohort	N = 69 male officer cadets Recruited from a sample of 191 cadets at the start of basic training	Local tenderness in the region of the tendon on palpation Thickening of the tendon Pain with resisted plantar flexion and passive ankle dorsiflexion Morning stiffness of the tendon	No significant differences in height, weight, BMI, physical activity between those with and without the condition Regression analysis showed increased risk of AT with reduced plantar flexion strength in the calf muscles	Low: 2-
Longo et al 2006[15]	Cross-sectional study	N = 178 athletes competing at a Veterans Championship competition Recruited on an ad hoc basis, participants represented 3.4% of total competitors	VISA-A questionnaire used to assess symptoms followed by examination by orthopaedic surgeon Tenderness on palpation, heat, Thickening of the tendon Nodule crepitation	N = 85 cases of AT No significant differences in age, weight, height, gender and impact profile between those with AT and those without	Low: 2-
Rabin et al 2014[21]	Prospective cohort	N = 70 male participants recruited through the Israeli Defence Force Mean age = 20 yrs N = 5 cases of AT	Pain during physical activity Tenderness on palpation over the tendon 2 - 6cm proximal to insertion with the calcaneal Assessed by orthopaedic surgeons	Range of motion: Limited bent knee ankle dorsiflexion ROM was associated with increased risk of Achilles tendinopathy	Low: 2-

Holmes and Lin 2006[10]	Case-control	Cases N = 82 patients with a diagnosis of AT Controls N = 100 consecutive foot and ankle patients	History of posterior Achilles tendon pain or heel pain aggravated by walking and weight-bearing activities Tenderness with direct palpation of the AT Nodularity within the AT Diagnosis by review of medical records, radiographs and MRI	Achilles tendinopathy significantly associated with the following: For men, being over 45 yrs and obese. For women being 35 – 55 yrs and obese Also an overall increased rate of AT in obese women and women with hypertension	Low: 2-
Kraemer et al 2012[14]	Case-control	Cases N = 161 athletes with chronic Achilles tendinopathy Controls = 89 healthy athletes with no history of AT Recruited through sports clubs and media publicity Groups matched by age, weight, height and gender	Symptoms collected via questionnaire. AT diagnosis: Pain, morning stiffness Tenderness with palpation lasting 3 months or more	Risk factors for AT included: - Family history of AT disorders Lower rate of cardiac disease and smoking in the AT group	Low: 2-
Van Ginckel et al 2009[28]	Prospective cohort	N = 129 injury-free novice runners (19 men, 110 women) Recruited through participation in Start to Run programme Followed for 10 weeks during training period	Participants examined by two researchers Gradual onset of mid-portion pain, tenderness to palpation over the tendon, (morning) stiffness, tenderness and pain on exertion	66/129 were not included in analyses because they had an acute injury, did not complete the programme, or had another overuse injury other than AT Dynamic force measurements made of 8 anatomical zones of the foot Risk factors for AT: More laterally directed force distribution under the forefoot Significantly decreased total displacement of the centre of force No significant differences in BMI, age, weight, height or physical activity score	Low: 2-
Titchener et al, 2014[25]	Case-control	Cases N = 5000 patients with rotator cuff disease (RCD) Controls N = 5000 patients without rotator cuff disease Recruited using very large database of patients at 479 GP practices in the UK THIN study	Diagnoses made using free-text search of medical records and read codes	Rotator cuff disease associated with increased likelihood of having AT. OR = 1.78, 95% CI 1.19 – 2.67) RCD also associated with lateral epicondylitis, trigger finger and CTS	Low: 2-
Taunton et al, 2002[24]	Case-control	Cases N = 96 patients with Achilles tendonitis Controls N = 1906 patients with other injuries Recruited using a database of 2002 patients at a Sports Medicine clinic in British Colombia	Diagnoses made by sports medicine doctors at the clinic – specifics of Achilles tendonitis diagnosis not available in the paper	Achilles tendinopathy significantly associated with older age (34 years or more) in men but not women. OR = 0.355 (95% CI 0.161 – 0.781) No association with BMI or weight	Low: 2-

Table 3. Overview of secondary studies of Achilles tendinopathy included in report

Reference	Study design	Inclusion criteria	Included studies	Main findings	Quality of evidence
Franceschi et al 2014[7]	Systematic review	Clinical studies investigating the relationship between obesity and one or more types of tendinopathy	N = 6 studies of AT 2 cross-sectional 4 case-control	Association between higher BMI and greater likelihood of having Achilles tendinopathy. Suggested obesity is a risk factor for tendinopathy.	Moderate: 2++
Gaida et al 2009[8]	Systematic review	Studies which compared adiposity between individuals with and without tendinopathy	N = 5 studies of AT	4/5 studies reported an association between BMI and Achilles tendinopathy. Suggested adiposity is a risk factor for tendinopathy.	Moderate: 2++
Munteanu and Barton 2011[19]	Systematic review	Prospective cohort and case-control studies which evaluated the association between biomechanical factors and AT	N = 9 studies 2 prospective cohort 7 case-control	No studies reported differences in gait velocity, stride length or frequency Some data indicated that greater eversion ROM of the ankle/rearfoot was associated with AT Some data indicated significant reductions to maximum ankle dorsiflexion in cases of AT Some data indicated associations between the distribution of centre of force and peak force and AT	Moderate: 2++
Dowling et al 2014[6]	Systematic review	Studies examining the relationship between dynamic foot function and lower limb overuse injury	N = 1 study of Achilles tendinopathy Van Ginckel (2009)	Very limited data with small to moderate effect sizes that aspects of dynamic foot function during walking and running, e.g. time to peak force, are risk factors for Achilles tendinopathy	Moderate: 2++

4.2 Overweight and obesity

Two systematic reviews[7,8], and one cohort study[20] investigated the association between BMI or adiposity and Achilles tendinopathy. Overall the studies were of low to moderate quality, and the systematic reviews were limited by a lack of high quality primary studies. However, a fairly consistent association between BMI and Achilles tendinopathy was apparent, with a BMI greater than 25 being associated with a greater likelihood of Achilles tendinopathy in several studies.

Gaida et al (2009)[8] focused on patterns of fat distribution and found that four out of five included studies showed significant associations between measures of adiposity (BMI, waist – hip ratio, waist circumference, adipose tissue volumes) and Achilles tendinopathy. Franceschi et al (2014)[7] reviewed studies investigating the association between BMI and tendinopathy and reported that five out of six studies indicated a positive association between increased BMI and greater likelihood of having Achilles tendinopathy. None of these studies were able to examine whether an increased BMI causes Achilles tendinopathy or is the result of an inability to participate in physical activities because of painful symptoms.

A large, well-conducted prospective cohort study[20] reported moderately increased odds of developing Achilles tendinopathy in military personnel who were classified as obese (BMI ≥ 30) at baseline. The cohort of 80,106 active duty personnel was followed over one year and 450 cases of Achilles tendinopathy developed during that time. Approximately 13.6% of those who went on to develop Achilles tendinopathy were classified as obese at baseline compared with 8.7% of those with no tendon injury over the one year follow-up period (Adjusted OR 1.59, 95% CI 1.16 – 2.04).

Table 4 presents the key findings of case control studies from the two systematic reviews[10,13,24] and the Owens prospective cohort study.

Table 4. Primary studies which examined the association between Achilles tendinopathy and BMI

Reference	BMI classifications	Main findings *(OR, 95% CI)*
Owens et al 2013[20]	Normal weight: 18.5 - 24.9kg/m^2 Overweight: 25.0 – 29.9kg/m^2 Obese: ≥ 30kg/m^2	*Significant positive associations with:* - Under or Normal Weight: Adjusted OR = 1.00 - Overweight: Adjusted OR = 1.29 (95% CI 1.04 – 1.59) - Obesity: Adjusted OR = 1.59 (95% CI 1.16 – 2.17)
Holmes and Lin 2006[10]	Obese: ≥ 30 kg/ m^2 Based on retrospective review of medical charts	*Significantly higher percentage of patients were obese in the group with Achilles tendinopathy compared with control patients with other foot or ankle problems:* - Men aged 45 – 54 yrs (55% v 14%), 65 – 74 years (50% v 0%), 75 years and older (100% v 0%) - Women aged 35 – 44 years (62% v 25%), 45 – 54 years (83% v 47%)
Klein et al 2013[13]	Normal weight: 18.6 - 24.9 kg/m^2 Overweight: 25.0 – 29.9 kg/m^2 Obese: 30.0 – 39.9 kg/m^2 Morbidly obese: >40.0	*Significant positive associations between increased BMI and Achilles tendinopathy:* - Overweight: OR = 2.6 (95% CI 1.88 – 3.61) - Obesity: OR = 3.81 (95% CI 2.58 – 5.63) - Morbid obesity: OR = 6.56 (95% CI 3.18 – 13.55)
Taunton et al 2002[24]	BMI not classified into groups but used in regression analyses as a continuous variable.	*No significant association between BMI and Achilles tendinopathy in runners with Achilles tendonitis versus runners with other injuries* *Mean BMI male participants = 24.0 (SD = 0.91)* *Mean BMI female participants = 21.6 (SD = 1.11)*

4.3   Gender

One prospective cohort[20] and one cross-sectional study[15] examined the association between gender and the risk of Achilles tendinopathy. Despite a higher risk of Achilles tendinopathy for men being reported in several non-systematic reviews, neither of the included studies found a significant difference in the rate of Achilles tendinopathy between men and women. Owens et al (2013)[20] reported equal odds ratios of Achilles tendinopathy for men and women in an active duty military cohort. Longo et al (2006)[15] reported no significant differences in the rate of Achilles tendinopathy between male and female masters' athletes. Of the remaining primary studies included in the current report, gender was unable to be analysed as a risk factor because participants' were matched for gender at the outset or the sample focused on an all-male cohort.

4.4   Age

Three studies compared the occurrence of Achilles tendinopathy in different age groups. Owens et al (2013)[20] identified a linear relationship between age and Achilles tendinopathy in a large, prospective cohort study of military personnel. Participants who were born in the 1980s or later (aged approximately in their 20s during the 1-year follow-up) were at significantly lower odds of developing Achilles tendinopathy compared with those born before 1960. The odds of developing Achilles tendinopathy increased linearly with each decade of birth, however confidence intervals were wide and overlapping, limiting the strength of these findings. The other two studies found no significant difference in the mean age of participants with and without Achilles tendinopathy between professional masters' athletes[15] and novice runners[28]. The remaining primary studies either matched cases and control participants for age, or did not have a spread of ages in their sample and so were unable to report any findings for this risk factor.

Table 5. Studies reporting association between age and Achilles tendinopathy

Reference	Main findings *(OR, (95% CI)*
Owens et al, 2013[20]	- Linear relationship between age at enrolment in the study and development of Achilles tendinopathy (however, note the wide and overlapping confidence intervals) Birth year: - 1980 and later: OR = 0.62 (0.38 – 1.00) - 1970 – 1979: OR = 0.67 (0.43 – 1.04) - 1960 – 1969: OR = 0.80 (0.53 – 1.21) - Before 1960: OR = 1.00
Longo et al, 2006[15]	- No significant differences based on age in a group of professional masters athletes (mean age with AT 55 yrs +/- 11.8 yrs; mean age without AT 52.4 yrs +/- 12.0 yrs)
Van Ginckel, 2009[28]	- No significant differences based on age in a group of novice runners (mean age 39 yrs +/- 10 years)

4.5 Lower limb biomechanics

Two systematic reviews[6,19] reported finding very limited evidence that biomechanical factors were associated with Achilles tendinopathy. Dowling et al (2014)[6] included only one primary study of Achilles tendinopathy (van Ginckel et al 2002) which found differences in the time to peak force and force distribution in novice runners with and without Achilles tendinopathy. Munteanu and Barton (2011)[19] looked more broadly at lower limb biomechanics and included a wider range of studies. Of the nine included studies, four were very low quality with significant flaws. The authors found little consistency in the risk factors identified by different studies. The authors calculated standard effect sizes for each kinematic variable to allow for comparison between studies. Forest plots of the frontal plane kinematics of the rearfoot, kinematics of the tibial segment and ankle, kinematics of the hip and knee joints and dynamic plantar loading variables were used to highlight significant and non-significant associations for each anatomical area. For each group of comparisons, only one or two comparisons were significant with the remainder indicating no difference between cases and controls. For example, for kinematics of the hip and knee joints, one study showed a significantly reduced magnitude of knee flexion between heel strike and midstance[2]. Fourteen other comparisons, including hip angle, knee angle and knee range of motion, were not significantly different between cases and controls.

Different methods of measuring range of motion and foot dynamics were employed across the primary studies, ranging from sophisticated equipment to assess gait and kinematic variables, to the use of simple visual assessments of movement (e.g. the lateral step-down test). Three additional primary studies not included in the systematic reviews reported data for the association between biomechanical variables and Achilles tendinopathy. Mahieu et al (2011)[16] found reduced ankle plantar flexor strength in military cadets who later developed Achilles tendinopathy over the course of their basic training. Rabin et al (2014)[21] examined ankle dorsiflexion range of motion as a risk factor, however only five cases of Achilles tendinopathy were identified in the cohort, limiting the strength of their findings. Van Ginckel et al (2009)[28] used a Footscan pressure plate to measure force-ratios in novice runners. More laterally-directed force and decreased displacement of the centre of force were both associated with greater likelihood of developing Achilles tendinopathy over the course of training in novice runners. No other gait-related factors were significantly different for those who developed Achilles tendinopathy.

Table 6 presents the key findings of high quality primary studies included in the Munteanu and Barton review, and additional primary studies identified for the current report

Table 6. Primary studies which examined the role of lower limb biomechanics in Achilles tendinopathy

Reference	Main findings (OR, (95% CI)
Azevedo et al, 2009[2]	*After controlling for age, height and weight, significant differences between the AT and non-AT participants were found for:* • Knee ROM – decreased knee flexion between heel strike and midstance • Muscle activity – tibialis anterior, rectus femoris, gluteus medius No other significant differences for ankle angles in midstance or at heel strike, hip angles at toe-off or heel strike, hip ROM No significant differences in stride characteristics or walking speed No significant differences in kinetic variables (peak ground reaction force or vertical loading rate)
Van Ginckel et al, 2009[28]	*Significant <u>positive</u> associations for AT:* • Earlier time to peak force in the medial heel and lateral heel • Delayed time to initial contact in the second metatarsal region • Greater peak force and higher absolute force time integral in the fifth metatarsal region • More laterally directed force distribution under the forefoot • Significantly decreased total displacement of the centre of force No other differences in any other intrinsic gait-related factors *Assessed 8 anatomical zones medial heel, lateral heel, metatarsal heads I-V, hallux. Five medio-lateral force ratios were calculated for a series of instances of foot contact and foot rollover.*
Mahieu et al, 2006[16]	*Significant positive associations with:* • Reduced calf muscle plantar flexor strength prior to basic training No significant association with: • Ankle dorsiflexion force measurements • Ankle joint range of motion • Stiffness of the Achilles tendon • Explosive strength measured using the standing broad jump
Rabin et al, 2014[21]	*Significant positive association with:* • Decreased peak ankle dorsiflexion *No significant association with:* • Quality of movement as measured by the Lateral Step-Down test

4.6 Previous injury

Most of the included primary studies excluded participants who had a previous history of tendinopathy or Achilles tendon rupture. Two studies examined the relationship between other tendinopathies or fracture diagnoses and Achilles tendinopathy. Owens et al (2013)[20] reported that a previous diagnosis of tendinopathy or fracture of the "lower extremities" was associated with increased odds of developing Achilles tendinopathy in a cohort of military personnel. Individuals with such a history had an adjusted odds ratio for Achilles tendinopathy of 3.87 (95% CI 3.16 – 4.75) relative to those with no history of tendinopathy or fracture. This relationship was consistent across the three conditions investigated by Owens (Achilles tendinopathy, patellar tendinopathy and plantar fasciitis). In addition a high physical health score, as measured by the Medical Outcomes Short-Form 36 Survey (SF-36) was associated with a decreased odds of developing Achilles tendinopathy (OR 0.69, 95% CI 0.49 – 0.97).

Titchener et al (2014)[25] utilised a large database of patient records (n= 5000 cases and 5000 controls) from 479 general practices in the United Kingdom to examine the comorbidities for rotator cuff disease. The incidence of Achilles tendonitis was 1.5% in those with rotator cuff disease and 0.8% in those without (Adj OR 1.78, 95% CI 1.19 – 2.67). Interestingly, a number of upper limb musculoskeletal conditions were also associated with rotator cuff disease after adjustment for potential confounders, namely, lateral epicondylitis, (Adj OR 1.71, 95% CI 1.39 – 2.1), trigger finger (Adj OR 1.99, 95% CI 1.21 – 3.3), and carpal tunnel syndrome (Adj OR 1.55, 95% CI 1.19 – 2.02).

Table 7. Studies reporting association between previous injury and Achilles tendinopathy

Reference	Main findings *(OR, (95% CI)*
Owens et al, 2013[20]	*Significant positive association with:* Participants with a previous tendinopathy or fracture diagnosis: OR = 3.87 (3.16 – 4.75)
Titchener et al, 2014[25]	*Presence of rotator cuff disease was associated with:* Achilles tendonitis: OR = 1.78 (1.19 – 2.67)
Taunton et al, 2002[24]	*No significant association between injury history and Achilles tendinpathy*

4.7   Specific job factors

One study (Owens et al 2013)[20] examined whether specific job factors within a military cohort were associated with Achilles tendinopathy but found no significant associations. Odds ratios for these roles are reported in Table 8.

A systematic review completed for ACC by a group of researchers at Auckland University of Technology (Boocock et al 2011)[3] also yielded no studies investigating the association between specific job factors and Achilles tendinopathy, but like other sources, reported a higher likelihood of the condition in athletes.

Table 8. Job factors and Achilles tendinopathy

Reference	Main findings *(OR, (95% CI)*
Owens et al, 2013[20]	**Electronic equipment repair:** 1.40 (0.98 – 2.00) **Communications/Intelligence:** 1.41 (0.98 – 2.02) **Healthcare:** 1.10 (0.75 – 1.62) **Other technical and allied specialists:** 0.77 (0.39 – 1.50) **Administration, functional support**: 1.15 (1.83-1.60) **Equipment repair:** 0.80 (0.55 – 1.16) **Craft work:** 1.21 (0.65 – 2.26) **Service and Supply:** 1.35 (0.93 – 1.94) **Students and trainees:** 1.46 (0.86 – 2.47)

5   Discussion

5.1   Nature and quality of the evidence

The overall body of evidence in the current report was of low to moderate quality, due in part to the study designs employed. Four prospective cohort, four case-control and two cross-sectional studies met inclusion criteria. Study participants included novice or experienced runners and other athletes, military recruits and active duty personnel, and patients at foot and ankle clinics. Rates of participation were not provided by the majority of studies. Researchers in the case-control and cross-sectional studies may have been subject to observation bias because they were aware which participants did and did not have Achilles tendinopathy prior to measuring risk factors. Diagnosis of Achilles tendinopathy was generally based on clinical examination by an appropriate specialist and using accepted criteria. Two studies used a retrospective analysis of patient records to identify cases of Achilles tendinopathy[10,25] and may have been more susceptible to inaccurate diagnoses.

Four systematic reviews were included in this report. Three were high quality[6,8,19] and one was rated lower quality because it did not include a critical appraisal of the quality of included studies[7]. Two systematic reviews focussed on the relationship between BMI and Achilles tendinopathy[7,8] and identified a consistent relationship between obesity and the presence of Achilles tendinopathy, although they were unable to examine whether the relationship is causal. The remaining two systematic reviews focussed on biomechanical variables[6,19], and while the reviews themselves were high quality, they were limited by wide variability in the participants and variables assessed. No firm conclusions about the association between specific variables and Achilles tendinopathy were able to be made.

5.2   Summary of findings

Despite limitations in the primary studies, some consistent findings emerged. The most consistent factor associated with Achilles tendinopathy was a high BMI (Table 4). Several studies were able to demonstrate a greater likelihood of developing Achilles tendinopathy in people with a BMI of 25 or more. The odds ratios varied in strength, with the highest quality study suggesting the odds of developing Achilles tendinopathy was approximately 1.6 times greater for obese military personnel than normal weight personnel[20]. The relationship was strongest for a BMI of 30 or more (classified as obese) and there was some low quality evidence indicating this may be more pronounced in people over the age of 35 years[10].

Gender was investigated by two studies, with no significant data indicating gender differences were associated with a likelihood of developing Achilles tendinopathy. Unfortunately gender was controlled for as a confounding variable in many of the primary studies included in this report so the evidence base is limited. Age was, likewise, controlled for in many of the studies in this report but there was some data indicating that Achilles tendinopathy was more likely in people over the age of 30 years. Owens et al (2013)[20] reported on a large cohort of military personnel followed prospectively for one year, and found that those born in 1980 and later (aged roughly in their 20s at the time of assessment) were significantly less likely to develop Achilles tendinopathy.

Lower limb biomechanic variables were investigated by several studies, however there was little consistency in the specific biomechanical variables measured. These variables included force-ratios during the stance phase of gait, measures of calcaneal eversion and range of motion in the knee and ankle joint. Two systematic reviews summarised studies of biomechanical variables and found little consistency in the relationship between biomechanical variables and Achilles tendinopathy. There was limited data to support associations between decreased knee range of motion between heel strike and midstance, more laterally directed force distribution and reduced ankle plantar flexor strength and a higher risk of Achilles tendinopathy. No studies demonstrated significant associations with particular occupational characteristics and Achilles tendinopathy.

Two studies showed significant associations between a previous diagnosis of tendinopathy or fracture and Achilles tendinopathy. A large prospective cohort study (Owens et al, 2013)[20] reported higher odds of developing Achilles tendinopathy in military personnel with a previous history of tendinopathy or fracture. Titchener et al (2014)[25] examined comorbidities for rotator cuff syndrome using a large database of GP patient records and found that Achilles tendinitis and other tendinopathies (e.g. lateral epicondylitis) were associated with a higher likelihood of having rotator cuff syndrome. Unfortunately the remaining studies used a previous history of tendinopathy as an exclusion criterion.

5.3 Comparisons with what is previously reported for risk factors of Achilles tendinopathy

The main finding of a consistent association between obesity and Achilles tendinopathy has been reported previously in the literature. The direction of the relationship and mechanism by which it occurs is still unclear however it does not appear to be solely due to mechanical loading[8]. Various links with vascularization and the consequences of metabolic syndrome have been proposed[7]. The rise in incidence of Achilles tendon problems over the past two decades has been explained as the result of increases in recreational running and cycling[17], but it is possible that the increasing rate of obesity is also partially responsible.

The current report found no significant data indicating a higher incidence of Achilles tendinopathy in men, which does not align with risk factors reported in some non-systematic reviews[11], but does align with a recent, large epidemiological study[5]. In this study similar overall rates of tendinopathy were reported for men (1.8/1000) and women (1.9/1000), but in people aged 41 – 60 years men had a higher incidence of the condition (2.8/1000) than women (2.0/1000). It may be that gender differences become more pronounced in older age groups.

Training factors have often been cited as risk factors for the development of Achilles tendinopathy, but in the current report no studies were identified which examined specific aspects of training. Likewise, biomechanical variables have been the focus of much study. The two systematic reviews and four primary studies included in the current report produced only limited data indicating a relationship between lower limb biomechanics and Achilles tendinopathy.

6   Conclusion

Overall the current report lends support to the body of evidence that the development of Achilles tendinopathy is multifactorial and may involve a combination of intrinsic and extrinsic factors. Data indicates that the occurrence of Achilles tendinopathy is higher in people who are overweight or obese. There is also limited evidence indicating that biomechanical variables, such as decreased knee range of motion, decreased ankle dorsiflexion motion and a more laterally directed force distribution under the forefoot are risk factors in the development of Achilles tendinopathy. Data from two studies indicated that a previous diagnosis of tendinopathy or fracture is associated with a higher likelihood of having Achilles tendinopathy, but further studies are needed to better understand the nature of this relationship.

6.1   Evidence statement

The available evidence on the risk factors that contribute to the causation of Achilles tendinopathy is of low to moderate quality, mainly due to study design. The best data in the current report is derived from prospective cohort studies but the overall evidence base is limited.

It is recommended that ACC review which read codes are used to lodge claims for Achilles tendinopathy. The current use of general foot and ankle sprain codes does not allow for in-depth analysis of the occurrence and costs associated with specific conditions, or the relationship between previous injury and Achilles tendinopathy for ACC clients.

7 References

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8 Appendices

8.1 Appendix A: Search Strategy

All databases were searched 25 May 2015.

Achilles tendinopathy, Medline

1. exp Tendinopathy/et, ge [Etiology, Genetics]

2. exp Tendon Injuries/et, ge [Etiology, Genetics]

3. Achilles Tendon/

4. 3 and (1 or 2)

5. achilles tendon/ and (exp *tendinopathy/ or exp *tendon injuries/)

6. 5 and (causation or etiolog$ or aetiolog$ or et.fs.).af.

7. risk factors/

8. risk factor$.ti.

9. 5 and (7 or 8)

10. 4 or 6 or 9

11. limit 10 to (english language and humans and yr="2000 -Current")

Achilles tendinopathy, Embase

1. exp achilles tendinitis/et [Etiology]

2. exp achilles tendinitis/ and ((causation or etiolog$ or aetiolog$).af. or et.fs.)

3. risk factors/

4. risk factor$.ti.

5. exp achilles tendinitis/ and (3 or 4)

6. 1 or 2 or 5

7. limit 6 to (human and english language and yr="2000 -Current")

8.2 Appendix B: Evidence tables

Systematic Reviews

Study	Methodology	Outcomes & results	Paper Grading		Reviewer comments & evidence level
Dowling et al (2014)[6] Journal of Foot and Ankle Research, 7: 53 - 65 **Study design:** Systematic review **Research Question** To investigate dynamic foot function as a risk factor for lower limb overuse injury	**Search strategy** CINAHL, Embase, Medline, SPORTDiscus searched up to April 2014 Handsearched references of reviews for additional studies Two authors retrieved and selected references for inclusion **Inclusion criteria** Prospective cohort studies Quantitative measurement of foot posture or function at baseline Prospective collection of specific or non-specific lower limb overuse injury data Human participants English language studies **Exclusion criteria** Included studies of dynamic and static foot function and posture, but static factors are reported in a separate review (with no Achilles tendinopathy studies identified)	**Included Studies** N = 80 studies identified N = 12 studies included of which 1 looked at Achilles tendinopathy (Williams et al) Studies quality assessed using Epidemiological Appraisal Instrument Two authors evaluated quality and resolved discrepancies by consensus. 11/12 studies were rated as low quality – main problems were not reporting confounding factors, not reporting on the validity or reliability of outcome measures or whether this was checked, and only reporting positive associations. Means and SDs extracted and standardised mean differences were calculated. SMD effect sizes were categorised as large (>1.2), moderate (0.6 – 1.2) and small (<0.6) RR and 95% CIs were calculated for nominal variables Pooling of data was not possible due to inconsistencies in outcomes measured **Findings:** 1 study of Achilles tendinopathy: Van Ginckel et al (2002) – rated as low quality Novice runners sample N=10 cases and n=53 controls Barefoot self-selected jogging pace Measured plantar loading using Footscan	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are provided Scientific quality of included studies assessed and documented Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings	Y Y Y Y N Y Y Y Y	A well-conducted systematic review which was limited by a lack of high quality studies Very limited evidence from one study that plantar loading may be associated with Achilles tendinopathy **Level of evidence: 2++**

			Paper Grading		
		Reported earlier time to peak force in the lateral heel, less posterior COF displacement/more posterior COF position, greater laterally directed force and delayed time to initial contact in the second metatarsal region	Likelihood of publication bias assessed	N	
		Authors conclusions	Conflicts of interest declared	Y	
		Very limited evidence, with small to moderate effect sizes, that dynamic foot function during walking and running is a risk factor for Achilles tendinopathy and non-specific lower-limb overuse injuries.	Are results of study directly applicable to patient group targeted by guideline?	Y	

Study	Methodology	Outcomes & results	Paper Grading		Reviewer comments & evidence level
Franceschi et al (2014)[7] **Int J Endocrinology,** **Study design:** Systematic review **Research question:** To examine whether obesity is a risk factor for the onset of tendinopathy **Funding**	**Search strategy** PubMed, Cochrane Central, Embase searched to 2013 **Inclusion criteria** English, Spanish, French, Italian language Definition of obesity based on BMI or WC or WHR Participants 18 years and over Clinical studies investigating the association between obesity and one or more types of tendinopathy **Exclusion criteria** Biomechanical studies, case reports, literature reviews, technical notes, instructional courses	**Included studies** N = 383 studies identified of which 368 were excluded N = 6 studies of Achilles tendinopathy: 2 cross-sectional 2 retrospective case-control 2 prognostic case-control **Findings** Frey and Zamora (2007) BMI > 25 associated with higher risk of AT OR 1.9 (95% CI 1.39-2.66) Holmes and Lin (2006) BMI significantly associated with AT Gaida et al (2010) Men with AT had a central fat distribution, women had a peripheral fat distribution	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are	Y Y Y N Y Y	No appraisal of included studies – quality of studies not taken into account in analysis of findings Adequate literature search and extraction of data **Level of evidence: 2++**

	Participants less than 18 years of age	Scott et al (2013) significant difference in BMI between cases (BMI 34.7 +/- 7.5) and controls (BMI 30.6 +/- 7.6)	provided		
		Klein et al (2013) Odds ratio for AT increased linearly with higher BMI. BMI 30 – 35: OR 3.81 (2.57 – 5.63); BMI 35-40: OR 3.77 (2.24 – 6.34); BMI 40+: OR 6.56 (3.18-13.55)	Scientific quality of included studies assessed and documented	N	
		Taunton et al (2002) No association between BMI and AT	Scientific quality of included studies assessed appropriately	N	
		Authors conclusions	Appropriate methods used to combine individual study findings	Y	
		Obesity seems to be a risk factor for tendinopathy, and in particular seems strong for AT. The relationship between BMI and AT is still unclear because many studies do not control for other metabolic diseases, and the cause-effect relationship is still unproven. The mechanism by which obesity effects the tendon has not been well studied either.	Likelihood of publication bias assessed	N	
			Conflicts of interest declared	Y	
			Are results of study directly applicable to patient group targeted by guideline?	Y	

* Used methodological assessment of cross-sectional study checklist devised by van der Windt (2000)

Study	Methodology	Outcomes & results	Paper Grading		Reviewer comments & evidence level
Gaida et al (2009)[8] Arthritis and Rheumatism, 61 (6), 840 - 849 **Study design:**	**Search strategy** Allied and Complimentary Medicine, Biological Abstracts, CINAHL, Embase, Medline, SPORTDiscus, Web of Science Handsearching of included articles	**Included Studies** N = 245 studies identified of which 228 excluded N = 18 studies identified plus 10 further studies included through handsearching reference lists Studies quality assessed – most points deducted for an inadequate description of potential	Clearly defined research question	Y	A well-conducted systematic review of the relationship between overweight and obesity and tendinopathy. Five studies of Achilles tendinopathy were included and showed a relatively consistent
			Two people selected studies and extract data	Y	
			Comprehensive	Y	

Systematic review	Findings	Checklist		Conclusions
Research Question To examine the association between adiposity and tendinopathy	reference lists Searched up to March 2007 Two authors retrieved and selected references for inclusion **Inclusion criteria** Compared adiposity between individuals with and without tendinopathy OR Examined the influence of adiposity on response to treatment Appropriate assessment of adiposity – WHR, WC, BMI, adipose tissue volumes, **Exclusion criteria** CTS excluded Measured adiposity using weight only	confounding variables and assessors not blind to exposure **Findings:** 5 studies of Achilles tendinopathy: Fahlstrom et al (2002) sporting sample – no association Holmes and Lin (2006) patient sample - BMI significantly associated with AT Mahieu et al (2006) military cohort - BMI associated with AT Mokone et al (2005) patient sample – BMI associated with AT (included rupture) Taunton et al (2002) patient sample – BMI associated with AT **Authors conclusions** Individuals with Achilles tendinopathy often have higher adiposity – suggests adiposity is an intrinsic risk factor for Achilles tendinopathy. The mechanism linking the two may be mechanical or systemic.	literature search carried out — **Y** Authors clearly state how limited review by publication type — **Y** Included and excluded studies listed — **Y** Characteristics of included studies are provided — **Y** Scientific quality of included studies assessed and documented — **Y** Scientific quality of included studies assessed appropriately — **Y** Appropriate methods used to combine individual study findings — **N** Likelihood of publication bias assessed — **N** Conflicts of interest declared — **Y** Are results of study directly applicable to patient group targeted by guideline?	relationship between elevated BMI and an increased risk of having Achilles tendinopathy. The authors noted that at the time of their review (2009) there was inadequate evidence to say whether increased BMI *causes* Achilles tendinopathy, or is the result of Achilles tendinopathy. **Level of evidence: 2++**

Study	Methodology	Outcomes & results	Paper Grading		Reviewer comments & evidence level
Munteanu and Barton (2011)[19] Journal of Foot and Ankle Research, 4: 15-30 **Study design:** Systematic review **Research Question:** To examine lower limb biomechanical factors associated with Achilles tendinopathy **Funding:** Prescription Foot Orthotic Laboratory Association	**Search strategy** Medline, Embase, CINAHL, Current Contents, SPORTDiscus searched up to November 2010 **Inclusion criteria** Prospective cohort and case-control studies Studies which evaluated the role of biomechanical factors (temporospatial parameters, lower limb kinematics, dynamic plantar pressures, kinetics, and muscle activity associated with mid-portion AT Participants with midsubstance tendinopathy of the Achilles, Achilles tendonitis, tenosynovitis, tendinosis, **Exclusion criteria** Unpublished studies, case series, non-peer reviewed articles, intervention studies, non-human studies, reviews, letters, opinion articles, non-English Participants with concomitant injury, pain from other structures or failed to localise the pathology in the tendon **Review process** Two authors retrieved and selected references for inclusion Methodological quality of studies	**Included Studies** N = 1575 studies identified in the search of which N=1566 excluded N = 9 studies included 2 prospective cohort and 7 case-control studies Mix of symptomatic and non-symptomatic cases Quality rating ranged from 4 to 15 out of a total of 16 4 studies scored 8/16 or lower Main areas where points were deducted were in reporting of valid and reliable outcome measures, description of participant characteristics, representativeness of the samples, blinding of outcome assessors, case-control matching Means, SD extracted and effect sizes calculated to allow comparison between studies **Findings:** Lower quality studies not included in the findings below, although they were included in the forest plot analyses in the actual review Temporospatial gait characteristics Azevedo et al: No difference in gait velocity, stride length, stride time or stride frequency between cases and controls Ryan et al: No significant difference in gait velocity between groups Lower limb kinematics Frontal plane rearfoot kinematics (3 studies):	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are provided Scientific quality of included studies assessed and documented Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings	Y Y Y Y N Y Y Y Y	High quality systematic review with rigorous inclusion criteria and analysis of data Limited by lack of high quality primary studies – half the studies scored 8/16 or lower on quality assessment All included studies were limited by the measurement of outcome measures – assessors not blinded or not clear whether measures were valid and reliable Some studies had very small sample sizes (n<15 cases) Authors reported many analyses of biomechanical factors but given the low quality of some studies and the small number of comparisons with significant differences, it is hard to identify any real effects. Majority of comparisons were not found to be different between groups. However there were some consistent findings for greater movement excursion of the rearfoot during gait and altered plantar pressures and ground reaction forces for AT cases. No evidence that torsional stress of the tendon was associated with AT. **Level of evidence: 2++**

	assessed using Quality Index Scale (Downs et al 1998) for randomised and non-randomised studies Two authors reviewed each study independently and came to consensus about discrepancies	Ryan : AT cases: greater rearfoot eversion when shod versus unshod; and greater eversion ROM of the ankle/rearfoot No other differences in other comparisons or studies Tibial segment and ankle joint kinematics (4 studies): Ryan et al – reduced maximum ankle dorsiflexion velocity in cases of AT No other significant differences in other comparisons <u>Knee and hip kinematics (3 studies)</u> Azevedo – reduced magnitude of knee flexion between heel strike and midstance in cases of AT No other significant differences in other comparisons <u>Plantar pressure parameters (3 studies):</u> Van Ginckel – many significant associations with AT and centre of force and peak force in AT cases Kaufman - Frequency of dynamic pes planus or pes cavus not significantly different between AT cases and controls <u>Lower limb external kinetics (4 studies):</u> Williams – peak tibial external rotation significantly reduced in AT cases Azevedo – no significant differences Lower limb muscle function (2 studies): Azevedo – no significant difference in amplitude of lateral gastrocnemius at pre and post-heel strike between AT cases and controls. Amplitude of tibialis anterior significantly reduced pre-heel strike in AT cases. Amplitude of peroneus longus at post-heel strike was significantly reduced in AT cases	Likelihood of publication bias assessed Conflicts of interest declared Are results of study directly applicable to patient group targeted by guideline?	N Y Y	

		Authors conclusions Limitations in the quality and focus of included studies (running gait only) reduce the reliability of the findings and applicability to people with AT. The findings suggest that those with AT have increased eversion ROM of the rearfoot, reduced maximum lower leg abduction, reduced ankle joint dorsiflexion velocity, reduced knee flexion during gait, altered plantar pressures and ground reaction forces.			

Cohort Studies

Study	Methodology	Outcomes & results	Paper grading[1]		ACC reviewer comments & evidence level
Owens et al, (2013)[20] Orthopaedic Journal of Sports Medicine, 1(1), 1 – 8 **Study design:** Prospective cohort using data from the Millennium Cohort Study **Research question:** To identify risk factors for the development of Achilles tendinopathy, patellar	**Participants** 151,587 military personnel were enrolled over three waves (2001, 2004, 2007). 80,106 active duty army personnel were followed up in the current study. They were followed for 1 year Demographic, military health, lifestyle and behavioural info, BMI, tobacco and alcohol consumption were collected using the Millennium Cohort Questionnaire. Date of birth, gender, race, education military occupation and other admin were collected by the Defense Manpower Data Centre	450 participants had plantar fasciitis within 1 year of baseline **Overweight** OR 1.29 (95% CI 1.04-1.59) **Obese** OR 1.59 (95% CI 1.16-2.17) **Moderate weekly alcohol** (7-13 drinks) OR 1.33 (95% CI 1.00-1.76) **Age under 30 yrs** OR 0.62 (95% CI 0.38 – 1.00) Linear relationship between age and AT with younger people being less likely to develop AT **Army personnel** more likely to develop AT compared with navy and airforce **Deployment** OR 0.96 (95% CI 0.68 – 1.34)	Appropriate and focused question?	Y	Of significance is the high odds ratio of AT associated with prior fracture or tendinopathy (OR 3.87). There was a linear relationship with age, with younger people being less likely to develop AT. Unfortunately people were grouped by year of birth and it is only possible to estimate age groups, but it seems people under 30 yrs have a lower likelihood of developing AT. Overweight and obese individuals were both more likely to develop AT than
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	N	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	

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

tendinopathy and plantar fasciitis in US military personnel	Electronic medical record data were obtained from Military Health Service Data Repository including all inpatient and outpatient hospitalisation records	**Prior tendinopathy or fracture** OR 3.87 (95% CI 3.16 – 4.75)	Assessment of outcome blind to exposure status	N	normal weight individuals
					Other variables were associated with AT but with low odds ratios which bordered on non-significant.
Funding		**High physical health score on SF-36** associated with lower risk of AT (OR 0.69, 95% CI 0.49 – 0.97)	Recognition knowledge of outcome could have affected assessment	NA	
Not clear but various military medicine funding groups may have been involved	SF-36 data used to calculate a physical health score	**Gender not significantly associated with AT**	Assessment method reliable	Y	**Level of evidence: 2+**
	Diagnosis of Achilles tendinopathy		Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	N	
	Determined by ICD codes using medical records up to 1 year after baseline measures	**Smoking not significantly associated with AT**	Exposure level measured more than once	N	
		Depression not significantly associated with AT			
		Sensitivity analyses (where prior injury removed from models) were consistent with main model.	Main confounders identified and taken into account	Y	
			Confidence intervals provided	Y	
		Author conclusion			
		This study identified several modifiable risk factors for the development of Achilles tendinopathy. These potential risk factors could serve as the focus for future preventive and intervention studies	Are results directly applicable to ACC claims for AT?	Y	

Study	Methodology	Outcomes & results	Paper grading[2]		ACC reviewer comments & evidence level
Mahieu et al (2006)[16]	**Participants**	10/69 (14.5%) of cadets had an Achilles overuse injury	Appropriate and focused question?	Y	Highly selected sample (young, male military cadets) which limits the applicability of the findings.
American Journal of Sports Medicine	N = 69 male officer cadets entering the Belgian Military Academy	Univariate analyses followed by logistic regression analyses	Two groups sourced from comparable source populations	Y	
Study design:	Source population = 191 male cadets	**No significant differences in height,**	Indicates how many people asked to took part in study	Y	Small sample and small number of cases (n=10)

Prospective cohort **Research question:** To identify intrinsic risk factors for Achilles overuse injury in a military cohort **Funding** Not stated	Mean age = 18.4 yrs (SD = 1.3 yrs) Followed over a 6 week basic training period Baseline Measures: Physical assessment – BMI, calf muscle strength, ankle joint range of motion, stiffness of the Achilles tendon, torque and tendon elongation, explosive strength Questionnaire – exercise, medical and injury history over the past 2 years Baecke questionnaire used to assess physical activity **Diagnosis of Achilles tendinopathy** 1) Local tenderness in the region of the tendon on palpation 2) Thickening of the tendon 3) Pain with resisted plantar flexion and passive ankle dorsiflexion 4) Morning stiffness of the tendon Exclusions: Insertional tendinopathy Previous injury – muscle injury to the lower extremities in the last 2 years	**weight, BMI, physical activity between those with and without the condition** **Plantar force measurements** Significantly less plantar flexor strength in the injured group prior to basic training **Dorsiflexion force measurements** No significant differences **Range of Motion** No significant differences **Stiffness of the Achilles tendon** No significant differences **Explosive Strength** No significant differences **Regression Analysis** The strength of the calf muscle plantar flexors and amount of dorsiflexion excursion were identified as significant predictors of an Achilles tendon overuse injury **Author conclusion** Reduced plantar flexion strength decreases the ability of the Achilles tendon to absorb high forces during intense stretch-shortening cycles. This leads to increased risk of developing Achilles overuse injury.	Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	CS	which may have limited the ability of the study to detect statistically significant differences. Previous injury to the lower limbs was an exclusion criterion for this study. **Level of evidence: 2-**
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	N	
			Assessment method reliable	CS	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for AT?	Y	

Study	Methodology	Outcomes & results	Paper grading[3]		ACC reviewer comments & evidence level
Rabin et al (2014)[21] Journal of Foot and Ankle Research, 7(1), 48-54 **Study design:** Prospective cohort **Research question:** To evaluate whether bent knee ankle dorsiflexion range of motion is a risk factor for AT **Funding** Not clear but Israel Defence Force Medical Corps may have contributed to the study funding	**Participants** N=70 healthy male participants recruited through the Israel Defence Force Mean age = 19.6 yrs +/- 1.0 yr Mean weight = 71.5 kg +/- 7.4 kg Screened for any musculoskeletal condition/injury prior to entering the study Followed for a 6 month period over the course of their basic training (rigorous physical fitness and military skill training) *Inclusion criteria* 18 yrs and over No current complaint of pain the lower extremities or lumbar spine *Exclusion criteria* Pain, imbalance, any other limitation which prevented them from completing the assessments in the study **Assessments** All ROM measurements carried out by one examiner All other measures carried out by another single examiner, including	75 participants screened, of whom 5 dropped out or were excluded from the study **Achilles tendinopathy cases:** N = 5 cases (all in the right leg) **Findings:** Bent knee ankle dorsiflexion ROM Reduced ankle joint dorsiflexion ROM associated with greater likelihood of developing AT. However, results were not consistent across all measures. Quality of movement (Lateral Step Down test) No significant differences between injured and uninjured groups **Author conclusion** Limited ankle DF ROM, as measured in NWB with the knee bent, may increase the risk of developing AT in army recruits taking part in intense physical training.	Appropriate and focused question?	Y	Very few cases contributed to wide confidence intervals for some measures and limited statistical power to detect significant differences ROM findings were conflicting and only partially support the authors' conclusion that ankle dorsiflexion ROM is associated with the development of AT. Given the small number of cases and lack of consistency in the findings these results should be interpreted cautiously. **Level of evidence: 2-**
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	N	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			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	N	
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	Y	

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

			Confidence intervals provided	Y	
	lateral step-down test				
	All diagnoses of AT conducted by 2 orthopaedic surgeons~- participants assessed every 2-3 weeks over the course of basic training				
	Diagnosis of Achilles tendinopathy				
	Pain over the tendon during physical activity, tenderness to palpation over the tendon 2-6cm proximal to calcaneal insertion				
	Baseline Measures		Are results directly applicable to ACC claims for AT?	Y	
	Age, weight, height, any past Achilles tendon disorder				
	Lateral step-down test – scored on a 7 point scale. Participants given 5 practice and 5 test repetitions. Scores grouped as good quality of movement or moderate quality of movement				
	Ankle ROM measured using weight-bearing and non-weight-bearing methods				

Study	Methodology	Outcomes & results	Paper grading[4]		ACC reviewer comments & evidence level
Van Ginckel et al (2009)[28] Gait and Posture,	**Participants** N=129 (19 men and 110 women) injury-free novice runners recruited	N = 10 cases of AT (2 men, 8 women) N = 53 injury-free cases (8 men, 45 women)	Appropriate and focused question?	Y	Sample is low on male participants (15% of the sample) with only 2 males with AT included in
			Two groups sourced from comparable source populations	CS	

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

29, 387-391

Study design:
Prospective cohort

Research question: To identify dynamic gait-related risk factors for Achilles tendinopathy in novice runners

Funding
Not stated

No conflicts of interest declared

from three Start to Run programmes

Mean age = 39yrs +/- 10.0 yr

Mean weight = 70.4 kg +/- 11.5 kg

Mean BMI = 24.8 +/- 3.5

Followed for 10 weeks over the course of the running programme – programme to support novice runners to build up to running 5km. Participants were coached 3 times per week.

Inclusion criteria

No current complaint of pain the lower extremities or lumbar spine

No injury to the lower back or lower extremities in the past year

Novice runner = no previous interest or experience in running prior to the start to run programme

Assessments

Baseline:

Physical activity score – Baecke questionnaire

Dynamic force measurements – Footscan pressure plate, runners barefoot.

During programme:

Symptoms of injuries assessed by two investigators blind to dynamic force measurements.

Overuse injuries classified as musculoskeletal ailment causing restriction of running speed/distance/duration for 1 week

N = 66 excluded from analysis (other overuse injury, did not complete programme, acute injury)

Findings

Assessed 8 anatomical zones – medial heel, lateral heel, metatarsal heads I-V, hallux. Five medio-lateral force ratios were calculated for a series of instances of foot contact and foot rollover.

Univariate analyses identified 6 gait factors to enter into the regression model

Stepwise logistic regression indicated that two intrinsic gait factors were associated with AT:

More laterally directed force distribution under the forefoot (p=0.016)

Significantly decreased total displacement of the centre of force (p=0.015)

No other differences in any other intrinsic gait-related factors

No differences in BMI, age, weight, height or physical activity score

Authors conclusions

The results identify a diminished total anterior displacement of the centre of force and a more laterally directed force distribution at the forefoot flat as risk factors for the development of AT.

Criteria	Response
Indicates how many people asked to took part in study	N
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	N
Comparison made between full participants and those lost to follow-up	N
Outcomes clearly defined	Y
Assessment of outcome blind to exposure status	Y
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	Y
Exposure level measured more than once	N
Main confounders identified and taken into account	N
Confidence intervals provided	Y
Are results directly applicable to ACC claims for AT?	CS

analyses. Given AT is more common in men, this sample may not be representative of the general population of people with AT. No indication of whether the participants represent the eligible population or how many people declined to participate.

Potential confounders were not adequately assessed e.g. previous injury history, medication use

Runners gait was measured prior to starting running and it is possible that they altered their foot rollover once they began running, so it could be some other characteristic which is a risk factor for AT.

Runners gait was measured barefoot but they trained and ran wearing shoes.

This study provides limited evidence that two gait characteristics (anterior displacement of centre of force and laterally directed force distribution at the forefoot flat) are risk factors for the development of AT in novice runners.

Level of evidence: 2

Diagnosis of Achilles tendinopathy Gradual onset of mid-portion pain, tenderness to palpation over the tendon, (morning) stiffness, tenderness and pain on exertion		

Cross-Sectional Studies

Study	Methodology	Outcomes & results	Paper grading[5]		ACC reviewer comments & evidence level
Longo et al (2006)[15] American J of Sports Med, 37 (7), 1400 - 1405 **Study design** Cross-sectional observational study **Research question** To evaluate the correlation between AT and age, gender, weight, height and impact profile in Masters track and field athletes **Funding**	N=178 (61.8% men and 38.2% women) athletes competing in the European Veterans Athletes Championships, July 2006 Total number competing at the championships = 5187 (71.9% men and 28.1% women) Response rate = 3.4% Participants recruited on an ad hoc basis (flyers, posters, personal approach) Veterans = 35 years and over **Methods** Participants completed the Victorian Institute of Sport Assessment – Achilles (VISA-A) **VISA-A** is a validated measure of	Abnormal tendon pathology: N= 85 cases of AT **Main findings** No significant gender difference in proportion with VISA-A scores <100 Gender Comparison[a] |	n	VISA-A Score <100, n (%)	VISA-A Score, mean (range)
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Men	119	69 (58.0)	88.9 (57-100)
Women	59	41 (69.5)	85.8 (26-100)
All	178	119 (66.9)	87.7 (26-100) | [a]VISA-A, Victorian Institute of Sport Assessment–Achilles questionnaire. No difference in age, weight and height between those with AT and those without AT	Clear objective described	Y	Symptomatic AT only – athletes had to report VISA-A score <100 to be examined for a formal diagnosis Participants who agreed to complete the questionnaire may not be representative of the group of masters' athletes at the competition or the wider community of athletes – very low response rate. Only symptomatic people were examined fully by an orthopaedic symptom – misses cases of asymptomatic (no pain) AT
			Study population described	CS	
			Cases and controls drawn from same population	Y	
			Participation rate >80%, or if lower is appropriately justified	N	
			Response at main moment of follow-up is >80% or non – response not selective	N	
			Methods: collected in an identical manner in cases and controls	N	
			More than one dimension measured for tendon pathology	Y	
			Data collected about injury history – participants had no history of AT pain	N	

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

	Achilles tendinopathy symptoms: 10 questions based on a VAS scoring system. 6 questions assess symptoms, 7-8 pain while performing sports, exercise and 9-10 pain during work activities Height and weight measured by research assistants **Diagnostic procedure for AT:** Athletes with scores <100 were examined by an orthopaedic surgeon who diagnosed any AT as appropriate Palpation to check for tenderness, heat, thickening, nodule crepitation Foot and heel inspected for malalignment, deformity, swelling in the tendon, Hagland heel, scarring Palpation with foot dorsiflexed and plantar flexed	Age, Weight, and Height for the 2 Groups (with and without Achilles tendinopathy) and Associated *P* Values of the Comparisons[a] 		Athletes With Achilles Tendinopathy	Athletes Without Achilles Tendinopathy	*P* Value
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Age, y	54.9 ± 11.8	52.4 ± 12.0	.20
Weight, kg	64.7 ± 9.9	65.8 ± 9.0	.21
Height, cm	169.3 ± 8.9	171.0 ± 8.1	.46 | [a]Values are given as means ± standard deviations. **Authors conclusions** We did not detect an influence of weight, height, age, gender or impact profile on the development of Achilles tendinopathy [in Masters athletes].	History of foot disorders investigated – no information about other foot disorders or illnesses **— N** Length time data collected for **— NA** Appropriate statistical models (univariate/multivariate) **— CS** Measures of association included: OR with 95% CIs **— N** Controlled for confounding or effect modifications **— N** Relevant to ACC report for causation of AT **— N**		**Level of evidence: 2-**

Case-Control Studies

Study	Methodology	Outcomes & results	Paper grading[6]		ACC reviewer comments & evidence level
Holmes and Lin (2006)[10] Foot and Ankle International, 27 (11), 952 - 959 **Study design** Case-control **Research question** To identify risk factors associated with symptomatic Achilles tendinopathy **Funding** Not stated	Cases: 82 patients with a diagnosis of Achilles tendinopathy Mean age = 50.5 yrs (range 27 – 77 yrs) N = 44 women and 38 men Controls: 100 foot and ankle patients recruited consecutively Also compared prevalence of risk factors with the national average *Diagnosis:* History of posterior Achilles tendon pain or posterior heel pain aggravated by weightbearing and walking activities, and tenderness with direct palpation of the AT. Visual and textural confirmation of nodularity within the AT Review of medical records, radiographs and MRI *Exclusions* Haglund deformity or Achilles tendinitis *Treatments* 26 patients had surgery for AT *Measurement of risk factors:*	*Main findings* **Men with abnormal Achilles tendon pathology (n = 38 cases):** Obesity was more likely in men with AT than other foot disorders in the following age groups: 45 – 54 yrs: 54.5% v 14.3%, p<0.001 65 -74 yrs: 50.0% v 0.0%, p<0.001 >74 yrs: 100% v 0.0%, p<0.001 No significant difference over all age groups No significant differences in occurrence of AT in participants with or without diabetes mellitus Hypertension more likely in men with AT for the following age groups: 55 -64 yrs: 90.0% v 42.9%, p<0.05 No difference for total group **Women with abnormal Achilles tendon pathology (n = 44 cases):** Obesity was more likely in women with AT than other foot disorders in the following age groups: 35 – 44 yrs: 61.5% v 25.0%, p<0.001	Clear objective described	Y	Design of this study makes it impossible to examine the causal relationship between risk factors and AT Used review of medical records, physical examination and MRI/x-ray to identify Achilles tendon pathology. Broke sample into age groups for analyses – small numbers for some of the subgroups (e.g. n=4) which makes it less likely that they had the statistical power to identify significant differences between groups Unclear whether patients were recruited consecutively in the AT group Unclear from this study whether the participants were physically active or sedentary people or their history of injury **Level of evidence: 2-**
			Study population described	Y	
			Cases and controls drawn from same population	Y	
			Participation rate >80%, or if lower is appropriately justified	CS	
			Response at main moment of follow-up is >80% or non – response not selective	CS	
			Methods: collected in an identical manner in cases and controls	N	
			More than one dimension measured for tendon pathology	Y	
			Data collected about injury history	N	
			History of foot disorders investigated	N	
			Length time data collected for	Y	
			Appropriate statistical models (univariate/multivariate)	Y	
			Measures of association included: OR with 95% CIs	Y	
			Controlled for confounding or effect modifications	N	

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

	Charts and patient medical history reviewed for obesity, hypertension, diabetes mellitus, steroid exposure, estrogen exposure BMI > 30 = obesity	45 – 54 yrs: 83.3% v 47.1%,, p<0.05 Total: 64.3% v 41.5%, p<0.05 No significant differences in occurrence of AT in participants with or without diabetes mellitus Hypertension more likely in women with AT for the following age groups: 35 -44 yrs: 30.8% v 0.0%, p < 0.001 45 – 54 yrs: 83.3% v 29.4%, p < 0.001 Total: 61.4% v 32.1%, p < 0.01 **Authors conclusions** This study suggests a possible relationship between systematic diseases and medication (e.g. HRT, contraceptive pill) in the development of Achilles tendinopathy	Relevant to ACC report for causation of AT	Y	

Study	Methodology	Outcomes & results	Paper grading[7]		ACC reviewer comments & evidence level
Kraemer et al (2012)[14] Arch Orthopaedic Trauma Surgery, 132: 847 – 853 **Research Question:** To identify risk factors for Achilles tendinopathy and Achilles tendon rupture	N = 310 athletes in the general population N=207 male and n=103 female athletes Mean age = 40 +/- 11 years Mean BMI = 24.8 +/- 3.6 Questionnaires distributed to sports clubs and general population via media publicity *Diagnosis*	N = 566 questionnaires received in a 1 yr period N = 310 questionnaires included in the final sample Participants allocated to one of 3 groups: **Healthy Achilles tendons (n=89):** mean age 39 +/- 11 yrs mean BMI = 25.1 +/- 3.9 **Chronic Achilles tendinopathy (n=161):**	Appropriate and focused question?	Y	Significant limitations to this study which greatly reduce the impact of its findings Questionnaire-based data collection including diagnostic criteria for Achilles tendinopathy – classified as pain, morning stiffness or tenderness to palpation of Achilles tendon lasting 3 months or more. Standard dx would include history and physical exam of
			Cases and controls are from comparable populations?	?	
			Same exclusion criteria used for both cases and controls?	Y	
			Percentage of each group (cases and controls) participated in the study	?	
			Comparison made between participants and non-participants to establish their similarities or differences	N	

Study	Methodology	Outcomes & results	Paper grading		ACC reviewer comments & evidence level
Study design: Matched case-control **Funding:** Not stated	Participants divided into 3 groups: Controls – no history of any tendinopathy or tendon rupture in any region of the body over the past 10 years Achilles tendinopathy – pain, morning stiffness or tenderness to palpation of the Achilles tendon lasting 3 months or more Achilles rupture – positive history of complete or partial rupture of the Achilles tendon *Inclusion criteria* 18 - 65 years Ability to understand the questionnaire Duplicate questionnaires excluded to avoid multiple responses	Mean age = 41 +/- 11 yrs Mean BMI = 24.4 +/- 3.7 **Acute Achilles tendon rupture (n = 60):** Mean age 40 +/- 9 yrs Mean BMI = 25.2 +/- 3.2 Groups matched by age, weight, height and gender **Risk Factors for Achilles tendinopathy:** Family history – higher rate of relatives with AT disorders Cardiac disease – higher rate in healthy controls Smoking – lower prevalence in the AT group	Cases clearly defined and differentiated from controls	Y	pain, tenderness and swelling of the Achilles tendon (DynaMed). Family history data relies on accurate definition and recall of AT disorders in relatives Concomitant diseases, medication, health history relies on self-report – potential recall and reporting bias Wide confidence intervals for most risk factors, suggesting a lack of precision in the estimates Low quality study with significant flaws **Level of evidence: 2-**
			Clearly established controls are non-cases	N	
			Exposure status is measured in a standard, valid and reliable way	N	
			Main potential confounders identified and taken into account in the design and analysis	N	
			Confidence intervals provided	Y	
			Did study minimize risk of bias or confounding?	N	
			Is there clear association between exposure and outcome?	N	
			Are the results directly applicable to ACC claims for AT?	N	

Study	Methodology	Outcomes & results	Paper grading[8]		ACC reviewer comments & evidence level
Taunton et al (2002)[24] British Journal of Sports Medicine, 36: 95-101 **Study design:** Case-control study **Research**	Patient charts drawn from records between 1998-2000 at a sports medicine clinic in British Colombia **Cases:** N = 96 patients with diagnosed Achilles tendinopathy **Controls:** N = 1906 patients with other running injuries Patients were seen by sports	**Mean BMI (SD) total sample** Men 24.0 (0.91) Women = 21.6 (1.11) **Descriptive analyses for patients with Achilles tendinopathy** Significantly higher proportion of men than women with AT:	Appropriate and focused question?	Y	While all cases of Achilles tendinopathy were diagnosed by Sports physicians, the diagnostic criteria used was not provided. Numbers of patients who refused to participate or who were lost to follow-up was not
			Cases and controls are from comparable populations?	Y	
			Same exclusion criteria used for both cases and controls?	?	
			Percentage of each group (cases and controls) participated in the study	?	

question: To examine risk factors for different running injuries **Funding** Nike Research Foundation, British Colombia Sport Medicine Research Foundation	physicians at the clinic and diagnoses using clinical examination and imaging where appropriate **Exposure Measures:** Height, weight, BMI, activity history, age, history of injury, calibre of runner, biomechanical variables – malalignment, leg length discrepancy	58% male 42% female Being younger (<34 years old) was a protective factor for AT for men but not women: OR = 0.355 (95% CI 0.161 – 0.781) No significant association with BMI, however the mean BMI and SD were low suggesting there may have been few participants in the overweight or obese categories. No significant association with previous injury **Author conclusion:** Being less than 34 years old was a protective factor against AT for male but not female runners in this study	Comparison made between participants and non-participants to establish their similarities or differences	Y	reported. The authors acknowledged that a control group of non-injured runners, rather than comparing against other injuries, would yield more useful data. **Level of evidence:2-**
			Cases clearly defined and differentiated from controls	Y	
			Clearly established controls are non-cases	?	
			Exposure status is measured in a standard, valid and reliable way	N	
			Main potential confounders identified and taken into account in the design and analysis	Y	
			Confidence intervals provided	Y	
			Did study minimize risk of bias or confounding?	Y	
			Is there clear association between exposure and outcome?	N	
			Are results directly applicable to ACC claims for AT?	Y	

Study	Methodology	Outcomes & results	Paper grading[9]		ACC reviewer comments & evidence level
Titchener et al	Sample drawn from the The Health Improvement Network (THIN)	**Sample characteristics**	Appropriate and focused question?	Y	Some problems with missing data and use of

(2014)[25] Journal of Shoulder and Elbow Surgery, 23, 1282-1288. **Study design:** Case-control study **Research question:** To examine comorbidities for rotator cuff disease in a large database of GP patients **Funding** British Elbow and Shoulder Society, UK	database which collects computerised information from routine patient visits at 479 GP clinics and specialist consultations in the UK. Represents 3.4 million patients (5.7% of population) **Cases:** n=5000 patients with rotator cuff disease and more than 6 months follow-up data **Cases identified using read codes:** - Rotator cuff tendonitis - Subacromial bursitis - Subacromial impingement - Rotator cuff tears - Calcific tendonitis *Exclusions* - Biceps tendon disease - Frozen shoulder - Gelnohumeral osteoarthritis **Controls:** n=5000 patients without rotator cuff disease Matched on age, sex and general practice **Exposure Measures:** Other conditions – lateral epicondylitis, medial epicondylitis, de Quervain disease, carpal tunnel syndrome, cubital tunnel syndrome, trigger finger, Achilles tendonitis, rheumatoid arthritis Prescriptions – antidiabetic drugs, oral steroids, insulin Smoking status, BMI, alcohol	**Table I** Demographics |	Cases		Controls	
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Total	5000		5000	
Male gender	2367	47.3%	2367	47.3%
Female gender	2633	52.7%	2633	52.7%
Deprivation (Townsend) score				
1 (least deprived)	1296	25.9%	1296	25.9%
2	1073	21.4%	1073	21.4%
3	999	20.0%	999	20.0%
4	799	16.0%	799	16.0%
5 (most deprived)	564	11.3%	564	11.3%
No data	269	5.4%	269	5.4% | **Associations with upper limb musculoskeletal conditions (adjusted for consultation rate):** Lateral epicondylitis OR = 1.71, (95% CI 1.39 – 2.10) Trigger finger OR = 1.99, (95% CI 1.21 – 3.30) CTS OR = 1.55, 95% (CI 1.19 – 2.02) **Associations with lower limb musculoskeletal conditions (adjusted for consultation rate):** Achilles tendonitis OR = 1.78, (95% CI 1.19 – 2.67) **Author conclusion:** This study has identified a number of other musculoskeletal conditions which are comorbidities for rotator cuff disease, including Achilles tendonitis. This adds weight to the theory that histologic degeneration plays a part in the clinical burden of these diseases. **Cases and controls with missing data were excluded from analyses** E.g. 21% of cases and 29% of controls had no smoking data, 32% of cases and 39% of controls had no BMI data, and	Cases and controls are from comparable populations?	Y
			Same exclusion criteria used for both cases and controls?	Y	clinical records to measure BMI, smoking, alcohol consumption reduces confidence in the findings for these risk factors Authors chose to exclude participants with missing data from analyses Large dataset, relies on accurate application of read codes **Level of evidence:2-**
			Percentage of each group (cases and controls) participated in the study	Y	
			Comparison made between participants and non-participants to establish their similarities or differences	Y	
			Cases clearly defined and differentiated from controls	Y	
			Clearly established controls are non-cases	Y	
			Exposure status is measured in a standard, valid and reliable way	N	
			Main potential confounders identified and taken into account in the design and analysis	?	
			Confidence intervals provided	Y	
			Did study minimize risk of bias or confounding?	N	
			Is there clear association between exposure and outcome?	N	
			Are results directly applicable to ACC claims for AT?	Y	

	consumption, SES, Measured using read codes and Additional Health Data information collected and computerised as part of routine appointments with patients			