

CLINICAL GUIDELINES

**CHRISTOPHER R. CARCIA, PT, PhD • ROBROY L. MARTIN, PT, PhD**  
**JEFF HOUCK, PT, PhD • DANE K. WUKICH, MD**

**Achilles Pain, Stiffness, and Muscle Power Deficits / Achilles Tendinitis:**

*Clinical Practice Guidelines*  
*Linked to the International Classification*  
*of Functioning, Disability, and Health*  
*from the Orthopaedic Section of the*  
*American Physical Therapy Association*

J Orthop Sports Phys Ther. 20XX:XX(\_):A\_-A\_.

RECOMMENDATIONS.....xxx

INTRODUCTION.....xxx

METHODS.....xxx

CLINICAL GUIDELINES:  
*Impairment/Function-Based Diagnosis*.....xxx

CLINICAL GUIDELINES  
*Examinations*.....xxx

CLINICAL GUIDELINES:  
*Interventions*.....xxx

SUMMARY OF RECOMMENDATIONS.....xxx

AUTHOR/REVIEWER AFFILIATIONS AND CONTACTS..xxx

REFERENCES..... xxx

**Reviewers:** Roy Altman, MD • Sandra Curwin BSc(Physio), PhD • Anthony Delitto, PT, PhD •  
John DeWitt, DPT • Amanda Ferland, DPT • Helene Fearon, PT • Joy MacDermid, PT, PhD  
James W. Matheson, DPT • Thomas G. McPoil PT, PhD • Philip McClure, PT, PhD  
Stephen Reischl, DPT • Paul Shekelle, MD, PhD • A. Russell Smith, Jr., PT, EdD  
Leslie Torburn, DPT • James Zachazewski, DPT

---

For author, coordinator, and reviewer affiliations, see end of text. ©2009 Orthopaedic Section American Physical Therapy Association (APTA), Inc, and the *Journal of Orthopaedic & Sports Physical Therapy*. The Orthopaedic Section, APTA, Inc., and the *Journal of Orthopaedic & Sports Physical Therapy* consent to the reproducing and distributing this guideline for educational purposes. Address correspondence to: Joseph J. Godges, DPT, ICF Practice Guidelines Coordinator, Orthopaedic Section, APTA Inc., 2920 East Avenue South, Suite 200; La Crosse, WI 54601. Email: [icf@orthopt.org](mailto:icf@orthopt.org)

## **Recommendations\***

**Risk Factors:** For specific groups of individuals clinicians should consider abnormal dorsiflexion range of motion, abnormal subtalar range of motion, decreased plantar flexion strength, increased pronation, and abnormal tendon structure as intrinsic risk factors associated with Achilles tendinopathy. Obesity, hypertension, hyperlipidemia, and diabetes are medical conditions associated with Achilles tendinopathy. Clinicians should also consider training errors, environmental factors, and faulty equipment as extrinsic risk factors associated with Achilles tendinopathy. (Recommendation based on moderate evidence).

**Diagnosis/Classification:** Self reported localized pain and perceived stiffness in the Achilles tendon following a period of inactivity (i.e. sleep, prolonged sitting), lessens with an acute bout of activity and may increase after the activity. Symptoms are frequently accompanied with Achilles tendon tenderness, a positive arc sign, and positive findings on the Royal London Hospital test. These signs and symptoms are useful clinical findings for classifying a patient with ankle pain into the ICD category of Achilles bursitis or tendinitis and the associated ICF impairment-based category of Achilles pain (b28015 Pain in lower limb), stiffness (b7800 Sensation of muscle stiffness), and muscle power deficits (b7301 Power of muscles of lower limb). (Recommendation based on weak evidence).

**Differential Diagnosis:** Clinicians should consider diagnostic classifications other than Achilles tendinopathy when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline - or - when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function. (Recommendation based on expert opinion).

**Examination – Outcome Measures:** Clinicians should incorporate validated functional outcome measures, such as the Victorian Institute of Sport Assessment and the Foot and Ankle Ability Measure. These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with Achilles tendinopathy. (Recommendation based on strong evidence.)

**Examination – Activity Limitation and Participation Restriction Measures:** When evaluating functional limitations over an episode of care for those with Achilles tendinopathy, measures of activity limitation and participation restriction can include objective and reproducible assessment of the ability to walk, descend stairs, perform unilateral heel raises, single limb hop, and participate in recreational activity. (Recommendation based on moderate evidence).

**Examination – Physical Impairment Measures:** When evaluating physical impairment over an episode of care for those with Achilles tendinopathy, one should consider measuring dorsiflexion range of motion, subtalar joint range of motion, plantar flexion strength and endurance, static arch height, forefoot alignment, and pain with palpation. (Recommendations based on moderate evidence).

**Interventions – Eccentric Loading:** Clinicians should consider implementing an eccentric loading program to decrease pain and improve function in patients with mid-portion Achilles tendinopathy. (Recommendation based on strong evidence).

**Interventions – Low Level Laser Therapy:** Clinicians should consider the use of low level laser therapy to decrease pain and stiffness in patients with Achilles tendinopathy. (Recommendation based on moderate evidence).

**Interventions – Iontophoresis:** Clinicians should consider the use of iontophoresis with dexamethasone to decrease pain and improve function in patients with Achilles tendinopathy. (Recommendation based on moderate evidence).

**Interventions – Stretching:** Stretching exercises can be used to reduce pain and improve function in patients with Achilles tendinopathy. (Recommendation based on weak evidence).

**Interventions – Foot Orthoses:** A foot orthosis can be used to reduce pain and alter ankle and foot kinematics while running in patients with Achilles tendinopathy. (Recommendation based on weak evidence).

**Interventions – Manual Therapy:** Soft tissue mobilization can be used to reduce pain, improve mobility function in patients with Achilles tendinopathy. (Recommendation based on expert opinion).

**Interventions – Taping:** Taping may be used in an attempt to decrease strain on the Achilles tendon in patients with Achilles tendinopathy. (Recommendation based on expert opinion).

**Interventions – Heel Lift:** Conflicting evidence exists for the use of heel lifts in patients with Achilles tendinopathy. (Recommendation based on conflicting evidence).

**Interventions – Night Splint:** Night splints are not beneficial in reducing pain when compared to other forms of interventions for patients with Achilles tendinopathy. (Recommendation based on weak evidence).

## **Introduction**

### **AIM OF THE GUIDELINE**

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based practice guidelines for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International Classification of Functioning, Disability, and Health (ICF).<sup>45</sup>

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice including diagnosis, prognosis, intervention, and assessment of outcome for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payors and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

### **STATEMENT OF INTENT**

This guideline is not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made in light of the clinical data presented by the patient, the diagnostic and treatment options available, and the patient's values, expectations, and preferences. However, we suggest the rationale for significant departures from accepted guidelines be documented in the patient's medical records at the time the relevant clinical decision is made.

## Methods

Content experts were appointed by the Orthopaedic Section, APTA as developers and authors of clinical practice guidelines for musculoskeletal conditions related to the Achilles tendon. These content experts were given the task to identify impairments of body function and structure, activity limitations, and participation restrictions, described using ICF terminology, that could 1) categorize patients into mutually exclusive impairment patterns upon which to base intervention strategies, and 2) serve as measures of changes in function over the course of an episode of care. The second task given to the content experts was to describe the supporting evidence for the identified impairment pattern classification as well as interventions for patients with activity limitations and impairments of body function and structure consistent with the identified impairment pattern classification. It was also acknowledged by the Orthopaedic Section, APTA content experts that only performing a systematic search and review of the evidence related to diagnostic categories based on International Statistical Classification of Diseases and Health Related Problems (ICD)<sup>44</sup> terminology would not be sufficient for these ICF-based clinical practice guidelines as most of the evidence associated with changes in levels of impairment or function in homogeneous populations is not readily searchable using the ICD terminology. For this reason, the content experts were directed to also search the scientific literature related to classification, outcome measures, and intervention strategies for musculoskeletal conditions commonly treated by physical therapists. Thus, the authors of this guideline independently performed a systematic search of the MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews (1967 through February 2009) for any relevant articles related to classification, examination, and intervention for musculoskeletal conditions related to the Achilles tendon. Additionally, when relevant articles were identified, their reference lists were hand-searched in an attempt to identify additional articles that might contribute to the outcome of this guideline. Articles from the searches were compiled and reviewed for accuracy by the authors. Articles with the highest levels of evidence that were most relevant to classification, examination, and intervention for patients musculoskeletal conditions related to the Achilles tendon were included in this guideline.

This guideline was issued in 2009 based upon publications in the scientific literature prior to February 2009. This guideline will be considered for review in 2014, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA website: [www.orthopt.org](http://www.orthopt.org)

### **LEVELS OF EVIDENCE**

#### **Levels of Evidence**

Individual clinical research articles will be graded according to criteria described by the Center for Evidence-Based Medicine, Oxford, United Kingdom (<http://www.cebm.net/index.aspx?o=1025>) for diagnostic, prospective, and therapeutic studies.<sup>103</sup> (Table 1)

I	Evidence obtained from high quality diagnostic studies, prospective studies, or randomized controlled trials.
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, or, randomized controlled trials (e.g., weaker diagnostic criteria and reference standards, improper randomization, no blinding, <80% follow-up)
III	Case controlled studies or retrospective studies

IV	Case series
V	Expert opinion

## GRADES OF EVIDENCE

The overall strength of the evidence supporting recommendations made in this guideline were graded according to guidelines described by Guyatt et al,<sup>42</sup> as modified by MacDermid and adopted by the coordinator and reviewers of this project. In this modified system, the typical A, B, C, and D grades of evidence have been modified to include the role of consensus expert opinion and basic science research to demonstrate biological or biomechanical plausibility (Table 2 below).

Grades of Recommendation		Strength of Evidence
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies including statements of consensus by content experts support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

## REVIEW PROCESS

The Orthopaedic Section, APTA also selected consultants from the following areas to serve as reviewers of the early drafts of this clinical practice guideline:

- Basic science in tendon pathology and healing
- Claims review
- Coding
- Epidemiology
- Rheumatology
- Foot and Ankle Special Interest Group of the Orthopaedic Section, APTA
- Medical practice guidelines
- Orthopaedic physical therapy residency education
- Physical therapy academic education
- Sports physical therapy residency education
- Sports rehabilitation

Comments from these reviewers were utilized by the authors to edit this clinical practice guideline prior to submitting it for publication to the *Journal of Orthopaedic & Sports Physical*

*Therapy.* In addition, several physical therapists practicing in orthopaedic and sports physical therapy settings were sent initial drafts of this clinical practice guideline along with feedback forms to assess its usefulness, validity, and impact.

## **CLASSIFICATION**

Commonly used terminology to describe disorders of the Achilles tendon can often be confusing. The terms ‘tendinitis’, ‘tendonitis’ or ‘paratenonitis’ suggest that an inflammatory condition is present. However, while inflammation of the paratenon can occur,<sup>91</sup> inflammatory cells are generally absent.<sup>10, 75, 93</sup> Lacking the presence of inflammatory cells, degeneration of the tendon (tendinosis) is typically evident. In either case the terms “tendinitis” or “tendinosis” may be misleading and should be replaced with “tendinopathy”, unless histological evidence has proven otherwise. Also the terminology used to describe the disorder should be tissue specific. Disorders of the tendon, paratenon, or both should be referred to as ‘tendinopathy’, ‘paratendinopathy’ or ‘pantendinopathy’, respectively.<sup>74, 78</sup> Another area of potential confusion relates to the location of the pathology. Achilles disorders are frequently described at two anatomical locations: 1) mid-portion (2-6 cm proximal to the insertion) of the tendon and 2) calcaneal insertion. Of these, those that afflict the mid-portion of the tendon are the most common.<sup>62</sup> In light of this, disorders of the mid-portion of the tendon described as “Achilles tendinopathy” will be the focus of this clinical guideline unless otherwise stated.

The ICD-10 code associated with Achilles tendinopathy is **M76.6 Achilles Tendinitis / Achilles bursitis**. The corresponding primary ICD-9 CM code, commonly used in the USA, is **726.71 Achilles bursitis or tendinitis**.

The primary ICF body function codes associated with Achilles tendinopathy are **b28015 pain in lower limb**, **b7301 power of muscles of lower limb**, and **b7800 Sensation of muscle stiffness**. The primary ICF body structures codes associate with Achilles tendinopathy are **s75022 muscles of ankle and foot** and **s75028 Structure of ankle and foot, specified as Achilles tendon**.

The primary ICF activities and participation codes associated with Achilles tendinopathy are **d4500 Walking short distances**, **d4501 Walking long distances**, **d4552 running**, **d4553 jumping**, and **d9201 sports**. The primary and secondary ICD-10 and ICF codes associated with Achilles tendinopathy are provided in Table 3 on the facing page.

## ICD-10 and ICF Codes Associated with Ankle Pain and Stiffness

### INTERNATIONAL STATISTICAL CLASSIFICATION OF DISEASES AND RELATED HEALTH PROBLEMS

ICD-10 code                      M76.6                      Achilles tendinitis / Achilles bursitis

### INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY, AND HEALTH

#### PRIMARY ICF CODES

Body functions	b28015 b7301 b7800	Pain in lower limb Power of muscles of lower limb Sensation of muscle stiffness
Body structure	s75022 s75028	Muscles of ankle and foot Structure of ankle and foot, specified as Achilles tendon
Activity and participation	d4500 d4501 d4552 d4553 d9201	Walking short distances Walking long distances Running Jumping Sports

#### SECONDARY ICF CODES

Body functions	b700 b7101 b7401 b770	Mobility of a single joint Mobility of several joints Endurance of muscle groups Gait pattern functions (antalgic gait)
Body structure	s75013	Muscles of lower leg
Activities and participation	d2302 d4151 d4350 d4600 d4601 d4602	Completing daily routine Climbing Pushing with lower extremity Moving around within the home Moving around within buildings other than home Moving around outside the home or other buildings



## Impairment/Function-based Diagnosis

### PREVALENCE

Disorders of the Achilles tendon rank among the most frequently reported overuse injuries in the literature.<sup>19, 63, 78, 80</sup> The majority of those suffering from Achilles tendinopathy are individuals engaged in activity, most often at a recreational or competitive level.<sup>61</sup> The annual incidence of Achilles tendinopathy in runners has been reported to be between 7 - 9%.<sup>47, 61</sup> The less active are not immune as a minority of cases have been reported in sedentary groups.<sup>43, 109</sup> Although runners appear to be the most commonly affected cohort,<sup>61, 63, 64, 100</sup> Achilles disorders have been reported in a wide variety of sports.<sup>32, 33, 61, 63, 135</sup> It was noted that athletes are more likely to become symptomatic when training as opposed to during competitive events.<sup>47, 135</sup> While there is an increased prevalence of Achilles injury as age increases,<sup>32, 60</sup> the mean age of those affected by Achilles disorders has been reported to be between 30 and 50 years.<sup>80, 102, 112</sup> While gender has not been overtly studied, data from multiple works suggest males are affected to a greater extent than females.<sup>63, 100, 112</sup>

### PATHOANATOMICAL FEATURES

The Achilles tendon is the largest<sup>114</sup> and strongest<sup>13, 97</sup> tendon in the body. The Achilles serves as the conjoined tendon for the gastrocnemius and soleus muscles. On average, the tendon has been reported to be 15 cm in length from the muscle tendon junction to its insertion on the posterior aspect of the calcaneus.<sup>97</sup> Of this, approximately half of the tendon is comprised of fibers from the gastrocnemius and half from the soleus.<sup>21</sup> Along its course, the tendon changes shape and orientation. Proximally, the tendon is broad and flat. As the tendon descends however, it takes on more of a rounded stature. With further descent, just proximal to its insertion, the Achilles once again becomes flattened as it broadly inserts into the posterior surface of the calcaneus. Spiraling causes fibers from the gastrocnemius to become oriented on the posterior and lateral portion of the tendon while fibers from the soleus become located on the anterior and medial portion of the tendon.<sup>131</sup> The tendon is not encased in a true synovial sheath but rather is surrounded by a paratenon, a single cell layer of fatty areolar tissue.<sup>117</sup> Blood supply to the tendon is evident at three locations: the muscle-tendon junction, along the course of the tendon and at the tendon-bone insertion.<sup>97</sup> Vascular density is greatest proximally and least in the mid-portion of the tendon.<sup>17, 65</sup> Nerve supply to the Achilles tendon is primarily supplied by branches of the sural nerve.<sup>13</sup> Nerve fibers have also been detected in the ventral portion of the paratenon. Further, afferent mechanoreceptors have been sparsely detected at the Achilles tendon proper and surrounding areolar tissue.<sup>13</sup>

The Achilles tendon, similar to other tendons and dense connective tissue alike, undergoes morphologic and biomechanical changes with increasing age. Morphologic changes include, but are not limited to, decreased collagen diameter<sup>28</sup> and density,<sup>130</sup> decreased glycosaminoglycans and water content,<sup>46</sup> and increased non-reducible cross-links.<sup>8</sup> Biomechanically, the aging tendon is characterized by decreased tensile strength, linear stiffness, and ultimate load.<sup>134</sup> Other characteristics of the aging tendon include a decreased capacity for collagen synthesis<sup>8</sup> and the accumulation of degraded macromolecules in the matrix.<sup>16</sup> Histopathological changes in tendon are common in individuals over

the age of 35.<sup>51</sup> A study of 891 ruptured tendons in humans revealed 97% of the observed histopathologic changes were degenerative in nature. Of these specimens, 397 (45%) were Achilles tendons.<sup>51</sup>

Acute irritation of a healthy (non-degenerated) Achilles tendon has been associated with inflammation of the paratenon. Localized swelling between the paratenon and Achilles can be visualized and palpated.<sup>126</sup> More commonly however, symptoms are chronic in nature and are associated with a degenerated tendon.<sup>50</sup> Tendinosis is thought to be non-inflammatory,<sup>10, 55</sup> though this remains an active area of exploration.<sup>37</sup> Tendinosis has been described as being either of the lipid or mucoid variety.<sup>55</sup> Lipoid degeneration, as the name implies, indicates the presence of fatty tissue deposited in the tendon. With mucoid degeneration, the normal white, glistening appearance of the tendon is lost and the tendon takes on a grayish or brown color which is mechanically softer.<sup>55</sup> The degenerated Achilles tendon, in addition to its color and substance changes, exhibits signs of increased vascularization or neovascularization.<sup>59</sup> The neovascularization has been reported to demonstrate an irregular (non-parallel) pattern and on occasion display a nodular appearance.<sup>10</sup> Further, the abnormal neovascularization is accompanied by increases in varicose nerve fibers.<sup>13</sup> Increased tendon thickness has been observed in subjects with symptomatic Achilles tendinopathy.<sup>59</sup> However, a recent study linked abnormal tendon structure and symptoms, but not tendon thickness, emphasizing the association of internal tendon structure with pain.<sup>38</sup> However, as classic signs of inflammation are typically not evident, the source of the pain in subjects with tendinopathy remains less certain. The involvement of neuropeptides in tendinopathy, and the nervous system in tendon healing, is an emerging area of research.<sup>1, 118</sup> It has been observed that neovascularization is accompanied by an in-growth of nerve fascicles.<sup>9</sup> These nerve fibers have both sensory and sympathetic components and may in part be responsible for the pain associated with Achilles tendinopathy.<sup>9</sup> Other theories suggest neurotransmitters (i.e. glutamate), which have been detected in heightened concentrations in pathologic specimens, may also explain the pain associated with Achilles tendinopathy.<sup>6</sup>

## **RISK FACTORS**

Numerous risk factors have been proposed to increase the likelihood of one developing an Achilles tendon disorder. Risk factors are commonly classified as those that are intrinsic or extrinsic to the individual. Intrinsic risk factors that have been associated with Achilles tendon disorders include: abnormal dorsiflexion range of motion, abnormal subtalar range of motion, decreased plantar flexion strength, increased pronation, and associated diseases. It is theorized that the etiology of chronic tendon disorders results from an interaction of both intrinsic and extrinsic factors.<sup>111</sup>

### **Intrinsic Risk Factors**

**Dorsiflexion Range of Motion:** Abnormal dorsiflexion range of motion, either decreased<sup>53</sup> or increased<sup>81</sup> has been associated with a higher incidence or risk of Achilles tendinopathy. In a two year prospective study, Kaufman et al<sup>53</sup>

identified  $< 11.5^\circ$  of dorsiflexion with the knee extended increased the risk of developing Achilles tendinopathy by 3.5x when compared to those who exhibited between 11.5 and 15 degrees. In a similar study, Mahieu et al<sup>81</sup> prospectively examined intrinsic risk factors associated with developing Achilles tendinopathy in a group of 69 military recruits. The authors identified that subjects with increased dorsiflexion range of motion ( $> 9^\circ$ ) were at a heightened risk for developing Achilles tendinopathy. However, the level of increased risk was low and added little to a logistic regression analysis predicting the occurrence of Achilles tendinopathy. Clinically, patients who exhibit decreased dorsiflexion with the knee extended are theorized to experience increased tension on the Achilles tendon and hence be at a greater risk of tendinopathy. How an increase in dorsiflexion range of motion likewise increases this risk is less clear.

I

**Abnormal Subtalar Range of Motion:** Abnormalities (increases or decreases) in subtalar range of motion have also been reported to be associated with Achilles tendinopathy.<sup>53, 63</sup> Kaufman et al<sup>53</sup> identified that inversion range of motion in excess of  $32.5^\circ$  increased Achilles tendinopathy risk by 2.8x when compared to those who displayed motion between  $26^\circ$  and  $32.5^\circ$ .<sup>53</sup> Conversely, other work has identified subjects with a decrease in total (inversion + eversion) passive subtalar joint range of motion ( $< 25^\circ$ ) has also been associated with an increased risk of Achilles tendinopathy.<sup>63</sup>

II

**Decreased Plantar flexion Strength:** Decreased plantar flexion strength has been associated with Achilles pathology.<sup>81, 88, 120</sup> McCrory et al<sup>88</sup> noted a 4 Newton-meter (N\*m) difference in isokinetic plantar flexion strength when comparing the strength of a healthy group of runners to the unaffected leg in a group of injured runners. While statistically significant, it is unlikely that a 4 N\*m difference is clinically important. In fact, it has been shown that there is a 6-11% difference between the left and right legs when testing plantar flexor strength.<sup>24</sup> A more recent study prospectively identified that decreased plantar flexion torque as tested on an isokinetic dynamometer ( $30^\circ/\text{second}$  and  $120^\circ/\text{second}$ ) with the knee extended was a discriminating factor between Belgium military recruits who developed ( $n = 10$ ) and those that did not develop ( $n = 59$ ) Achilles tendinopathy during 6 weeks of basic training.<sup>81</sup> At  $30^\circ/\text{second}$  and  $120^\circ/\text{second}$ , the uninjured group generated 17.7 and 11.1 more Newton-meters respectively when compared to the group that ultimately developed Achilles tendinopathy.<sup>81</sup> Because this study focused on male military recruits, this finding may be specific to young individuals, with low plantar flexion strength levels ( $< 50 \text{ Nm}$ ) pre-training. In other work, Silbernagel and colleagues<sup>120</sup> reported subjects with Achilles tendinopathy ( $n = 42$ ) had a decreased capacity to perform a maximal concentric heel raise as well as a maximal eccentric-concentric heel raise when comparing the affected to unaffected or least affected side (when the pathology was present bilaterally). Thus, based on these works, it seems that subjects with decreased plantar flexion strength are at a heightened risk of developing Achilles tendinopathy and those with Achilles tendinopathy exhibit a decreased ability to generate plantarflexor torque.

II

**Pronation:** As it relates to pronation, comparing a healthy ( $n = 58$ ) and injured

II

group of runners with Achilles tendinopathy (n = 31), McCrory et al<sup>88</sup> identified that the injured group had more calcaneal inversion at initial contact, displayed greater pronation, and took less time to achieve maximal pronation. Likewise, other work has identified a significant relationship between Achilles tendinopathy and a forefoot varus structural abnormality.<sup>63</sup> The exact mechanism by which increased pronation places greater stress on the Achilles tendon is unclear and likely multi-factorial. Increased pronation has been observed to cause a “whipping effect” on the Achilles and is hypothesized to decrease blood flow to the Achilles tendon.<sup>19</sup> Further, given that the Achilles tendon is located medial to the subtalar joint axis, it assumes some responsibility with decelerating pronation. Lastly, given the Achilles tendon is grossly oriented in a proximal-distal fashion, it seems logical that the Achilles tendon may be less capable of attenuating forces that occur in the frontal and transverse planes.

**Tendon Structure:** Tendinopathy, defined by abnormal ultrasound signal, may precede the experience of pain. Fredberg et al<sup>34</sup> found that 11% of 96 asymptomatic professional soccer players (18 – 35 years old) showed abnormal ultrasound signal prior to the start of the season. At the end of the season 45% of the individuals with abnormal ultrasound signal developed a painful Achilles tendinosis where only 1% of the athletes with normal signal at the start of the season experienced a painful Achilles tendonosis. In a subsequent follow up study by Fredberg et al.<sup>35</sup> of elite soccer players they calculated a relative risk of 2.8 for developing Achilles tendinosis if abnormal ultrasound signal was identified prior to the start of the season. However, other research has contested these findings. In one study, 6 out of 64 athletes reported Achilles tendon pain at the time of the study and none showed abnormal signal.<sup>133</sup> The differences in exposure to running intensive sports was less in this study compared to the previous 2, which may partially explain the contradictory results. The results of these 3 studies underscore the potential relationship between tendon structure, exposure, and symptoms.

**Comorbidity:** Diseases associated with Achilles tendinopathy include obesity, hypertension, increased cholesterol and diabetes.<sup>43</sup> It has been suggested that these diseases diminish the blood flow that may ultimately reach the Achilles tendon.<sup>43</sup> These disease processes in part explain the prevalence of this disorder in the sedentary population. Interestingly, Achilles tendinopathy has been reported in 6% of cases after taking the antibiotic fluoroquinolone.<sup>11, 40</sup> Further, patients who suffer from systemic inflammatory arthritis (e.g. rheumatoid arthritis, psoriatic arthritis and reactive arthritis) may exhibit signs and symptoms consistent with Achilles tendinopathy.<sup>39</sup> However, symptoms and signs in these cohorts are typically confined to the insertion.<sup>106</sup>

### **Extrinsic Risk Factors**

Extrinsic risk factors that have been associated with Achilles tendinopathy include training errors, environmental factors, and faulty equipment. Training errors in runners are cited as a sudden increase in mileage, an increase in intensity, hill training, returning from a “layoff”, or a combination of these factors.<sup>19</sup> As it relates to environmental factors, Milgrom et al<sup>91</sup> compared the

II

III

II

influence of training season on the incidence of Achilles tendinopathy in military recruits. The investigators identified a greater number of recruits developed Achilles tendinopathy when training in Winter versus Summer months. The authors hypothesized the colder temperatures may have increased the friction between the Achilles tendon and paratenon thereby increasing the likelihood of developing symptoms.<sup>91</sup>

B

For specific groups of individuals, clinicians should consider abnormal dorsiflexion range of motion, abnormal subtalar range of motion, decreased plantar flexion strength, increased pronation, and abnormal tendon structure as intrinsic risk factors associated with Achilles tendinopathy. Obesity, hypertension, hyperlipidemia, and diabetes are medical conditions associated with Achilles tendinopathy. Clinicians should also consider training errors, environmental factors, and faulty equipment as extrinsic risk factors associated with Achilles tendinopathy.

## DIAGNOSIS/CLASSIFICATION

A thorough history in conjunction with a physical examination is usually sufficient to arrive at a diagnosis of Achilles tendinopathy.<sup>2, 114</sup> There is no accepted classification system for Achilles tendinopathy. Several classification systems have been proposed: Curwin and Stanish proposed a seven level classification system, based on pain intensity and functional limitation.<sup>22,127</sup> The “Nirschl Pain Phase Scale of Athletic Overuse Injuries” uses a nearly identical seven-phase scale.<sup>98</sup> Puffer and Zachazewski<sup>104</sup> has also proposed a simpler four-level scale. However, none of these have been widely accepted or validated for use.

Symptoms are local to the mid-portion of the Achilles tendon and typically consist of:

- Intermittent pain related to exercises or activity.<sup>72</sup>
- Stiffness upon weight bearing after prolonged immobility such as sleeping.<sup>64</sup>
- Stiffness and pain at the commencement of an exercise training session that lessens as exercise continues.<sup>64, 117</sup> As the condition worsens, a progression from pain felt towards the end of the exercise session to pain throughout the duration of activity occurs.<sup>64</sup> Eventually exercise may be forced to be discontinued.<sup>117</sup>

Signs that have been used in diagnosis include:

- Positive Achilles Tendon Palpation Test. Specifically, local tenderness of the Achilles 2-6 cm proximal to its insertion.<sup>73</sup>
- Decreased plantar flexor strength on affected side.<sup>69, 120</sup>
- Decreased plantar flexor endurance as demonstrated by a limited ability to perform repetitive unilateral heel raises when compared to unaffected (or lesser affected) contralateral side.<sup>120</sup>
- Arc Sign where the area of palpated swelling moves with dorsi- and plantar flexion.<sup>73</sup>
- Royal London Hospital Test. This test is positive when tenderness occurs 3 cm proximal to the calcaneus with the ankle in slight plantar flexion, that decreases as the ankle is dorsiflexed.<sup>73</sup>

C

Self reported localized pain and perceived stiffness in the Achilles tendon following a period of inactivity (i.e., sleep, prolonged sitting) lessens with an acute bout of activity and may increase after the activity. Symptoms are frequently accompanied with Achilles tendon tenderness, a positive arc sign, and positive findings on the Royal London Hospital test. These signs and symptoms are useful clinical findings for classifying a patient with ankle pain into the ICD category of Achilles bursitis or tendinitis and the associated ICF impairment-based category of Achilles pain (b28015 Pain in lower limb), stiffness (b7800 Sensation of muscle stiffness), and muscle power deficits (b7301 Power of muscles of lower limb).

V

II

## DIFFERENTIAL DIAGNOSIS

The following conditions should be considered in the differential diagnosis when a patient with posterior ankle pain presents:

- Acute Achilles tendon rupture<sup>2, 111</sup>
- Partial tear of the Achilles tendon<sup>54</sup>
- Retrocalcaneal bursitis<sup>49</sup>
- Posterior Ankle Impingement<sup>115</sup>
- Irritation or Neuroma of the Sural Nerve<sup>2</sup>
- Os trigonum Syndrome<sup>82</sup>
- Accessory Soleus Muscle<sup>69</sup>
- Achilles tendon ossification<sup>107</sup>
- Systemic inflammatory disease<sup>7</sup>
- Insertional Achilles tendinopathy

V

F

Clinicians should consider diagnostic classifications other than Achilles tendinopathy when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline - or - when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

## IMAGING STUDIES

When a diagnosis of Achilles tendinopathy is not clear from the history and physical examination, imaging studies are warranted. Ultrasound (US) and magnetic resonance imaging (MRI) have been advocated to be beneficial when diagnosing Achilles tendinopathy.<sup>14, 72, 95</sup> In a prospective head to head comparison between US and MRI that included blinding of examiners to clinical assessment, their performance in identifying Achilles tendinopathy was similar.<sup>56</sup> Imaging using US was reported to have a sensitivity of 80%, specificity of 49%, a positive predictive value (PPV) of 65% and a negative predictive value (NPV) of 68%. Similarly, imaging using MRI was reported to have a sensitivity of 95%, specificity of 50%, positive predictive value of 56% and negative predictive value of 94%.<sup>56</sup> In this study by Kahn et al,<sup>56</sup> only conservatively treated cases were included, suggesting this study was more prone to false negative/positive findings. However, given its three dimensional capabilities coupled with its ability to display soft tissue, some prefer MRI for visualization of the Achilles tendon.<sup>14</sup> For example, in a prospective study that combined clinical assessment and MRI imaging, the detection of cases with a painful Achilles tendon, sensitivity was 94%; specificity, 81%; positive predictive value, 90%; negative predictive value, 88%; and overall accuracy, 89%.<sup>52</sup> However, in this study a specific MRI sequence was used which is not common. Further, It is likely that both US and MRI imaging will continue to play an important role in verifying tendon structure to augment clinical decision making.

**Examination**

**OUTCOME MEASURES**

The Victorian Institute of Sport Assessment (VISA-A) is unique in that it was developed to specifically assess the severity of Achilles tendinopathy.<sup>108</sup> The VISA-A consists of 8 items that assesses stiffness, pain, and function. Evidence for test re-test reliability and construct validity for this instrument has been demonstrated.<sup>108</sup> Specifically, in conservatively managed patients (n = 45) and athletes (n = 24) with Achilles tendinopathy, the VISA-A demonstrated good intra- (r = 0.90) and inter-rater (r = 0.90) reliability as well as good short-term (1 week) test-retest reliability (r = 0.81).<sup>90</sup> Construct validity was established by comparing the VISA-A scores of non-surgical patients with Achilles tendinopathy (n = 45) to scores on two other previously established tendon grading forms and by comparing VISA-A scores of a pre-surgical group (n = 14) to a control group (n = 87).<sup>90</sup> Additionally, in experimental studies involving those with Achilles tendinopathy the VISA-A has demonstrated sensitivity to change following an intervention.<sup>112, 116, 122</sup>

I

The Foot and Ankle Ability Measure (FAAM) is a region-specific instrument designed to assess activity limitations and participation restrictions for individuals with general musculoskeletal foot and ankle disorders.<sup>83</sup> This includes those with Achilles tendinopathy. It consists of a 21 item Activities of Daily Living (ADL) and separately scored 8 item Sports subscale. The FAAM has evidence for content validity, construct validity, test re-test reliability, and responsiveness.<sup>84</sup> This evidence includes a defined meaningful change in score over time for patients involved in physical therapy.<sup>84</sup>

I

**A** Clinicians should use validated functional outcome measures, such as the Victorian Institute of Sport Assessment and the Foot and Ankle Ability Measure before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with Achilles tendinopathy.



## ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES

Silbernagel and colleagues developed a series of six tests to assess Achilles tendon function.<sup>120</sup> The set of tests included three jump tests, two separate strength (heel raise concentric; heel raise eccentric-concentric) tests and a muscular endurance test (repetitive heel raise). Reliability of these tests was established in a group of 15 healthy volunteers ( $30 \pm 2$  years). With the exception of the concentric heel raise test ( $ICC = 0.73$ ), day to day reliability was reported as excellent ( $ICC = 0.76 - 0.94$ ). In a group of patients ( $n = 37$ ) with Achilles tendinopathy (symptom duration =  $37 \pm 67$  months) the investigators identified that the series or 'test battery' was capable of detecting differences between injured and uninjured (or less injured in the case of bilateral symptoms [12 of the 37 cases]) Achilles tendons. The authors noted that while individual tests (hopping, drop counter movement jump (CMJ), concentric and eccentric-concentric heel raises) were capable of discriminating between affected and either unaffected or lesser affected sides, the test battery was most sensitive if used collectively. Of those tests described in the battery, several are functional measures including the CMJ, Drop CMJ and hopping. The results of this work suggest that patients with Achilles tendinopathy demonstrate a decreased capacity to perform activities that include hopping, jumping, and those that require repetitive forceful ankle plantar flexion. Unfortunately, while many of the tests described may be administered in a clinical setting, the methods employed to quantify the data utilized sophisticated laboratory equipment which is not practical in the majority of clinical environments. Whether more simplistic measures of the same tests would yield the same information is unclear and requires additional study.

II

The functional measures included in the previously mentioned VISA-A questions the patient's ability to walk, descend stairs, perform unilateral heel raises, single limb hop, and participate in recreational activity. When using these measures, the activity needs to be objective and reproducible.

I

B

When evaluating functional limitations over an episode of care for those with Achilles tendinopathy measures of activity limitation and participation restriction can include objective and reproducible assessment of the ability to walk, descend stairs, perform unilateral heel raises, single limb hop, and participate in recreational activity.

## PHYSICAL IMPAIRMENT MEASURES

### ANKLE DORSIFLEXION RANGE OF MOTION

ICF category:	Measurement of impairment of body function – mobility of a single joint.
Description:	Passive non-weight bearing goniometric measure of dorsiflexion with the knee extended to 0° and flexed to 45°. Measures with the knee extended are intended to be descriptive of gastrocnemius flexibility while those with the knee flexed of soleus flexibility.
Measurement Method	Patient assumed a supine position on examination table with ankle and foot suspended over the end of the table for taking the goniometric measure of ankle dorsiflexion with subtalar joint in neutral. The stationary arm of the goniometer is aligned with fibular head. The axis of the goniometer placed just distal to lateral malleolus and the moveable arm of goniometer aligned parallel with plantar aspect of calcaneus and fifth metatarsal.
Nature of variable	Continuous
Units of measurement	Degrees
Measurement properties	Martin and McPoil <sup>85</sup> published a review of the literature for goniometric ankle measures including dorsiflexion. Most of the identified works in this review reported intra-tester reliability measures greater than 0.90 while the median inter-tester rater reliability was 0.69. <sup>85</sup>

## SUBTALAR JOINT RANGE OF MOTION

ICF category:	Measurement of impairment of body function – mobility of a single joint.
Description:	Passive non-weight bearing goniometric measure of rearfoot inversion and eversion range of motion.
Measurement Method	The stationary arm of the goniometer is held over a bisection of the distal one-third of the tibia and fibula. The axis is placed over the subtalar joint while the moveable arm is placed over a bisection of the posterior aspect of the calcaneus.
Nature of variable	Continuous
Units of measurement	Degrees
Measurement properties	Intra- and inter-tester reliability of passive subtalar joint inversion and eversion have been reported in 50 feet from a group of 43 patients (mean age = 35.9 years) with both orthopedic (37 feet) and neurologic (13 feet) disorders. <sup>23</sup> Intra-tester reliability (ICC) for inversion without reference to the subtalar joint neutral position in all subjects was 0.74 for inversion and 0.79 for those with orthopedic diagnoses. Similarly, eversion values for all subjects were 0.75 and 0.78 for those with orthopedic diagnoses. Inter-tester reliability of passive subtalar joint inversion and eversion in this same cohort were poor with values of 0.32 and 0.17. <sup>29</sup> Other research studies, one completed using a patient population <sup>124</sup> and the other examining healthy subjects <sup>132</sup> have identified either comparable or higher inter-rater reliability values for non-weight bearing (NWB) measures of passive inversion (0.28 <sup>132</sup> ; 0.42 <sup>124</sup> ) and eversion (0.25; <sup>124</sup> 0.49 <sup>132</sup> ) range of motion.

## PLANTAR FLEXION STRENGTH

ICF category:	Measurement of impairment of body function – mobility of a single joint.
Description:	Assessment of plantar flexion force production at a controlled speed.
Measurement Method	Plantar flexion torque (both average and peak torque) were assessed with an isokinetic dynamometer in two positions (Sitting with knee flexed to 90°; and supine with knee extended to 0°) at 30 and 180°/second using both concentric and eccentric contractions.
Nature of variable	Continuous
Units of measurement	Newton-meters
Measurement properties	Test-re-test (5-7 days between tests) reliability coefficients (ICCs) of data obtained from 10 healthy recreationally active subjects between the ages of 31 and 43 (mean age = 37 years) ranged between 0.66 – 0.95 with the knee flexed and between 0.55 – 0.76 with the knee extended. <sup>92</sup>
Instrument Variations	Resisted unilateral heel raises with the knee extended using a weight machine has also been described to document strength deficits in this population. <sup>120</sup> Tests have been performed concentrically and in an eccentric-concentric fashion. The reliability (ICC) for the unilateral concentric (0.82) and eccentric-concentric (0.86) heel raise in a healthy population was excellent. Patients with Achilles tendinopathy generate less power ( $P = 0.005$ ) on their most symptomatic side ( $199 \pm 122$ Watts) compared to their least symptomatic side ( $275 \pm 128$ Watts) when performing a concentric unilateral heel raise versus 33 kilograms of external resistance. Similar findings were evident for the eccentric-concentric test in the same study. It is appreciated that most clinics do not possess the instrumentation described above and will commonly determine plantarflexor strength based on the number of unilateral heel raises the patient is able to perform. While this method may detect overt plantarflexor weakness, it is a more appropriate measure of endurance and is subsequently described in that section.

## PLANTAR FLEXION ENDURANCE

ICF category:	Measurement of impairment of body function – mobility of a single joint.
Description:	Assessment of plantar flexion endurance in weight bearing.
Measurement Method	Patient assumes unilateral stance on a level surface facing either a standard treatment table or wall. Subject is allowed to use fingertips versus either treatment table or wall for balance. Patient performs unilateral heel raises with knee fully extended through the full available range of motion at a pace of approximately one repetition every two seconds until he or she is unable to complete a full repetition either due to fatigue or pain. Following a rest period of several minutes, the process is repeated on the contralateral side and the number of repetitions are compared bilaterally.
Nature of variable	Interval
Units of measurement	Quantity of repetitions performed.
Measurement properties	Using similar methods, Lunsford and Perry <sup>70</sup> identified a mean of 27.9 repetitions after testing the dominant lower extremity in 203 healthy subjects (122 male; 81 female) of various ages (range 20 – 59 years). The reliability of this method was established in both ankles of 10 recreationally active male subjects (mean age = 37 years; range = 31 – 43) free from lower extremity pathology. <sup>92</sup> Re-testing was performed by the same examiner at an interval of 5-7 days with identical methodology. On the right side subjects completed an average of $29.2 \pm 5.1$ repetitions on the first test session and an average of $30.4 \pm 7.4$ repetitions on the second session ( $P = 0.71$ ; $ICC = 0.84$ ). On the left side subjects completed an average of $27.2 \pm 5.2$ repetitions on the first test session and an average of $28.9 \pm 5.1$ repetitions on the second session ( $P = 0.42$ ; $ICC = 0.78$ ). As it relates to the validity of this measure, the number of unilateral heel raises performed was evaluated in a group of 42 patients by Silbernagel and colleagues. <sup>120</sup> On the most symptomatic side the patients performed fewer unilateral heel raises ( $22 \pm 9.9$ repetitions) when compared to the least symptomatic side ( $24 \pm 9.1$ ) though this difference was not significant ( $P = 0.07$ ). It is worth noting that while a control group was not associated with this comparison, the number of unilateral heel raises performed in the patient population of this study was less than the number of unilateral heel raises performed in healthy subjects. <sup>92, 120</sup>
Instrument Variations	Recently, Silbernagel et al. <sup>121</sup> examined the total work performed during heel-raises (body weight x total displacement) and found this measure to be more discriminating than the number of heel raises for patients after Achilles tendon repair. When calculating work, the displacement of the body weight during each heel-rise must be quantified.

## TRUNCATED ARCH HEIGHT RATIO

ICF category:	Measurement of impairment of body function – mobility of a multiple joints.
Description:	Static partial (50%) weight bearing descriptor of arch height in relation to truncated foot length.
Measurement Method	Heel to toe length (HTL) is measured from the posterior, inferior central aspect of the calcaneus to the end of the longest toe. Heel to ball length (HBL) is measured from the posterior, inferior central aspect of the calcaneus to the medial aspect of the 1 <sup>st</sup> metatarsal head. The truncated arch height ratio is calculated by dividing by the dorsal arch height (obtained at 50% of HTL) by HBL. Dorsal arch height is defined as the vertical distance from the floor to the dorsal aspect of the foot at the specified location.
Nature of variable	Continuous
Units of measurement	No units are associated with this measure
Measurement properties	Intra-rater reliability for the truncated arch height ratio in 850 healthy subjects was ‘near perfect’ (ICC = $0.98 \pm 0.03$ cm) when the subject stood with equal weight on both feet. <sup>89</sup> Similarly, inter-tester reliability was $0.98 \pm 0.04$ cm when compared across three raters. Validity was established in 12 feet (n = 12) by comparing clinical to radiographic measures. Dorsal arch height (p = 0.47) and HBL (p = 0.22) were not significantly different between the two methods suggesting the clinical measures are valid. <sup>89</sup>

## FOREFOOT ALIGNMENT

ICF category:	Measurement of impairment of body function – mobility of a multiple joint.
Description:	Static non-weight bearing descriptor of frontal plane alignment of the forefoot in relation to the rearfoot with the subtalar joint in neutral.
Measurement Method	Prone, with the subtalar joint in neutral. The stationary arm of goniometer is placed parallel to the plantar aspect of the calcaneus, while the moveable arm is placed in line with the metatarsal heads.
Nature of variable	Continuous
Units of measurement	Degrees
Measurement properties	Correlation coefficients (ICCs) for two methods (goniometric and visual estimation) of forefoot alignment as measured by inexperienced (two physical therapy students) and experienced (2 physical therapists $\geq 10$ years of experience) raters in a group of 10 subjects (5 male; 5 female) with no history of lower extremity pathology have been reported. <sup>125</sup> For the goniometric method, intra-tester reliability ( $ICC_{[2,1]}$ ) ranged from 0.08 – 0.78 in experienced raters and from 0.16 – 0.65 in inexperienced raters. For the visual estimation method, intra-tester reliability ( $ICC_{[2,1]}$ ) ranged from 0.51 to 0.76 in experienced raters and from 0.53 – 0.57 in the inexperienced raters. Inter-tester reliability ( $ICC_{[2,2]}$ ) for the goniometric method was 0.38 and 0.42 for experienced and inexperienced raters respectively. Inter-tester reliability ( $ICC_{[2,2]}$ ) for the visual estimation method was 0.81 and 0.72 for experienced and inexperienced raters respectively. <sup>125</sup> A more recent study using the goniometric method to quantify forefoot alignment in a larger group ( $n = 30$ ; 60 feet) of adult (age = 35.6 years) subjects revealed good intra-rater reliability among four raters with ICC values ranging between 0.77 and 0.90. <sup>30</sup> Inter-rater reliability for the same study was considered moderate ( $ICC = 0.70$ ). <sup>30</sup>

## ACHILLES TENDON PALPATION TEST

ICF category:	Measurement of impairment of body function – Pain in body part
Description:	Subjects are positioned prone on an examination table with their ankles hanging just over the edge of the table. Gentle palpation of the entire Achilles tendon is performed by squeezing the tendon between first and second digits.
Measurement Method	Subjects are asked to indicate whether pain was present or absent with palpation.
Nature of variable	Dichotomous
Units of measurement	N/A
Measurement properties	A group of 10 male athletes ( $28.5 \pm 6.8$ years) with confirmed unilateral Achilles tendinopathy were evaluated by three expert raters and then compared to a group of 14 healthy controls ( $27.1 \pm 7.4$ years), the palpation test was reported to have a sensitivity of 0.58 and specificity of 0.84. Kappa values for intra-tester reliability were reported between 0.27 to 0.72 while kappa values for inter-tester reliability have been reported between 0.72 and 0.85. <sup>73</sup>



## ARC SIGN

ICF category:	Measurement of impairment of body function – Pain in body part
Description:	Subjects are positioned prone on an examination table with their ankles hanging relaxed just over the edge of the table. Subjects are asked to actively plantarflex and dorsiflex their ankles.
Measurement Method	Examiners are instructed to determine if the area of maximal localized swelling moves proximal and distal with the tendon during active range of motion or remains static. If the identified area moves proximal and distal, the result is classified as ‘tendinopathy – present’. Conversely, if the area remains static, the result is classified as ‘tendinopathy – absent’.
Nature of variable	Dichotomous
Units of measurement	N/A
Measurement properties	When a group of 10 male athletes ( $28.5 \pm 6.8$ years) with confirmed unilateral Achilles tendinopathy were evaluated by three expert raters and then compared to a group of 14 healthy controls ( $27.1 \pm 7.4$ years), the arc sign was reported to have a sensitivity of 0.52 and specificity of 0.83. Kappa values for intra-tester reliability were reported between 0.28 to 0.75 while kappa values for inter-tester reliability have been reported between 0.55 and 0.72. <sup>73</sup>

## ROYAL LONDON TEST

ICF category:	Measurement of impairment of body function – Pain in body part
Description:	Subjects are positioned prone on an examination table with their ankles hanging relaxed just over the edge of the table. In this position, the examiner identifies the portion of the Achilles tendon which is maximally tender to palpation. The subject is then asked to actively dorsiflex their ankle. The examiner once again palpates the part of the tendon that was identified as maximally tender however this time in maximal dorsiflexion. Subjects with Achilles tendinopathy often report a substantial decrease or absence of pain when the palpation technique is repeated in dorsiflexion.
Measurement Method	With the ankle in maximal active dorsiflexion, the examiner classifies the identified area with palpation as ‘tenderness present’ or ‘tenderness absent’.
Nature of variable	Dichotomous
Units of measurement	N/A
Measurement properties	When a group of 10 male athletes ( $28.5 \pm 6.8$ years) with confirmed unilateral Achilles tendinopathy were evaluated by three expert raters and then compared to a group of 14 healthy controls ( $27.1 \pm 7.4$ years), the Arc Sign was reported to have a sensitivity of 0.54 and specificity of 0.91. Kappa values for intra-tester reliability were reported between 0.60 to 0.89 while kappa values for inter-tester reliability have been reported between 0.63 and 0.76. <sup>73</sup>

## PROGNOSIS

The long-term prognosis for patients with acute-to-subchronic Achilles tendinopathy is favorable with non-operative treatment.<sup>2, 100</sup> Significant decreases in pain and improvement in function have been reported following 6 -12 weeks of intervention.<sup>5, 113</sup> Long term follow up ranging between 2 and 8 years suggests between 71 – 100% of patients with Achilles tendinopathy are able to return to their prior level of activity with minimal or no complaints.<sup>3, 99, 100</sup> Interestingly, the results of both conservative<sup>116</sup> and operative care<sup>76</sup> are less favorable in non athletic populations.

Conservative therapy is initially recommended for those with Achilles tendinopathy. When conservative treatment fails, surgery is recommended to remove fibrotic adhesions and degenerative nodules to restore vascularity.<sup>111</sup>

Paavola et al<sup>100</sup> found in their 8-year follow-up study that 29% of those with acute to subacute Achilles tendinopathy required surgical intervention.<sup>100</sup> Those that did undergo surgery had favorable outcomes with post operative treatment.

Retrospective studies have reported surgical rates for those failing conservative treatment ranging from 24-49%.<sup>48, 63, 67</sup> Those patients who responded to non-operative therapy tended to be younger (average age, 33 years) than those requiring surgery (average age, 48 years).<sup>48</sup> Four to 6 months of conservative intervention is recommended for those with Achilles tendinopathy.<sup>48</sup>

## CLINICAL GUIDELINES

### Interventions

Numerous interventions have been employed by practitioners in the treatment of Achilles tendinopathy. Varying levels of success and evidence is available for each of these interventions as outlined below. While the purpose of this guideline is to focus on interventions within the scope of physical therapy practice, other interventions have been studied.<sup>2, 80, 105, 111, 117, 126</sup> These include extracorporeal shockwave therapy, where there has been some evidence reported;<sup>20, 112</sup> local steroid injection, where there has been conflicting evidence reported;<sup>23, 36</sup> sclerosing injection, where there has been conflicting evidence reported;<sup>4, 15</sup> and oral nonsteroidal anti-inflammatory medications where there has been no evidence reported.<sup>111</sup>

### ECCENTRIC LOADING

The use of eccentric exercise in the treatment of Achilles tendinopathy has received considerable attention. There are 3 studies with Level I evidence<sup>110, 112, 123</sup> and 11 studies with Level II evidence.<sup>5, 25, 31, 58, 77, 79, 99, 113, 116, 119, 123</sup> Although these studies generally note good outcomes with athletic individuals who have midportion Achilles tendinopathy, it is reported that nonathletic individuals<sup>77, 116</sup> and those with insertional Achilles tendinopathy<sup>31</sup> do not seem to respond as favorably. Curwin and Stanish developed the eccentric program in the early 1980s. Their program consisted of three sets of ten repetitions of progressive eccentric loading, titrated by pain occurring between repetitions 20-30, and increased weekly.<sup>22</sup> Load was increased weekly, while speed of movement was changed daily. They reported, in a series of seventy-five patients with Achilles tendinopathy, that 95% of patients had symptom resolution within six to eight weeks.<sup>128</sup> Alfredson et al.<sup>5</sup> modified the eccentric loading program to consist of unilateral eccentric heel raises with no concentric component removing the gradual progression originally described. The unaffected contralateral lower extremity returns the affected ankle to the starting position. Movements are to be slow and controlled with moderate but not disabling pain. Exercises consisting of three sets of fifteen repetitions, both with the knee extended and flexed, are to be performed twice daily for 12 weeks. Subjects are to add external resistance via a back pack if the exercise becomes too easy. If a greater amount of external resistance is necessary, subjects are to use a weight machine.<sup>5</sup> This eccentric training may be beneficial because of its effect on improving microcirculation<sup>58</sup> and peritendinous type I collagen synthesis.<sup>57</sup> There is considerable variability in the way eccentric exercise are performed, and it is not currently known which protocol is most effective.<sup>90</sup>

Studies have specifically shown a decrease in pain<sup>110, 112, 123</sup> and improved VISA-A scores<sup>110, 112</sup> with an eccentric training program for those with mid-portion Achilles tendinopathy. Although Silbernagel et al<sup>123</sup> found a significant decrease in pain at 1 year follow-up, performance with jumping and toe raising did not improve with the eccentric program when compared to a control group. The eccentric program was found to be superior to low-energy shock wave treatment<sup>112</sup> however extracorporeal shockwave therapy (ESWT) combined with the eccentric program was better than eccentric exercises alone.<sup>110</sup>

I

Additional studies have also noted an eccentric training program for those with

II

midportion Achilles tendinopathy to decrease pain,<sup>5, 31, 58, 79, 113, 119</sup> improve function,<sup>113</sup> improve VISA-A scores,<sup>77, 122</sup> and increase strength.<sup>5</sup> Concentric exercises do not seem to have the same effect as an eccentric program.<sup>79</sup> Studies have also shown localized decreases in tendon thickness and normalized tendon structure.<sup>99</sup>

A

Clinicians should consider implementing an eccentric loading program to decrease pain and improve function in patients with midportion Achilles tendinopathy.

## LASER THERAPY

Low level laser therapy (LLLT) enhanced outcomes in a group of 20 subjects (12 male; 8 female) when coupled with eccentric exercises compared to 20 subjects (13 male; 7 female) in an eccentric exercise group who received placebo laser treatment.<sup>129</sup> There were no statistical differences in age, height, weight, symptom duration or quantity of active ankle dorsiflexion between the randomly assigned groups. Treatment was administered for 12 sessions over eight weeks in a blinded fashion. Six points along the painful Achilles tendon were irradiated. All laser sessions were performed by the same physical therapist. Laser parameters included an 820nm wavelength with an intensity of 0.9 Joules (J) per point. While there were no differences in perceived pain (100mm visual analog scale) at baseline between placebo ( $81.8 \pm 11.6$ ) and intervention groups ( $79.8 \pm 9.5$ ), a significant ( $P < 0.01$ ) difference between groups was reported at 4, 8 and 12 weeks. Specifically, the intervention group perceived less pain with differences of 17.9, 33.6 and 20mm between groups at 4, 8 and 12 weeks respectively. Improvements in the intervention group were also noted in secondary measures including tenderness to palpation, creptitation, morning stiffness and active dorsiflexion range of motion.<sup>129</sup> An additional study in seven patients with bilateral Achilles tendinopathy has yielded positive results when examining the influence of LLLT.<sup>12</sup> Using a 904nm probe, at 5.4 J per point, Bjordal and colleagues, identified that LLLT can reduce pain and inflammation associated with an acute (exercise induced) exacerbation of Achilles tendonitis. Based on these limited works, the future of LLLT is promising for patients suffering from Achilles tendon pain.<sup>12</sup>

I

B

Clinicians should consider the use of low level laser therapy to decrease pain and stiffness in patients with Achilles tendinopathy.

## IONTOPHORESIS

In a double blind study, Neeter and colleagues evaluated the influence of iontophoresis in 25 patients with Achilles tendon symptoms of less than 3 months duration.<sup>94</sup> Patients were randomly assigned to either experimental or control groups. The experimental group consisted of 14 subjects (5 female; 9 male) with a mean age of  $38.0 \pm 15.6$  years while the control group consisted of 11 subjects (5 female; 6 male) with a mean age of  $39.0 \pm 3.9$  years. Over the course of 2 weeks, patients received 4 treatments of iontophoresis either with 3 ml of dexamethasone or saline solution for approximately 20 minutes (neither the intensity of iontophoresis nor concentration of dexamethasone was reported). Following the iontophoresis treatments, both groups followed the same rehabilitation program for 10 weeks. Dependent measures were assessed at 2 weeks, 6 weeks, 3 months, 6 months and 1 year. While there were no differences between groups in the ability to perform repeated unilateral heel raises, in ankle dorsi- or plantar flexion range of motion or morning stiffness at any of the assessment intervals, significant improvements were observed in several dependent measures in the experimental group over the course of the study. At 6 weeks (and again at 6 and 12 months), the experimental group reported less pain during walking compared to before treatment. At 6 and 12 months, the experimental group reported less pain post physical activity and while ascending and descending stairs when compared to the control group. Both groups noted improvements in Achilles tendon pain during activity over the course of the study.<sup>94</sup> While the majority of differences between groups were observed at the 6 month assessment interval and iontophoresis was only administered 4 sessions at the beginning of the study, the strength of the inherent design suggests iontophoresis with dexamethasone is of benefit for patients with Achilles tendinopathy. Additional studies incorporating the use of iontophoresis are warranted.

**II**

**B**

Clinicians should consider the use of iontophoresis with dexamethasone to decrease pain and improve function in patients with Achilles tendinopathy.

## STRETCHING

Stretching has anecdotally been recommended as an intervention for patients with Achilles tendinopathy. Surprisingly, little evidence supporting stretching to prevent or as an effective intervention for Achilles tendinopathy is available.<sup>101</sup>

Only one study examined the influence of stretching as an isolated intervention.<sup>96</sup> Forty-five subjects with Achilles tendon pain of at least three months duration were randomly assigned to either an eccentric loading program or a calf stretching program. At the onset of the study, the authors reported no statistical difference between groups related to age, male/female distribution, number of subjects with bilateral symptoms or duration of symptoms. The interventions were performed for a twelve week period of time. Follow up measures (tendon tenderness, ultrasonographic measures of tendon thickness, self-reported symptoms and the patient's global self-assessment) were evaluated at 3, 6, 9, 12 and 52 weeks. The self-report outcome measure was described as a modification of the knee osteoarthritis outcome score (KOOS) for the ankle. Reliability and validity of the modified questionnaire was not reported. The global assessment asked the subjects to choose among one of eight categories related to symptom behavior (e.g. levels of worsening symptoms, improvement or no change). Over the course of the study several subjects were excluded largely due to non-compliance. The authors reported 38 of the 45 randomized subjects were followed for at least three months. While it was unclear exactly how many subjects were ultimately in each group, the authors reported 21 and 23 tendons were evaluated at three and 12 months in the eccentric group. Similarly, 24 and 19 tendons were evaluated at three and 12 months in the stretching group. Both groups gradually improved though no differences were noted between groups.<sup>96</sup> As there was not a control group, it is unclear as to whether or not subjects improved because of the intervention, the passage of time or a combination of both. Common sense suggests patients with limited dorsiflexion and Achilles tendinopathy may benefit most from a calf stretching program in hopes of alleviating symptoms. Unfortunately, we did not identify evidence in this regard. Additional study including a control group and measures of dorsiflexion range of motion in conjunction with the appropriate self report outcome measures would be valuable contributions to the existing literature.

II

C

Stretching exercises can be used to reduce pain and improve function in patients with Achilles tendinopathy.



## FOOT ORTHOSES

As increased pronation has been associated with Achilles tendinopathy,<sup>19, 63, 88</sup> it seems logical to incorporate the use of a foot orthosis as a component of the overall intervention program in those subjects who exhibit increased pronation. However, only limited evidence exists to support the use of foot orthoses in this population.

Mayer and colleagues conducted a four week study in which they randomly assigned runners with unilateral Achilles tendinopathy to one of three groups: 1) custom semi-rigid inserts (n = 9); 2) physical therapy intervention (n = 11), or to a control group (n = 8).<sup>87</sup> Subjects in each group (inserts [I], physical therapy [PT]; control [C]) were similar in age (I = 35 ± 6.7 years; PT = 41 ± 5.9; C = 38 ± 4.9), height, weight, as well as kilometers run per week (I = 50 ± 13.5; PT = 50 ± 13.6; C = 53.1 ± 10.6). Subjects in the inserts group had a custom insert that was prescribed and fitted by the same technician. Subjects were instructed to wear the inserts for all physical activities during the four week intervention phase. Subjects in the PT group received 10 physical therapy sessions over a four week period of time. Treatment consisted of ice, pulsed ultrasound, deep friction massage and therapeutic exercise and activities. Dependent measures included pain level and isokinetic plantar flexion torque (concentric and eccentric). Significant improvements (>10%) in eccentric plantar flexion torque were apparent in both intervention groups after four weeks. No differences (<10%) however were noted between groups with concentric plantar flexion torque. Both intervention groups reported pain decreased to less than 50% of the baseline measures after 4 weeks.

A more recent biomechanical study utilizing three-dimensional kinematic analysis compared the effect of custom orthoses in a group of runners suffering from mild Achilles tendinopathy (n = 12) to a group of control subjects (n = 12).<sup>27</sup> Each group consisted of 1 female and 11 male participants. Subjects in the control group were similar in age (38.7 ± 8.1 years), height (1.75 ± 0.05m) and weight (73.3 ± 8.5kg) when compared to the symptomatic group (age = 44.3 ± 8.4 years; height = 1.78 ± 0.05m; 79.3 ± 12.2kg). Subjects in the symptomatic group were pre-screened by the same clinician and qualitatively exhibited signs of increased pronation. Subjects with a pes cavus foot structure despite having Achilles tendinopathy were excluded from the symptomatic group. Without orthotics, the group with Achilles tendinopathy exhibited kinematic differences that included a more inverted calcaneal position at heel strike, increased peak calcaneal eversion, ankle dorsiflexion and knee flexion during stance when compared to the control group. These results are consistent with those previously described by McCrory et al.<sup>88</sup> Amongst subjects with Achilles tendinopathy, when no-orthotic and orthotic conditions were compared, subjects displayed less ankle dorsiflexion but exhibited an increase in calcaneal eversion when using the orthotic device.<sup>27</sup> Though an increase in calcaneal eversion with the orthotics was a counterintuitive finding, it illustrates the complexity of human locomotion. While unknown, it is possible that without an orthotic device designed to limit excessive pronation, subjects with Achilles tendinopathy subconsciously maintained their foot in greater amounts of supination to prevent the potential deleterious effects of excessive pronation on the soft tissue. With an orthotic device designed to limit pronation, subjects may have then allowed their foot to proceed through pronation as excessive movement was restricted by the orthotic device. If true, this logic would explain why increased pronation may have been observed during the orthotic condition in this study.

II

An additional study identified that runners experience a decrease in symptoms with the use of orthotic inserts for a variety of lower extremity orthopedic diagnoses including Achilles tendinopathy.<sup>41</sup>

III

C

A foot orthosis can be used to reduce pain and alter ankle and foot kinematics while running in patients with Achilles tendinopathy.

## MANUAL THERAPY

A single case study ABA design evaluated the effectiveness of a treatment protocol of accessory and combined specific soft tissue mobilization (STM) in a 39 year old female with a 5-year history of Achilles tendinosis.<sup>18</sup> The study involved three six week phases (pre-intervention, intervention and post-intervention) and a follow-up 3 month evaluation. The pre-intervention phase consisted of obtaining baseline measures for all dependent variables (pain, dorsiflexion range of motion and a self-report outcome measure [VISA-A]) once a week. The intervention phase initially consisted of “accessory” STM to the Achilles tendon with the gastrocnemius-soleus complex on slack. Specifically, this STM procedure consisted of gliding the Achilles tendon in a direction in which it was deemed hypomobile (in this case study the direction was medially). The STM was progressed such that the gastrocnemius-soleus complex was placed on stretch and ultimately performed while the patient was performing non-weight bearing concentric and eccentric contractions versus resistance with an elastic band. When the STM was performed in conjunction with either a stretch or muscular contraction, it was described as “combined” STM. Following intervention, substantial improvements in all dependent measures were observed. Specifically, pain was reported as a 0/10, dorsiflexion range of motion both with the knee flexed and extended increased significantly, and a 100% score (indicating no limitations) on the VISA-A was recorded.<sup>18</sup> Further contributions to the evidence could include the investigating the interventions used in this case study using a larger sample and an experimental design.

IV

E

Soft tissue mobilization can be used to reduce pain, improve mobility and function in patients with Achilles tendinopathy.

## TAPING

Taping techniques to alleviate pain and improve function in patients with Achilles tendinopathy have long been used by clinicians. We were unable however to locate any published studies that examined the efficacy of taping in this population. Common techniques that have been suggested by clinicians include the ‘off-loading’ and ‘equinus constraint’ methods.<sup>86</sup> The ‘off-loading’ method attempts to directly limit longitudinal strain on the Achilles tendon while the ‘equinus constraint’ is designed to limit dorsiflexion range of motion and hence longitudinal strain on the Achilles tendon. As patients with Achilles tendinopathy frequently exhibit signs of increased pronation, other taping techniques (e.g. low dye arch tape) aimed at limiting pronation may be effective in the short term of alleviating pain and improving function in this population. However, until formal research studies are completed in this regard the effectiveness of taping in this population is largely unknown and based primarily on expert opinion.

V

F

Taping may be used in an attempt to decrease strain on the Achilles tendon in patients with Achilles tendinopathy

## HEEL LIFTS

The use of a heel lift on a temporary basis is commonly recommended to reduce stress on the Achilles tendon by putting proximal calf musculature and Achilles tendon itself on slack. Classically, heel lifts of 12-15 mm have been advocated.<sup>19</sup>

In individuals without pathology heel lifts needed to be between 1.9-5.7 cm to decrease gastrocnemius muscle activity during level walking.<sup>66</sup>

II

Lowdon and colleagues<sup>68</sup> randomly assigned 33 subjects with Achilles tendonitis to one of three groups. Group I consisted of 11 subjects (7 males, 4 females; age = 26 years) and were issued a commercially available viscoelastic insert of undisclosed height. Group II consisted of 10 subjects (7 males, 3 females; age = 27 years) and were issued compressible rubber pads 15mm in height when uncompressed. Group III was comprised of 12 subjects (6 males, 6 females; age = 30 years) who served as controls. Next, each group received identical intervention including five pulsed ultrasound sessions and instruction in stretching and strengthening the calf musculature. Specific details of these activities were not disclosed. Dependent measures including perceived pain, swelling and tenderness, activity level, the magnitude of forces at heel strike and toe-off as quantified by a force plate as well as stance duration were assessed at baseline, 10 days and after 2 months. Despite random allocation, a significant difference in symptom duration existed between the groups with Group III being shorter when compared to Groups I and II. This finding made comparisons of Group III to Groups I and II of little value. No differences in gait parameters were observed for subjects in Group I. A significant ( $P < 0.05$ ) decrease in stance duration from  $629 \pm 39$ msec to  $599 \pm 56$ msec of the affected lower extremity was noted in Group II. The authors interpreted this finding as the ability of the subjects to ambulate with an increase in cadence. Otherwise, subjects in Group II generally had a more favorable response with respect to pain, swelling and tenderness and ability to participate in activity when compared to Group I.

I

A case series of 14 consecutive athletes (mean age = 30.6 years; range 13 – 46; 9 male, 5 female) with Achilles tendonitis (symptom duration 1 week – 10 years) that received a pair of viscoelastic heel lifts was identified.<sup>71</sup> The athletes were competing in a wide range of sports at various levels of activity. The authors reported that after 3 months of wearing the viscoelastic lifts all but one patient had returned to unrestricted pain-free activity. Further, the authors reported half of the patients failed to improve with other forms of intervention including local modalities, physiotherapy and casting. While the results from this report describe the potential benefits of viscoelastic heel inserts for patients with Achilles tendonitis, the scientific value of the report is limited. Specifically, the authors did not report the height of the insert, a control group was not utilized and discrimination between disorders of the paratenon and tendon were not performed.

IV

Though the literature does not currently support the use of heel lifts for patients with symptoms of Achilles tendinopathy, the use of a rigid lift, 12mm in height, on a temporary basis to alleviate symptoms associated with this disorder could be a simple, cost effective and potentially beneficial intervention. Additional studies in the future will assist in determining the efficacy of heel lifts in management of Achilles tendinopathy.

V

D

Conflicting evidence exists for the use of heel lifts in patients with Achilles tendinopathy.

## NIGHT SPLINTS

Two studies were identified that investigated the efficacy of a night splint in patients with Achilles tendinopathy.<sup>26, 113</sup> Of these, only one examined the influence of a night splint alone on the symptoms and function of subjects.<sup>113</sup> Specifically, Roos and colleagues randomly assigned 44 subjects with Achilles tendinopathy (mean age = 45 years; 23 female, 22 male participants) to one of three groups: 1) eccentric exercise; 2) night splint or 3) both eccentric exercise and a night splint for 12 weeks. Dependent measures (pain, self report outcome score [Foot and Ankle Outcome Score]) were captured at 0, 6, 12, 26 and 52 weeks. At 12 weeks, the eccentric group reported less pain ( $P = 0.04$ ) when compared to the night splint only group. Also at this timeframe, a greater number of subjects in the eccentric exercise only group were able to return to sport activity when compared to the splint only group. Results from this work suggest that a night splint is inferior when compared to an eccentric training program. Supporting this, further study has found no additional value of a night splint when coupled with an eccentric training program.<sup>21</sup>

II

C

Night splints are not beneficial in reducing pain when compared to other forms of interventions for patients with Achilles tendinopathy.

## CLINICAL GUIDELINES

### SUMMARY OF RECOMMENDATIONS

#### **Risk Factors**

B

For specific groups of individuals, clinicians should consider abnormal dorsiflexion range of motion, abnormal subtalar range of motion, decreased plantar flexion strength, increased pronation, and abnormal tendon structure as intrinsic risk factors associated with Achilles tendinopathy. Obesity, hypertension, hyperlipidemia, and diabetes are medical conditions associated with Achilles tendinopathy. Clinicians should also consider training errors, environmental factors, and faulty equipment as extrinsic risk factors associated with Achilles tendinopathy.

#### **Diagnosis/Classification**

C

Self reported localized pain and perceived stiffness in the Achilles tendon following a period of inactivity (ie, sleep, prolonged sitting), lessens with an acute bout of activity and may increase after the activity. Symptoms are frequently accompanied with Achilles tendon tenderness, a positive arc sign, and positive findings on the Royal London Hospital test. These signs and symptoms are useful clinical findings for classifying a patient with ankle pain into the ICD category of Achilles bursitis or tendinitis and the associated ICF impairment-based category of Achilles pain (b28015 Pain in lower limb), stiffness (b7800 Sensation of muscle stiffness), and muscle power deficits (b7301 Power of muscles of lower limb).

#### **Differential Diagnosis**

F

Clinicians should consider diagnostic classifications other than Achilles tendonopathy when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline – or – when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

#### **Examination – Outcome Measures**

A

Clinicians should use validated functional outcome measures, such as the Victorian Institute of Sport Assessment and the Foot and Ankle Ability Measure, before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with Achilles tendinopathy.

#### **Examination – Activity Limitation and Participation Restriction Measures**

B

When evaluating functional limitations over an episode of care for those with Achilles tendinopathy measures of activity limitation and participation restriction can include objective and reproducible assessment of the ability to walk, descend stairs, perform unilateral heel raises, single limb hop, and participate in recreational activity.

#### **Examination – Physical Impairment Measures:**

B

When evaluating physical impairment over an episode of care for those with Achilles tendinopathy one should consider measuring dorsiflexion range of motion, subtalar joint range of motion, plantar flexion strength and endurance, static arch height, forefoot alignment, and pain with palpation.

#### **Interventions – Eccentric Loading**

A

Clinicians should consider implementing an eccentric loading program to decrease pain and improve function in patients with midportion Achilles tendinopathy.

#### **Interventions – Low Level Laser Therapy**

B

Clinicians should consider the use of low level laser therapy to decrease pain and stiffness in patients with Achilles tendinopathy.

**Interventions – Iontophoresis**

B

Clinicians should consider the use of iontophoresis with dexamethasone to decrease pain and improve function in patients with Achilles tendinopathy.

**Interventions – Stretching**

C

Stretching exercises can be used to reduce pain and improve function in patients who exhibit limited dorsiflexion range of motion with Achilles tendinopathy.

**Interventions – Foot Orthoses**

C

A foot orthosis can be used to reduce pain and alter ankle and foot kinematics while running in patients with Achilles tendinopathy.

**Interventions – Manual Therapy**

F

Soft tissue mobilization can be used to reduce pain, improve mobility and function in patients with Achilles tendinopathy.

**Interventions – Taping**

F

Taping may be used in an attempt to decrease strain on the Achilles tendon in patients with Achilles tendinopathy

**Interventions – Heel lifts**

D

Conflicting evidence exists for the use of heel lifts in patients with Achilles tendinopathy.

**Interventions – Night Splints**

C

Night splints are not beneficial in reducing pain when compared to other forms of interventions for patients with Achilles tendinopathy.



## AFFILIATIONS & CONTACTS

### Authors:

**Christopher R. Carcia**, PT, PhD  
Associate Professor  
Department of Physical Therapy  
and  
Director, PhD program in Rehabilitation  
Science  
Duquesne University  
Pittsburgh, PA  
carcia@duq.edu

**RobRoy L. Martin**, PT, PhD  
Associate Professor  
Department of Physical Therapy  
Duquesne University  
Pittsburgh, PA  
and  
Staff Physical Therapist  
Center for Rehab Services  
University of Pittsburgh Medical Center  
Pittsburgh, PA  
martinr280@duq.edu

**Jeff Houck**, PT, PhD  
Associate Professor  
Department of Physical Therapy  
Ithaca University  
Rochester, NY  
jhouck@ithaca.edu

**Dane K. Wukich**, MD  
Chief, Division of Foot and Ankle Surgery  
Assistant Professor of Orthopaedic Surgery  
University of Pittsburgh Comprehensive  
Foot and Ankle Center  
Pittsburgh, PA  
wukichdk@upmc.edu

### Coordinator

**Joseph Godges**, DPT  
ICF Practice Guidelines Coordinator  
Orthopaedic Section, APTA Inc.  
La Crosse, Wisconsin  
icf@orthopt.org

### Reviewers

**Roy D. Altman**, MD  
Professor of Medicine  
Division of Rheumatology and Immunology  
David Geffen School of Medicine at UCLA  
Los Angeles, California  
journals@royaltman.com

**Sandra Curwin**, BSc(Physio), PhD  
Associate Professor  
School of Physiotherapy  
Dalhousie University  
Halifax, NS  
Sandra.Curwin@dal.ca

**Anthony Delitto**, PT, PhD  
Professor and Chair  
School of Health & Rehabilitation Sciences  
University of Pittsburgh  
Pittsburgh, Pennsylvania  
delitto@pitt.edu

**John DeWitt**, DPT  
Director of Physical Therapy Sports &  
Orthopaedic Residencies  
The Ohio State University  
Columbus, Ohio  
john.dewitt@osumc.edu

**Amanda Ferland**, DPT  
Clinic Director  
MVP Physical Therapy  
Federal Way, Washington  
aferland@mvppt.com

**Helene Fearon**, PT  
Fearon/Levine Consulting  
Phoenix, Arizona  
helenefearon@fearonlevine.com

**Joy MacDermid**, PT, PhD  
Associate Professor  
School of Rehabilitation Science  
McMaster University  
Hamilton, Ontario, Canada  
macderj@mcmaster.ca

**James W. Matheson, DPT**  
Larsen Sports Medicine and Physical Therapy  
Hudson, Wisconsin  
jw@eipconsulting.com

**Philip McClure, PT, PhD**  
Professor  
Department of Physical Therapy  
Arcadia University  
Glenside, Pennsylvania  
mcclure@arcadia.edu

**Thomas G. McPoil, PT, PhD**  
Regents' Professor  
Department of Physical Therapy  
Northern Arizona University  
Flagstaff, Arizona  
tom.mcpoil.nau.edu

**Stephen Reischl, DPT**  
Adjunct Associate Professor of Clinical Physical  
Therapy  
Division of Biokinesiology and Physical Therapy  
at the School of Dentistry  
University of Southern California  
reischl@usc.edu

**Paul Shekelle, MD, PhD**  
Director  
Southern California Evidenced-Based Practice  
Center  
Rand Corporation  
Santa Monica, California  
shekelle@rand.org

**A. Russell Smith, Jr., PT, EdD**  
Chair  
Clinical & Applied Movement Sciences  
University of North Florida  
Jacksonville, Florida  
arsmith@unf.edu

**Leslie Torburn, DPT**  
Principal and Consultant  
Silhouette Consulting, Inc.  
Redwood City, California  
torburn@yahoo.com

**James Zachazewski, DPT**

Clinical Director  
Department of Physical and Occupational Therapy  
Massachusetts General Hospital  
Boston, MA  
[jzachazewski@partners.org](mailto:jzachazewski@partners.org)

## REFERENCES

1. Ackerman PW, Sato PT, Hart DANpithFB-: Neuronal pathways in tendon healing. *Front. Biosci.* 2009; 1: 5165-5187.
2. Alfredson H, Cook J: A treatment algorithm for managing Achilles tendinopathy: new treatment options. *Br J Sports Med.* 2007; 41: 211-216.
3. Alfredson H, Lorentzon R: Chronic Achilles tendinosis: recommendations for treatment and prevention. *Sports Med.* 2000; 29: 135-146.
4. Alfredson H, Ohberg L: Sclerosing injections to areas of neo-vascularisation reduce pain in chronic Achilles tendinopathy: a double-blind randomised controlled trial. *Knee Surg Sports Traumatol Arthrosc.* 2005; 13: 338-344.
5. Alfredson H, Pietila T, Jonsson P, Lorentzon R: Heavy-load eccentric calf muscle training for the treatment of chronic Achilles tendinosis. *Am J Sports Med.* 1998; 26: 360-366.
6. Alfredson H, Thorsen K, Lorentzon R: In situ microdialysis in tendon tissue: high levels of glutamate, but not prostaglandin E2 in chronic Achilles tendon pain. *Knee Surg Sports Traumatol Arthrosc.* 1999; 7: 378-381.
7. Ames PR, Longo UG, Denaro V, Maffulli N: Achilles tendon problems: not just an orthopaedic issue. *Disabil Rehabil.* 2008; 30: 1646-1650.
8. Amiel D, Kuiper SD, Wallace CD, Harwood FL, VandeBerg JS: Age-related properties of medial collateral ligament and anterior cruciate ligament: a morphologic and collagen maturation study in the rabbit. *J Gerontol.* 1991; 46: B159-165.
9. Andersson G, Danielson P, Alfredson H, Forsgren S: Nerve-related characteristics of ventral paratendinous tissue in chronic Achilles tendinosis. *Knee Surg Sports Traumatol Arthrosc.* 2007; 15: 1272-1279.
10. Astrom M, Rausing A: Chronic Achilles tendinopathy. A survey of surgical and histopathologic findings. *Clin Orthop Relat Res.* 1995: 151-164.
11. Barge-Caballero E, Crespo-Leiro MG, Paniagua-Martin MJ, et al.: Quinolone-related Achilles tendinopathy in heart transplant patients: incidence and risk factors. *J Heart Lung Transplant.* 2008; 27: 46-51.
12. Bjordal JM, Lopes-Martins RA, Iversen VV: A randomised, placebo controlled trial of low level laser therapy for activated Achilles tendinitis with microdialysis measurement of peritendinous prostaglandin E2 concentrations. *Br J Sports Med.* 2006; 40: 76-80; discussion 76-80.
13. Bjur D, Alfredson H, Forsgren S: The innervation pattern of the human Achilles tendon: studies of the normal and tendinosis tendon with markers for general and sensory innervation. *Cell Tissue Res.* 2005; 320: 201-206.
14. Bleakney RR, White LM: Imaging of the Achilles tendon. *Foot Ankle Clin.* 2005; 10: 239-254.
15. Brown R, Orchard J, Kinchington M, Hooper A, Nalder G: Aprotinin in the management of Achilles tendinopathy: a randomised controlled trial. *Br J Sports Med.* 2006; 40: 275-279.
16. Buckwalter JA, Woo SL, Goldberg VM, et al.: Soft-tissue aging and musculoskeletal function. *J Bone Joint Surg Am.* 1993; 75: 1533-1548.
17. Carr AJ, Norris SH: The blood supply of the calcaneal tendon. *J Bone Joint Surg Br.* 1989; 71: 100-101.
18. Christenson RE: Effectiveness of specific soft tissue mobilizations for the management of Achilles tendinosis: single case study--experimental design. *Man Ther.* 2007; 12: 63-71.
19. Clement DB, Taunton JE, Smart GW: Achilles tendinitis and peritendinitis: etiology and treatment. *Am J Sports Med.* 1984; 12: 179-184.

20. Costa ML, Shepstone L, Donnell ST, Thomas TL: Shock wave therapy for chronic Achilles tendon pain: a randomized placebo-controlled trial. *Clin Orthop Relat Res.* 2005; 440: 199-204.
21. Cummins EJ, Anson BJ, Carr BW, Wright RR, Hauser EDW: The structure of the calcaneal tendon in relation to orthopedic surgery. *Surgery, Gynecology and Obstetrics.* 1946; 83: 107-116.
22. Curwin S, Stanish WD: Tendinitis: its etiology and treatment. Lexington, MA: DC Collamore Press, 1984.
23. DaCruz DJ, Geeson M, Allen MJ, Phair I: Achilles paratendonitis: an evaluation of steroid injection. *Br J Sports Med.* 1988; 22: 64-65.
24. Damholt V, Termansen NB: Asymmetry of plantar flexion strength in the foot. *Acta Orthop Scand.* 1978; 49: 215-219.
25. de Jonge S, de Vos RJ, van Schie HT, Verhaar JA, Weir A, Tol JL: One-year follow-up of a randomised controlled trial on added splinting to eccentric exercises in chronic midportion Achilles tendinopathy. *Br J Sports Med.* 2008.
26. de Vos RJ, Weir A, Visser RJ, de Winter T, Tol JL: The additional value of a night splint to eccentric exercises in chronic midportion Achilles tendinopathy: a randomised controlled trial. *Br J Sports Med.* 2007; 41: e5.
27. Donoghue OA, Harrison AJ, Laxton P, Jones RK: Orthotic control of rear foot and lower limb motion during running in participants with chronic Achilles tendon injury. *Sports Biomech.* 2008; 7: 194-205.
28. Dressler MR, Butler DL, Wenstrup R, Awad HA, Smith F, Boivin GP: A potential mechanism for age-related declines in patellar tendon biomechanics. *J Orthop Res.* 2002; 20: 1315-1322.
29. Elveru RA, Rothstein JM, Lamb RL: Goniometric reliability in a clinical setting. Subtalar and ankle joint measurements. *Phys Ther.* 1988; 68: 672-677.
30. Evans AM, Copper AW, Scharfbillig RW, Scutter SD, Williams MT: Reliability of the foot posture index and traditional measures of foot position. *J Am Podiatr Med Assoc.* 2003; 93: 203-213.
31. Fahlstrom M, Jonsson P, Lorentzon R, Alfredson H: Chronic Achilles tendon pain treated with eccentric calf-muscle training. *Knee Surg Sports Traumatol Arthrosc.* 2003; 11: 327-333.
32. Fahlstrom M, Lorentzon R, Alfredson H: Painful conditions in the Achilles tendon region in elite badminton players. *Am J Sports Med.* 2002; 30: 51-54.
33. Fordham S, Garbutt G, Lopes P: Epidemiology of injuries in adventure racing athletes. *Br J Sports Med.* 2004; 38: 300-303.
34. Fredberg U, Bolvig L: Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and achilles tendons of elite soccer players: a longitudinal study. *Am J Sports Med.* 2002; 30: 488-491.
35. Fredberg U, Bolvig L, Lauridsen A, Stengaard-Pedersen K: Influence of acute physical activity immediately before ultrasonographic measurement of Achilles tendon thickness. *Scand J Rheumatol.* 2007; 36: 488-489.
36. Fredberg U, Bolvig L, Pfeiffer-Jensen M, Clemmensen D, Jakobsen BW, Stengaard-Pedersen K: Ultrasonography as a tool for diagnosis, guidance of local steroid injection and, together with pressure algometry, monitoring of the treatment of athletes with chronic jumper's knee and Achilles tendinitis: a randomized, double-blind, placebo-controlled study. *Scand J Rheumatol.* 2004; 33: 94-101.
37. Fredberg U, Stengaard-Pedersen K: Chronic tendinopathy tissue pathology, pain mechanisms, and etiology with a special focus on inflammation. *Scand J Med Sci Sports.* 2008; 18: 3-15.

- 38.** Gardin A, Bruno J, Movin T, Kristoffersen-Wiberg M, Shalabi A: Magnetic resonance signal, rather than tendon volume, correlates to pain and functional impairment in chronic Achilles tendinopathy. *Acta Radiol.* 2006; 47: 718-724.
- 39.** Gerster JC, Vischer TL, Bennani A, Fallet GH: The painful heel. Comparative study in rheumatoid arthritis, ankylosing spondylitis, Reiter's syndrome, and generalized osteoarthritis. *Ann Rheum Dis.* 1977; 36: 343-348.
- 40.** Greene BL: Physical therapist management of fluoroquinolone-induced Achilles tendinopathy. *Phys Ther.* 2002; 82: 1224-1231.
- 41.** Gross ML, Davlin LB, Evanski PM: Effectiveness of orthotic shoe inserts in the long-distance runner. *Am J Sports Med.* 1991; 19: 409-412.
- 42.** Guyatt G, Sackett D, Sinclair J, Hayward R, Cook D, Cook R: Users' guides to the medical literature. IX. A method for grading health care recommendations. Evidence-Based Medicine Working Group. *JAMA.* 1995; 274: 1800-1804.
- 43.** Holmes GB, Lin J: Etiologic factors associated with symptomatic achilles tendinopathy. *Foot Ankle Int.* 2006; 27: 952-959.
- 44.** *International: (The) ICD-10.*, 2nd ed. Geneva, Switzerland: World Health Organization, 2005.
- 45.** International Classification of Functioning DaHI: World Health Organization. Geneva, Switzerland, 2001.
- 46.** Ippolito E, Natali PG, Postacchini F, Accinni L, De Martino C: Morphological, immunochemical, and biochemical study of rabbit achilles tendon at various ages. *J Bone Joint Surg Am.* 1980; 62: 583-598.
- 47.** Johansson C: Injuries in elite orienteers. *Am J Sports Med.* 1986; 14: 410-415.
- 48.** Johnston E, Scranton P, Jr., Pfeffer GB: Chronic disorders of the Achilles tendon: results of conservative and surgical treatments. *Foot Ankle Int.* 1997; 18: 570-574.
- 49.** Kachlik D, Baca V, Cepelik M, et al.: Clinical anatomy of the retrocalcaneal bursa. *Surg Radiol Anat.* 2008; 30: 347-353.
- 50.** Kader D, Saxena A, Movin T, Maffulli N: Achilles tendinopathy: some aspects of basic science and clinical management. *Br J Sports Med.* 2002; 36: 239-249.
- 51.** Kannus P, Jozsa L: Histopathological changes preceding spontaneous rupture of a tendon. A controlled study of 891 patients. *J Bone Joint Surg Am.* 1991; 73: 1507-1525.
- 52.** Karjalainen PT, Soila K, Aronen HJ, et al.: MR imaging of overuse injuries of the Achilles tendon. *AJR Am J Roentgenol.* 2000; 175: 251-260.
- 53.** Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR: The effect of foot structure and range of motion on musculoskeletal overuse injuries. *Am J Sports Med.* 1999; 27: 585-593.
- 54.** Kayser R, Mahlfeld K, Heyde CE: Partial rupture of the proximal Achilles tendon: a differential diagnostic problem in ultrasound imaging. *Br J Sports Med.* 2005; 39: 838-842; discussion 838-842.
- 55.** Khan KM, Cook JL, Bonar F, Harcourt P, Astrom M: Histopathology of common tendinopathies. Update and implications for clinical management. *Sports Med.* 1999; 27: 393-408.
- 56.** Khan KM, Forster BB, Robinson J, et al.: Are ultrasound and magnetic resonance imaging of value in assessment of Achilles tendon disorders? A two year prospective study. *Br J Sports Med.* 2003; 37: 149-153.
- 57.** Knobloch K: Eccentric rehabilitation exercise increases peritendinous type I collagen synthesis in humans with Achilles tendinosis. *Scand J Med Sci Sports.* 2007; 17: 298-299.

58. Knobloch K, Kraemer R, Jagodzinski M, Zeichen J, Meller R, Vogt PM: Eccentric training decreases paratendon capillary blood flow and preserves paratendon oxygen saturation in chronic achilles tendinopathy. *J Orthop Sports Phys Ther.* 2007; 37: 269-276.
59. Knobloch K, Kraemer R, Lichtenberg A, et al.: Achilles tendon and paratendon microcirculation in midportion and insertional tendinopathy in athletes. *Am J Sports Med.* 2006; 34: 92-97.
60. Krolo I, Viskovic K, Ikic D, Klaric-Custovic R, Marotti M, Cicvara T: The risk of sports activities--the injuries of the Achilles tendon in sportsmen. *Coll Antropol.* 2007; 31: 275-278.
61. Kujala UM, Sarna S, Kaprio J: Cumulative incidence of achilles tendon rupture and tendinopathy in male former elite athletes. *Clin J Sport Med.* 2005; 15: 133-135.
62. Kvist M: Achilles tendon injuries in athletes. *Sports Med.* 1994; 18: 173-201.
63. Kvist M: Achilles tendon injuries in athletes. *Ann Chir Gynaecol.* 1991; 80: 188-201.
64. Leach RE, James S, Wasilewski S: Achilles tendinitis. *Am J Sports Med.* 1981; 9: 93-98.
65. Leadbetter WB, Mooar PA, Lane GJ, Lee SJ: The surgical treatment of tendinitis. Clinical rationale and biologic basis. *Clin Sports Med.* 1992; 11: 679-712.
66. Lee KH, Matteliano A, Medige J, Smiehorowski T: Electromyographic changes of leg muscles with heel lift: therapeutic implications. *Arch Phys Med Rehabil.* 1987; 68: 298-301.
67. Leppilahti J, Orava S, Karpakka J, Takala T: Overuse injuries of the Achilles tendon. *Ann Chir Gynaecol.* 1991; 80: 202-207.
68. Lowdon A, Bader DL, Mowat AG: The effect of heel pads on the treatment of Achilles tendinitis: a double blind trial. *Am J Sports Med.* 1984; 12: 431-435.
69. Luck MD, Gordon AG, Blebea JS, Dalinka MK: High association between accessory soleus muscle and Achilles tendonopathy. *Skeletal Radiol.* 2008; 37: 1129-1133.
70. Lunsford BR, Perry J: The standing heel-rise test for ankle plantar flexion: criterion for normal. *Phys Ther.* 1995; 75: 694-698.
71. MacLellan GE, Vyvyan B: Management of pain beneath the heel and Achilles tendonitis with visco-elastic heel inserts. *Br J Sports Med.* 1981; 15: 117-121.
72. Maffulli N, Kader D: Tendinopathy of tendo achillis. *J Bone Joint Surg Br.* 2002; 84: 1-8.
73. Maffulli N, Kenward MG, Testa V, Capasso G, Regine R, King JB: Clinical diagnosis of Achilles tendinopathy with tendinosis. *Clin J Sport Med.* 2003; 13: 11-15.
74. Maffulli N, Khan KM, Puddu G: Overuse tendon conditions: time to change a confusing terminology. *Arthroscopy.* 1998; 14: 840-843.
75. Maffulli N, Sharma P, Luscombe KL: Achilles tendinopathy: aetiology and management. *J R Soc Med.* 2004; 97: 472-476.
76. Maffulli N, Testa V, Capasso G, et al.: Surgery for chronic Achilles tendinopathy yields worse results in nonathletic patients. *Clin J Sport Med.* 2006; 16: 123-128.
77. Maffulli N, Walley G, Sayana MK, Longo UG, Denaro V: Eccentric calf muscle training in athletic patients with Achilles tendinopathy. *Disabil Rehabil.* 2008; 30: 1677-1684.
78. Maffulli N, Wong J, Almekinders LC: Types and epidemiology of tendinopathy. *Clin Sports Med.* 2003; 22: 675-692.
79. Mafi N, Lorentzon R, Alfredson H: Superior short-term results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis. *Knee Surg Sports Traumatol Arthrosc.* 2001; 9: 42-47.
80. Magnussen RA, Dunn WR, Thomson AB: Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med.* 2009; 19: 54-64.
81. Mahieu NN, Witvrouw E, Stevens V, Van Tiggelen D, Roget P: Intrinsic risk factors for the development of achilles tendon overuse injury: a prospective study. *Am J Sports Med.* 2006; 34: 226-235.

- 82.** Martin RL: Considerations for differential diagnosis of an ankle sprain in the adolescent. *Orthopaedic Physical Therapy Practice*. 2004; 16: 21-22.
- 83.** Martin RL, Irrgang JJ: A survey of self-reported outcome instruments for the foot and ankle. *J Orthop Sports Phys Ther*. 2007; 37: 72-84.
- 84.** Martin RL, Irrgang JJ, Burdett RG, Conti SF, Van Swearingen JM: Evidence of validity for the Foot and Ankle Ability Measure (FAAM). *Foot Ankle Int*. 2005; 26: 968-983.
- 85.** Martin RL, McPoil TG: Reliability of ankle goniometric measurements: a literature review. *J Am Podiatr Med Assoc*. 2005; 95: 564-572.
- 86.** Martin RL, Paulseth S, Carcia CR: Taping Techniques for Achilles Tendinopathy. *Orthopaedic Physical Therapy Practice*. 2009; 20: 106-107.
- 87.** Mayer F, Hirschmuller A, Muller S, Schuberth M, Baur H: Effects of short-term treatment strategies over 4 weeks in Achilles tendinopathy. *Br J Sports Med*. 2007; 41: e6.
- 88.** McCrory JL, Martin DF, Lowery RB, et al.: Etiologic factors associated with Achilles tendinitis in runners. *Med Sci Sports Exerc*. 1999; 31: 1374-1381.
- 89.** McPoil TG, Cornwall MW, Vicenzino B, et al.: Effect of using truncated versus total foot length to calculate the arch height ratio. *The Foot*. 2008; 18: 220-227.
- 90.** Meyer A, Tumilty S, Baxter GD: Eccentric exercise protocols for chronic non-insertional Achilles tendinopathy: how much is enough? *Scand J Med Sci Sports*. 2009; 19: 609-615.
- 91.** Milgrom C, Finestone A, Zin D, Mandel D, Novack V: Cold weather training: a risk factor for Achilles paratendinitis among recruits. *Foot Ankle Int*. 2003; 24: 398-401.
- 92.** Moller M, Lind K, Styf J, Karlsson J: The reliability of isokinetic testing of the ankle joint and a heel-raise test for endurance. *Knee Surg Sports Traumatol Arthrosc*. 2005; 13: 60-71.
- 93.** Movin T, Gad A, Reinholt FP, Rolf C: Tendon pathology in long-standing achillodynia. Biopsy findings in 40 patients. *Acta Orthop Scand*. 1997; 68: 170-175.
- 94.** Neeter C, Thomee R, Silbernagel KG, Thomee P, Karlsson J: Iontophoresis with or without dexamethazone in the treatment of acute Achilles tendon pain. *Scand J Med Sci Sports*. 2003; 13: 376-382.
- 95.** Neuhold A, Stiskal M, Kainberger F, Schwaighofer B: Degenerative Achilles tendon disease: assessment by magnetic resonance and ultrasonography. *Eur J Radiol*. 1992; 14: 213-220.
- 96.** Norregaard J, Larsen CC, Bieler T, Langberg H: Eccentric exercise in treatment of Achilles tendinopathy. *Scand J Med Sci Sports*. 2007; 17: 133-138.
- 97.** O'Brien M: The anatomy of the Achilles tendon. *Foot Ankle Clin*. 2005; 10: 225-238.
- 98.** O'Connor FG, Howard TM, Fieseler CM, Nirschl RP: Managing overuse injuries: a systematic approach. *Phys Sportsmed*. 1997; 25: 88-113.
- 99.** Ohberg L, Lorentzon R, Alfredson H: Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up. *Br J Sports Med*. 2004; 38: 8-11; discussion 11.
- 100.** Paavola M, Kannus P, Paakkala T, Pasanen M, Jarvinen M: Long-term prognosis of patients with achilles tendinopathy. An observational 8-year follow-up study. *Am J Sports Med*. 2000; 28: 634-642.
- 101.** Park DY, Chou L: Stretching for prevention of Achilles tendon injuries: a review of the literature. *Foot Ankle Int*. 2006; 27: 1086-1095.
- 102.** Petersen W, Welp R, Rosenbaum D: Chronic Achilles tendinopathy: a prospective randomized study comparing the therapeutic effect of eccentric training, the AirHeel brace, and a combination of both. *Am J Sports Med*. 2007; 35: 1659-1667.
- 103.** Phillips B, Ball C, Sackett D, et al.: Levels of Evidence. In: *Medicine CfEB*, ed., vol 2009. Oxford, UK, 2009.
- 104.** Puffer JC, Zachazewski JE: Management of overuse injuries. *Am Fam Physician*. 1988; 38: 225-232.



- 105.** Rees JD, Maffulli N, Cook J: Management of Tendinopathy. *Am J Sports Med.* 2009.
- 106.** Resnick D, Feingold ML, Curd J, Niwayama G, Goergen TG: Calcaneal abnormalities in articular disorders. Rheumatoid arthritis, ankylosing spondylitis, psoriatic arthritis, and Reiter syndrome. *Radiology.* 1977; 125: 355-366.
- 107.** Richards PJ, Braid JC, Carmont MR, Maffulli N: Achilles tendon ossification: pathology, imaging and aetiology. *Disabil Rehabil.* 2008; 30: 1651-1665.
- 108.** Robinson JM, Cook JL, Purdam C, et al.: The VISA-A questionnaire: a valid and reliable index of the clinical severity of Achilles tendinopathy. *Br J Sports Med.* 2001; 35: 335-341.
- 109.** Rolf C, Movin T: Etiology, histopathology, and outcome of surgery in achillodynia. *Foot Ankle Int.* 1997; 18: 565-569.
- 110.** Rompe JD, Furia J, Maffulli N: Eccentric loading versus eccentric loading plus shock-wave treatment for midportion achilles tendinopathy: a randomized controlled trial. *Am J Sports Med.* 2009; 37: 463-470.
- 111.** Rompe JD, Furia JP, Maffulli N: Mid-portion Achilles tendinopathy--current options for treatment. *Disabil Rehabil.* 2008; 30: 1666-1676.
- 112.** Rompe JD, Nafe B, Furia JP, Maffulli N: Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo Achillis: a randomized controlled trial. *Am J Sports Med.* 2007; 35: 374-383.
- 113.** Roos EM, Engstrom M, Lagerquist A, Soderberg B: Clinical improvement after 6 weeks of eccentric exercise in patients with mid-portion Achilles tendinopathy -- a randomized trial with 1-year follow-up. *Scand J Med Sci Sports.* 2004; 14: 286-295.
- 114.** Saltzman CL, Tearse DS: Achilles tendon injuries. *J Am Acad Orthop Surg.* 1998; 6: 316-325.
- 115.** Sanders TG, Rathur SK: Impingement syndromes of the ankle. *Magn Reson Imaging Clin N Am.* 2008; 16: 29-38, v.
- 116.** Sayana MK, Maffulli N: Eccentric calf muscle training in non-athletic patients with Achilles tendinopathy. *J Sci Med Sport.* 2007; 10: 52-58.
- 117.** Schepesis AA, Jones H, Haas AL: Achilles tendon disorders in athletes. *Am J Sports Med.* 2002; 30: 287-305.
- 118.** Scott A, Bahr R: Neuropeptides in tendinopathy. *Front Biosci.* 2009; 1: 2203-2211.
- 119.** Shalabi A, Kristoffersen-Wilberg M, Svensson L, Aspelin P, Movin T: Eccentric training of the gastrocnemius-soleus complex in chronic Achilles tendinopathy results in decreased tendon volume and intratendinous signal as evaluated by MRI. *Am J Sports Med.* 2004; 32: 1286-1296.
- 120.** Silbernagel KG, Gustavsson A, Thomee R, Karlsson J: Evaluation of lower leg function in patients with Achilles tendinopathy. *Knee Surg Sports Traumatol Arthrosc.* 2006; 14: 1207-1217.
- 121.** Silbernagel KG, Nilsson-Helander K, Thomee R, Eriksson BI, Karlsson J: A new measurement of heel-rise endurance with the ability to detect functional deficits in patients with Achilles tendon rupture. *Knee Surg Sports Traumatol Arthrosc.* 2010; 18: 258-264.
- 122.** Silbernagel KG, Thomee R, Eriksson BI, Karlsson J: Full symptomatic recovery does not ensure full recovery of muscle-tendon function in patients with Achilles tendinopathy. *Br J Sports Med.* 2007; 41: 276-280; discussion 280.
- 123.** Silbernagel KG, Thomee R, Thomee P, Karlsson J: Eccentric overload training for patients with chronic Achilles tendon pain--a randomised controlled study with reliability testing of the evaluation methods. *Scand J Med Sci Sports.* 2001; 11: 197-206.
- 124.** Smith-Oricchio K, Harris BA: Interrater reliability of subtalar neutral, calcaneal inversion and eversion. *J Orthop Sports Phys Ther.* 1990; 12: 10-15.

- 125.** Somers DL, Hanson JA, Kedzierski CM, Nestor KL, Quinlivan KY: The influence of experience on the reliability of goniometric and visual measurement of forefoot position. *J Orthop Sports Phys Ther.* 1997; 25: 192-202.
- 126.** Sorosky B, Press J, Plastaras C, Rittenberg J: The practical management of Achilles tendinopathy. *Clin J Sport Med.* 2004; 14: 40-44.
- 127.** Stanish WD, Curwin S, Mandel S: Tendinitis: its etiology and treatment. New York, NY: Oxford, 2000.
- 128.** Stanish WD, Rubinovich RM, Curwin S: Eccentric exercise in chronic tendinitis. *Clin Orthop Relat Res.* 1986: 65-68.
- 129.** Stergioulas A, Stergioula M, Aarskog R, Lopes-Martins RA, Bjordal JM: Effects of low-level laser therapy and eccentric exercises in the treatment of recreational athletes with chronic achilles tendinopathy. *Am J Sports Med.* 2008; 36: 881-887.
- 130.** Stocchi R, De Pasquale V, Guizzardi S, et al.: Human Achilles tendon: morphological and morphometric variations as a function of age. *Foot Ankle.* 1991; 12: 100-104.
- 131.** Szaro P, Witkowski G, Smigielski R, Krajewski P, Ciszek B: Fascicles of the adult human Achilles tendon - an anatomical study. *Ann Anat.* 2009; 191: 586-593.
- 132.** Van Gheluwe B, Kirby KA, Roosen P, Phillips RD: Reliability and accuracy of biomechanical measurements of the lower extremities. *J Am Podiatr Med Assoc.* 2002; 92: 317-326.
- 133.** van Snellenberg W, Wiley JP, Brunet G: Achilles tendon pain intensity and level of neovascularization in athletes as determined by color Doppler ultrasound. *Scand J Med Sci Sports.* 2007; 17: 530-534.
- 134.** Woo SL, Hollis JM, Adams DJ, Lyon RM, Takai S: Tensile properties of the human femur-anterior cruciate ligament-tibia complex. The effects of specimen age and orientation. *Am J Sports Med.* 1991; 19: 217-225.
- 135.** Woods C, Hawkins R, Hulse M, Hodson A: The Football Association Medical Research Programme: an audit of injuries in professional football-analysis of preseason injuries. *Br J Sports Med.* 2002; 36: 436-441; discussion 441.