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A Proposed Return-to-Sport Program for Patients With Midportion Achilles Tendinopathy: Rationale and Implementation

Despite being the largest tendon in the body, the Achilles tendon is one of the most commonly injured tendons, especially in athletes involved in running and jumping sports/activities.[40,74] The incidence rate of injury is reported to be 2.35 per 1000 in the adult population,[20] and it is not unusual for patients to have pain intermittently for many years.[5,64]

Achilles tendinopathy is a painful overuse injury that affects an athlete's ability to be physically active.[16] During the early stages of the injury, the patient might be able to continue with regular activities and sports, but as the injury progresses the patient's ability to be physically active is progressively impaired.[44] Repetitive overloading of the Achilles tendon and training errors, such as rapidly increasing training intensity or duration, are reported to be contributing factors in 60% to 80% of those who develop Achilles tendinopathy.[29,39] Greater number of running years and mileage were evident in injured runners compared to uninjured runners.[26] Recurrence of Achilles tendinopathy symptoms was common, and reinjury risk high, in elite soccer players with short recovery periods.[23]

Because return to sport is the goal of rehabilitation, this clinical commentary aims to describe a rationale for and the implementation of a return-to-sport program for athletes with midportion Achilles tendinopathy that incorporates clinical decision making. This return-to-sport program was developed based on knowledge gained from a randomized clinical trial that investigated the effect of running and jumping during the rehabilitation process.[64] This program has also been used successfully in a clinic for recreational and elite athletes, with which the first author (K.G.S.) has been affiliated for 10 years. Successful return-to-sport planning also requires an understanding of the injury and knowledge of how to effectively manage the injury in the earlier stages of treatment. This clinical commentary will also include a brief description of the injury and the evidence and recommendations for the treatment preceding the initiation of the return-to-sport program.

SYNOPSIS: Achilles tendinopathy is a common overuse injury in athletes involved in running and jumping activities and sports. The intervention with the highest level of evidence is exercise therapy, and it is recommended that all patients initially be treated with exercise for at least 3 months prior to considering other treatment options. Recovery from Achilles tendinopathy can take up to a year, and there is a high propensity for recurrence, especially during the return-to-sport phase. The extent of the tendon injury, the age and sex of the athlete, the magnitude of pain/symptoms, the extent of impairments, and the demands of the sport all need to be considered when planning for return to sport. This clinical commentary describes an approach to return to sport for patients with midportion Achilles tendinopathy. The aim of the return-to-sport program is to facilitate the decision-making process in returning an athlete with midportion Achilles tendinopathy back to full sport participation and to minimize the chances for recurrence of the injury. *J Orthop Sports Phys Ther 2015;45(11):876-886. Epub 21 Sep 2015. doi:10.2519/jospt.2015.5885*

KEY WORDS: *Achilles tendon, eccentric, exercise, jumping, running, tendinosis*

Achilles Tendinopathy

Achilles tendinopathy is an overuse injury characterized by a combination of pain, swelling (diffuse or localized), and impaired performance.[38,46] The diagnosis is based on the patient's history and the findings of the physical examination. Achilles tendinopathy can be divided into midpor-

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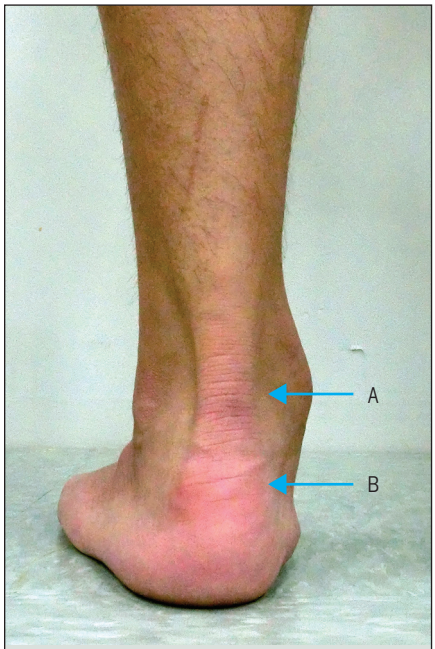

FIGURE 1. Localization of Achilles tendinopathy: (A) midportion and (B) insertional.

tion or insertional tendinopathy, depending on the location of the pain (**FIGURE 1**). Midportion Achilles tendinopathy is located 2 to 6 cm proximal to the insertion of the tendon on the calcaneus.[29] Patients usually report pain occurring during activity and a sensation of morning stiffness, and the clinical examination reveals tenderness to palpation and possibly palpable thickening in the area of the pain. Most patients report a gradual onset of pain and often have pain for several months or even intermittently for many years.

Patients with insertional (also called distal) Achilles tendinopathy report symptoms similar to those of midportion injury, but the discomfort is localized at the tendon insertion onto the calcaneus.[29] The majority (55%-65%) of Achilles tendinopathies are located in the midportion of the tendon.[29,40] While the clinical presentation, with the exception of the location, of midportion and insertional tendinopathies is similar, there are clear distinctions in the management of these 2 conditions. This clinical commentary and return-to-sport program pertains specifically to those athletes with midportion Achilles tendinopathy.

TABLE 1 The Eccentric Exercise Protocol[4]

Exercise	Exercise Dosage	Progression
Heel drop: knee straight (**FIGURE 2**) Standing on the edge of a step on the involved side. Start with standing on the toes, then lower the heel as far down as possible. Rise back on the toes with the assistance of the other foot	3 sets of 15 repetitions 2 times per day 7 days a week for 12 weeks	Do exercise even if painful (stop if pain becomes disabling) and perform until it becomes pain free Once pain free, progressively add loads in either a backpack or in your hands until the exercise is again painful
Heel drop: knee bent (**FIGURE 2**) Same as above, but keep the knee of the involved side slightly bent	3 sets of 15 repetitions 2 times per day 7 days a week for 12 weeks	Do exercise even if painful (stop if pain becomes disabling) and perform until it becomes pain free Once pain free, progressively add loads in either a backpack or in your hands until the exercise is again painful

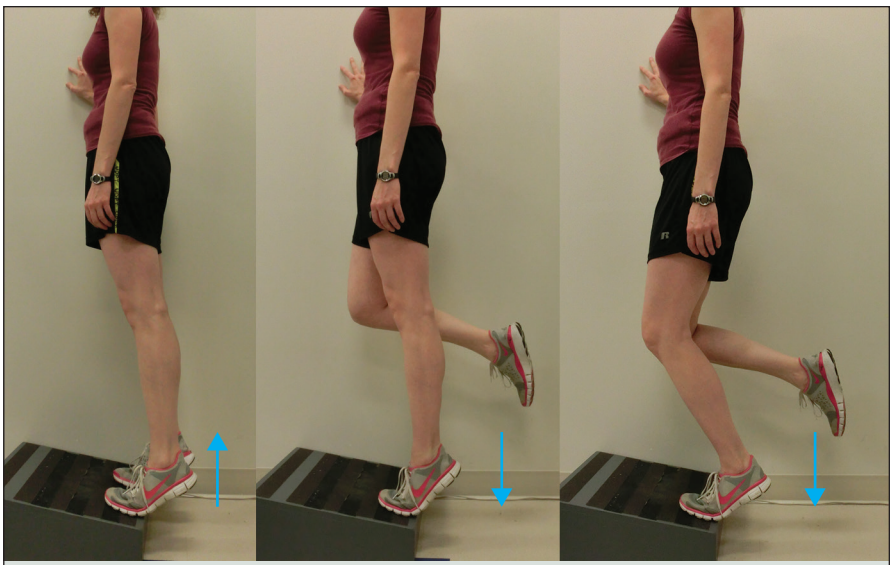

FIGURE 2. The heel drop: knee straight and heel drop: knee bent exercises.

Treatment for Achilles Tendinopathy

Treatment for Achilles tendinopathy has been increasingly investigated, with several systematic reviews evaluating the evidence of effectiveness of various intervention options.[2,24,35,48,70] Evidence-based clinical practice guidelines for physical therapists were published in 2010.[16] Exercise therapy is consistently supported with the highest level of evidence, and eccentric exercise is the most investigated type of exercise therapy.[35,48,50,70] It is recommended to initially treat all patients with exercise therapy for at least 3 months prior to considering other treatment options.[3,30,48,70]

In addition to exercise, many other interventions, such as foot orthoses, ultrasound, electrical stimulation, injection therapies (using platelet-rich plasma, autologous blood, corticosteroids, high-volume saline, sclerosing agents, protease inhibitors, and hyperosmolar dextrose), shockwave therapy, low-level laser therapy, anti-inflammatory medications, and surgery, are also often considered for the management of patients with Achilles tendinopathy.[24,48,57,70] The amount and quality of evidence related to the effectiveness of these interventions vary, but none of these options in isolation is as effective as exercise therapy.[48,70] However,

some of these interventions, for example, extracorporeal shockwave therapy and low-level laser therapy, when used in conjunction with exercise therapy, may result in a faster recovery than when using exercise therapy alone.[2,68]

There is an urgent need to rigorously evaluate other treatment modalities that may serve as adjuncts or alternatives to exercise therapy. Currently, patient-reported outcomes (symptoms) are the primary outcome used in most studies, with only a few studies evaluating lower-leg function and tendon structure.[48] Further research is needed to compare the effects of various interventions and dosages not only on symptoms, but also on function and tendon structure, in patients with Achilles tendinopathy.

Exercise as Treatment

The use of exercise as a treatment for Achilles tendinopathy involves 2 important clinical questions: what is the most effective type of exercise, and what is the most appropriate dosage?[50] Currently, the most commonly advocated therapeutic approach consists of eccentric exercises, using 3 sets of 15 repetitions done with the knee extended and slightly flexed, performed twice daily (**TABLE 1**, **FIGURE 2**).[4]

While the initial research showed encouraging results for this program when used in the athletic population,[4] it has been less successful in patients who are not athletes.[61] In addition, the results of more recent studies[50,69] have brought into question this one-size-fits-all dosage for exercise for Achilles tendinopathy. Stevens and Tan[69] compared the described eccentric program (**TABLE 1**), in which patients performed 180 repetitions per day, with a do-as-tolerated protocol using the same exercises. After 6 weeks of treatment, both groups had significantly improved, with no difference between groups.

A different progressive Achilles tendon–loading strengthening program[64,66] promotes exercise once daily and uses concentric/eccentric exercises (**TABLE 2**, **FIGURES 3** through **9**). This program has been shown to result in both short- and long-term positive outcomes.[62,64] With this program, a pain-monitoring model (**FIGURE 10**) is used to assist with grading the dosage of exercise for each patient.[64,66,71]

TABLE 2 A Progressive Achilles Tendon–Loading Strengthening Program[64]

Phase 1: Weeks 1 to 2
Patient Status
Pain and difficulty with all activities, difficulty performing 10 one-legged heel rises
Goals
Start to exercise and understanding nature of the injury and how to use the pain-monitoring model
Treatment Program
Perform exercises every day:
- Pain-monitoring model information and advice on exercise activity
- Circulation exercises (moving foot up/down)
- Two-legged heel rises standing on the floor (3 × 10-15 repetitions)
- One-legged heel rises standing on the floor (3 × 10 repetitions)
- Sitting heel rises (3 × 10 repetitions)
- Eccentric heel rises standing on the floor (3 × 10 repetitions)

Phase 2: Weeks 2 to 5
If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Pain with exercise, morning stiffness, pain when performing heel rises
Goals
Start strengthening
Treatment Program
Perform exercises every day:
- Two-legged heel rises standing on edge of a step (3 × 15 repetitions)
- One-legged heel rises standing on edge of a step (3 × 15 repetitions)
- Sitting heel rises (3 × 15 repetitions)
- Eccentric heel rises standing on edge of a step (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)

Phase 3: Weeks 3 to 12 (or Longer if Needed)
If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Tolerates the phase 2 exercise program well, no pain at the distal tendon insertion, possibly decreased or increased morning stiffness
Goals
Heavier strength training, increase or start running and/or jumping activity
Treatment Program
Perform exercises every day and with heavier load 2 to 3 times per week:
- One-legged heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Sitting heel rises (3 × 15 repetitions)
- Eccentric heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)
- Plyometrics training

Phase 4: 3 to 6 months (or Longer if Needed)
If pain at the distal insertion of the tendon, continue standing on the floor
Patient Status
Minimal symptoms, not morning stiffness every day, can participate in sports without difficulty
Goals
Maintenance exercise, no symptoms
Treatment Program
Perform exercises 2 to 3 times per week:
- One-legged heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Eccentric heel rises standing on edge of step with added weight (3 × 15 repetitions)
- Quick rebounding heel rises (3 × 20 repetitions)

The importance of the dosage of mechanical loading, as treatment for Achilles tendinopathy, has been addressed in a recent systematic review by Malliaras

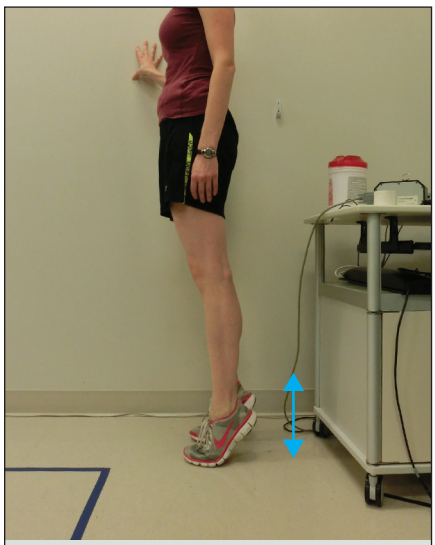

FIGURE 3. Two-legged heel rise standing on the floor.

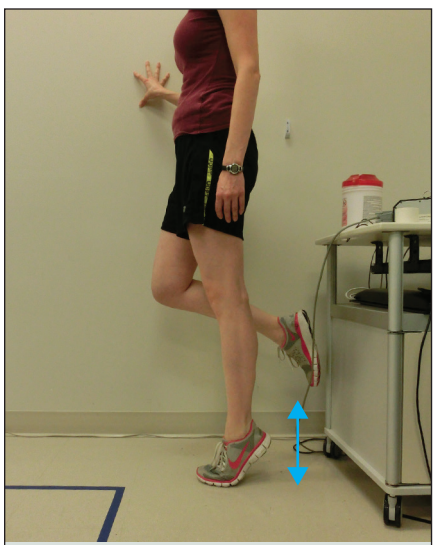

FIGURE 4. One-legged heel rise standing on the floor.

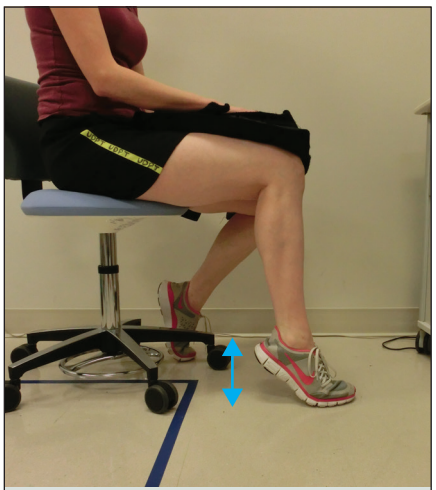

FIGURE 5. Sitting heel rise performed seated.

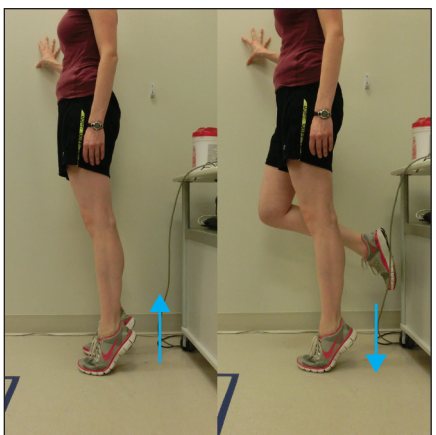

FIGURE 6. Eccentric heel rise standing on the floor.

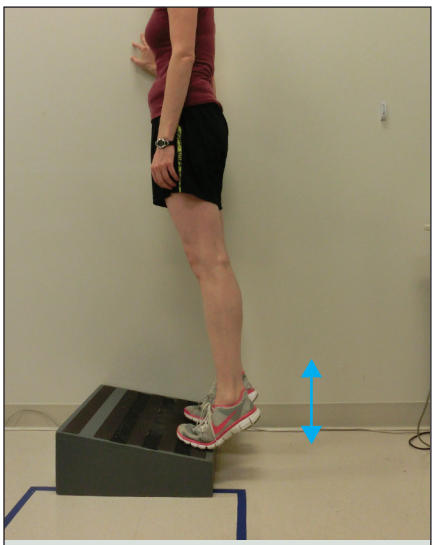

FIGURE 7. Two-legged heel rise standing on a step.

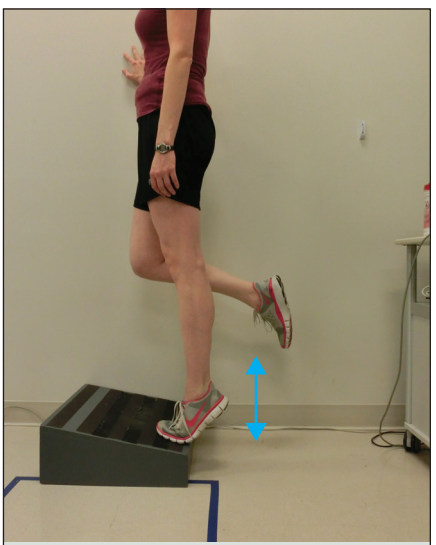

FIGURE 8. One-legged heel rise standing on a step.

et al.[50] The authors concluded that there is a paucity of evidence comparing various loading programs and that the current simplistic approach of the eccentric training program should be questioned. Further research is needed in this area and should consider patient characteristics such as age, sex, and activity level.

Return to Sport

Irrespective of the treatment path, a question still remains: how do we most efficiently return patients back to sport with a low risk of reinjury or risk for other injuries? Inadequate rehabilitation and returning to sport prior to full recovery are risks that might be minimized with appropriate guidance in the return-to-sport phase. Reinjury rates of Achilles tendinopathy in soccer players range from 27%[23] to 44%.[25] Notably, reinjury was more common following short recovery periods[23] and in those who received no assistance with the return-to-sport phase, compared with those who were given a standardized progression program that gradually increased loading during the return-to-sport phase.[25] Thus, at the return-to-sport phase, it appears important to have a gradual and controlled progression that allows the athlete sufficient time to recover and gives the therapist time to evaluate symptoms. Because athletes may not have symptoms from the Achilles tendon during sports participation, they may be tempted to return prematurely. The evaluation of symptoms such as stiffness, pain, and swelling after training, especially the following day, can assist in determining appropriate increases in training intensity or volume.[64]

In the literature, the success of returning to sport and previous activity level is often varied. In a systematic review of nonoperative treatment for midportion Achilles tendinopathy, Magnussen et al[48] identified 4 randomized clinical trials

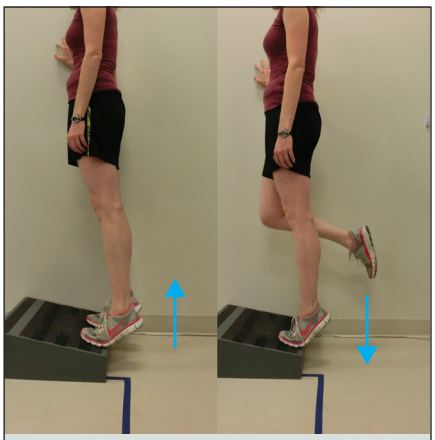

FIGURE 9. Eccentric heel rise standing on a step.

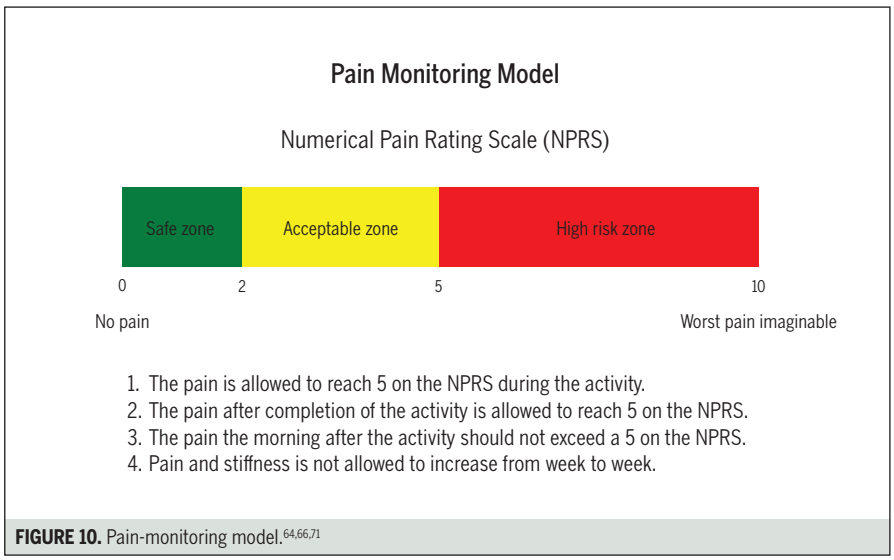

FIGURE 10. Pain-monitoring model.[64,66,71]

with return to sport or return to previous activity level as an outcome. Based on that study, after 12 weeks of treatment, the percentage of participants who reported a return to sport ranged from 10% to 86%.[13,47,60] At 1-year follow-up, 55% to 90% of the participants were reportedly back to sport participation.[13,66] However, the symptomatic state of the participants who returned to sport in the above-mentioned study was not reported.

In the literature, resumption of activities such as running and jumping is generally recommended when the symptoms have subsided.[4,67] Often, studies include an intervention for a minimum of 12 weeks, and then describe that return to sport is allowed.[30,56] However, resting from sporting activities during the early phase of treatment may not be necessary. The only known study to allow monitored sporting activity early in the rehabilitation[64] observed no negative impact of this approach, which might also have the benefits of improving compliance and helping to maintain the athlete's overall health status. Gradual progression into the specific sport activity is generally recommended.[25,28]

What we have learned from research and clinical practice is that the return-to-sport phase is a balancing act between a swift return to full activity and avoiding overloading and reinjury of the tendon. There are various factors that need to be considered when planning the return to sport after Achilles tendinopathy (**TABLE 3**). The most obvious factor, which is also the one most often addressed in the literature, is the level of pain with physical activity.[48] Other important factors that need to be included in the decision-making process are the healing and recovery of the tendon tissue[18,30,43]; the recovery of strength, range of motion, and function; as well as the demands of the specific sport.[19,65] The objective with this return-to-sport program[15] was to design a program that would achieve optimal loading for the Achilles tendon in preparation for full return to sports.

Factors to Consider When Planning Return to Sports

Tendon Injury The pathology of tendinopathy is described as either failed healing or degeneration due to continuous overloading.[18] Chronic tendinopathy has also been found not to be an inflammatory condition.[10,34,58] Clinically, patients with Achilles tendinopathy are diverse and show a symptom duration ranging from a week to intermittent symptoms for many years. Cook and Purdam[18] proposed a pathology model to explain the various clinical presentations of load-induced tendinopathy. In their model, the reactive tendinopathy/early tendon disrepair stage is the acutely overloaded tendon more often seen in younger individuals. The tendon disrepair/degeneration stage presents as the chronically overloaded tendon with a more focal Achilles tendon thickening and pain, more often seen in the middle-aged recreational athlete. As pointed out by the authors, this model is a simplification of the complexity of tendinopathy but provides some guidelines for the clinician.

Mechanical loading of injured tendons is of major importance for promoting healing and recovery of tendon tissue.[36,37] At the same time, overloading of the tendon with insufficient recovery may result in tendon damage.[43] The tendon's structural remodeling, which is considered an integral part of the healing, is affected by the duration, magnitude, and timing of loading.[21] During recovery from tendinopathy, it is therefore important to ensure that the dosage of loading is appropriate to the capacity of the individual and the stage of tendon pathology, with appropriate monitoring of response to loading. The above-mentioned pain-monitoring model (**FIGURE 10**) helps guide appropriate loading for the pathology and the individual. The continuous use of valid and reliable outcome measures to evaluate patient-reported symptoms, such as the Victorian Institute of Sport Assessment-Achilles[59] (VISA-A) questionnaire, and recovery of impairments[63] (eg, strength, endurance, and jumping ability) can assist in evaluating the individual athlete's response.

TABLE 3 Factors to Consider When Planning Return to Sports

Factor	Consideration
Tendon healing	• Consider what stage of tendon healing the patient is in • Full tendon healing can take up to 12 months[32] • Mechanical loading of the tendon is important for promoting tendon healing[36,37] • Age, hormonal levels, medication, and genetics affect healing[9,44,52]
Tendon recovery	• The tendon seems to take up to 3 days to recover from heavy loading, so plan for appropriate recovery days[37,41,42,51]
Pain and symptoms	• It is acceptable to exercise and load the Achilles tendon even if it is painful; use the pain-monitoring model (**FIGURE 10**) as a guide[64,66] • It is important to also evaluate pain and symptoms the day after tendon-loading activity, especially in the latter stages of the return-to-sport phase
Impairments	• Patients with Achilles tendinopathy have been found to have deficits in strength, endurance, range of motion, and jumping ability, and these should be addressed[5,49,63] • The impairments might not automatically be resolved even if symptoms are no longer present[65]
Load on the Achilles tendon	• It is important to remember that speed and the specific task affect Achilles tendon load[6,14,38]
Perceived rate of exertion[11]	• Because individual patients have different baseline abilities, using their perceived exertion will assist in determining how to progress the specific sport activities

Tendon Recovery During running and jumping, the Achilles tendon is subjected to tensile loads as high as 6 to 12 times body weight.[22,38] If the recovery time between heavy-loading exercise sessions is inadequate, cumulative trauma may lead to major injury such as Achilles tendinopathy.[1,43,56] It is proposed that tendinopathy is a result of collagen degradation occurring at a greater rate than collagen synthesis.[7] Exercise in humans has been shown to result in a net decrease of collagen during the first 24 to 36 hours following the exercises, but a net increase after 36 to 78 hours.[37,41,42,51] This indicates that the tendon's response to loading might take up to 3 days to occur, suggesting that athletes should plan for 2 to 3 days of recovery between heavy Achilles tendon–loading activities. Our return-to-sport program therefore incorporates 3 recovery days between heavy tendon-loading activities to ensure that the tendon has adequate time to repair itself. In the clinic, we recommend 3 recovery days between heavy tendon-loading activities while increasing the training level. At the latter stages, the amount of recovery days can be decreased. It must also be considered that in addition to the tendon needing to recover from the injury, the forced decrease in activity may also affect the tendon's loading capacity, which needs to be regained during the latter stages of rehabilitation.

Factors that can influence the rate of tendon tissue recovery need to be considered when planning for return to sports. These factors include age, hormonal levels, medications, and genetics.[9,44,52] It has been suggested that patients less than 35 years of age tend to develop load-related degenerative tendinopathy and older individuals tend to develop more of an age-related disease.[73] Because the turnover rate of collagen may decrease with advancing age,[36] it may take longer for older athletes to recover from tendinopathy.

Pain and Symptoms The most common symptoms of Achilles tendinopathy are pain and stiffness.[30] Allowing the patient to experience pain during rehabilitation appears to have no negative effect on recovery.[4,66] In fact, allowing for pain may be necessary to ensure that the Achilles tendon load is sufficient to create meaningful adaptive changes in the tendon.[3]

Patients who have had painful tendinopathy for an extended period may have developed central sensitization with hyperalgesia and allodynia.[27] The pain-monitoring model (**FIGURE 10**) can guide patients on how to cope with and respond to pain during rehabilitation[64,66] by facilitating patients' understanding of the amount of pain allowed during and after exercise. A study[64] that used the pain-monitoring model to determine the level of continued sports activity (including running and jumping) allowed during rehabilitation found no negative effects from continuing such activities and incorporating recovery days between activities. This indicates that an athlete may not have to completely stop athletic activity and that graded return-to-sport activity may be started prior to complete absence of symptoms. This approach may also minimize deconditioning of the athlete.

Visnes et al[72] also allowed continued physical activity during treatment of elite volleyball players with patellar tendinopathy but found no positive effect of eccentric training combined with normal in-season training. These contrasting results may reflect not using a physical activity–monitoring model, such as the pain-monitoring model, or not incorporating recovery days. The VISA-A questionnaire[59] should also be used to evaluate the patient-reported symptoms over time.

During the latter stage of recovery from tendon injury, symptoms might be absent during activity; however, the athlete may notice increased pain and/or stiffness on the following day.[1,43] Therefore, monitoring the athlete over the 2 to 48 hours following the activity is critical to determine whether the intensity level was appropriate. In the clinic, the use of a training diary in which the athlete documents the pain level during the activity, as well as the next day (especially morning stiffness), is of great use both for the athlete and the clinician.

Impairments Achilles tendinopathy is not only associated with pain and symp-

toms, but also with impairments such as decreases in strength, endurance, and plyometric ability.[5,49,55,63] The mechanical properties of the tendon also change with tendinopathy.[8,17] The tendinopathic tendon has been found to have lower tendon stiffness,[8,17] which might also affect the tendon's force-generating capabilities.

Risk factors for developing Achilles tendinopathy include calf muscle weakness and/or muscle imbalance and altered joint mobility of the foot and ankle complex.[16,33,49,53] Addressing these factors with the aim of regaining full capacity is important for athletes prior to full sports participation.[19] It has also been found that full symptomatic recovery does not ensure full recovery of musculotendinous function of the lower extremity in patients with Achilles tendinopathy.[65] Therefore, athletes should be advised that, even though the symptoms have subsided, they may not have fully recovered from the injury. Continued monitoring and evaluation of various physical parameters during the rehabilitation and return-to-sport phase might prevent overtraining and guide how to design a maintenance program for that specific athlete.

A battery of tests of lower-limb strength, endurance, and jumping ability has also been developed for patients with Achilles tendinopathy.[63] This test battery has been found to be reliable and valid and can be used to evaluate changes in function over time. Functional deficits may not only increase the risk of reinjury but also put the athlete at risk for other injuries.[54] Rehabilitation for the injury and addressing impairments as well as functional deficits and possible risk factors are important during the return-to-sport phase. Following full return to sports, a maintenance program is recommended to be continued for at least a whole season.[67]

The Load of the Activity In the literature, there appears to be a consensus that return to full sports activity should involve a gradual loading progression. It is therefore of great importance to have knowledge of the rate and magnitude of Achilles tendon loads during various activities. At low rates of loading, tendons are more viscous or ductile and, consequently, can absorb more energy compared to high loading rates.[14] At high rates of loading, tendons become more brittle and absorb less energy, but they are more effective at transferring loads.[14] Therefore, tendon load can be increased in 2 ways when prescribing exercise: by the external load or by the speed of movement.[31]

In vivo measurements of the Achilles tendon performed by Komi et al[38] indicated that the Achilles tendon was loaded up to 12 times body weight during running, with the actual load being related to running speed. Their work[38] also indicated that when walking, the force was approximately 3.5 times body weight, whereas during cycling the load was close to body weight. The authors[38] also measured the Achilles tendon load during hopping (a submaximal jump similar to jumping rope), and the force was approximately 5 times body weight. It is important to remember that this invasive study was conducted on a few participants and that the tendon forces are likely to vary considerably between individuals. But, in

TABLE 4 The Borg Category-Ratio Rating of Perceived Exertion Scale[11]

Score	Description
0	Nothing at all
0.5	Very, very weak
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong
6	...
7	Very strong
8	...
9	...
10	Very, very strong

TABLE 5 The Classification Schema

	Classification of Activities		
	Light	Medium	High
Pain level during activity, NPRS (0-10)	1-2	2-3	4-5
Pain level after activity (next day), NPRS (0-10)	1-2	3-4	5-6
The athlete's RPE (with regard to the Achilles tendon) (0-10)	0-1	2-4	5-10
Recovery days needed between activities	0 (can be performed daily)	2	3
Examples of activities for a runner	Walking for 70 minutes	Jogging on flat surface for 30 minutes	Running 85% of preinjury speed for 20 minutes

Abbreviations: NPRS, numeric pain-rating scale; RPE, rate of perceived exertion.

TABLE 6 A 3-Week Return-to-Sport Plan for a Long-Distance Runner

Day	Activity	Symptoms/Perceived Exertion Documented by the Athlete
1	Jogging 30 minutes plus rehabilitation exercises	
2	Walking 70 minutes plus rehabilitation exercises	
3	Walking 70 minutes plus rehabilitation exercises	
4	Running 85% for 20 minutes plus rehabilitation exercises	
5	Walking 70 minutes plus rehabilitation exercises	
6	Walking 70 minutes plus rehabilitation exercises	
7	Walking 70 minutes plus rehabilitation exercises	
8	Running 85% for 20 minutes plus rehabilitation exercises	
9	Walking 70 minutes plus rehabilitation exercises	
10	Walking 70 minutes plus rehabilitation exercises	
11	Walking 70 minutes plus rehabilitation exercises	
12	Jogging 30 minutes plus rehabilitation exercises	
13	Walking 70 minutes plus rehabilitation exercises	
14	Walking 70 minutes plus rehabilitation exercises	
15	Running 85% for 20 minutes plus rehabilitation exercises	
16	Walking 70 minutes plus rehabilitation exercises	
17	Walking 70 minutes plus rehabilitation exercises	
18	Walking 70 minutes plus rehabilitation exercises	
19	Running 85% for 20 minutes plus rehabilitation exercises	
20	Walking 70 minutes plus rehabilitation exercises	
21	Walking 70 minutes plus rehabilitation exercises	

general, it is mostly considered that activities such as slower walking are associated with less force than faster walking, and a slower running pace produces less force than a faster running pace on the Achilles tendon.[38]

Furthermore, running with a rearfoot-strike pattern is considered to load the Achilles tendon less than running with a forefoot-strike pattern.[38] One recent study determined that running with a midfoot- or forefoot-strike pattern, as opposed to a rearfoot-strike pattern, added an additional load of 48 times body weight for each mile (1.6 km) run.[6] Therefore, within the context of return to sport, to control for overall loading, a runner who runs with a forefoot-strike pattern would not be allowed to run as far as a runner with a rearfoot-strike pattern.

A systematic review found that a high breaking force during running may be a risk factor for Achilles tendinopathy.[45] Using a shorter step length when running could be an appropriate adaptation for some runners. In addition, the authors of that systematic review[45] found that running on a stiffer surface was related to decreased injury risk. The above knowledge is part of the basis on which the specific athlete's activity is modified to ensure a gradual progression into his or her specific sport.

Perceived Rate of Exertion Because the loading response of the tendon varies between individuals, we also believe that it is important to add the athlete's rating of perceived Achilles tendon exertion into the equation. An athlete's perception of task difficulty, in reference to the Achilles tendon, will vary depending on the sport and individual characteristics. The rating of perceived exertion (RPE)[11] has been used by clinicians, coaches, and researchers as a simple tool to monitor and adjust exercise intensity since it was developed in the 1960s.[12] In the return-to-sport program, the Borg category-ratio scale (**TABLE 4**) is used as a tool for the patient/athlete to grade how heavy they perceive various activities are for their Achilles tendon. The RPE scale is also a familiar measurement for coaches and athletes and provides an additional measure to assist in designing the individual athlete's return-to-sport progression. This is especially useful when working with elite athletes in a variety of sports, where the clinician might not have an in-depth knowledge of the various components of the athlete's training program.

Principles of the Return-to-Sport Program

The guiding principle of the return-to-sport program (**TABLE 5**) is to progressively increase the demand on the tendon by controlling the intensity, duration, and frequency of Achilles tendon loading. Before an athlete is allowed to return to any running or jumping activity, he or she should have minimal (1/10 to 2/10 on the numeric pain-rating scale) to no pain with all activities of daily living. It is also important to consider that during the return-to-sport phase the rehabilitation program (**TABLE 2**) is continued daily, including days when the athlete runs, jumps, or performs other athletic activities.

Step 1 is to educate the athlete about the injury. In our opinion, important aspects to discuss with the athletes are that tendons take longer than muscles to heal and that the symptoms may subside prior to full recovery of the tendon.[43] Explaining the pain-monitoring model and how to use it is done during the initial treatment session but also revisited throughout the rehabilitation and return-to-sport phase. Clinically, we introduce the principles of the return-to-sport program within a few weeks after the start of the

TABLE 7 The Second Revised Plan for the Same Long-Distance Runner, With Changes in Classification of Light, Medium, and High Activities

Day	Activity	Symptoms/Perceived Exertion Documented by the Athlete
1	Jogging 40 minutes plus rehabilitation exercises	
2	Walking 90 minutes plus rehabilitation exercises	
3	Walking 90 minutes plus rehabilitation exercises	
4	Running 90% for 25 minutes plus rehabilitation exercises	
5	Walking 90 minutes plus rehabilitation exercises	
6	Walking 90 minutes plus rehabilitation exercises	
7	Walking 90 minutes plus rehabilitation exercises	
8	Running 90% for 25 minutes plus rehabilitation exercises	
9	Walking 90 minutes plus rehabilitation exercises	
10	Walking 90 minutes plus rehabilitation exercises	
11	Walking 90 minutes plus rehabilitation exercises	
12	Jogging 40 minutes plus rehabilitation exercises	
13	Walking 90 minutes plus rehabilitation exercises	
14	Walking 90 minutes plus rehabilitation exercises	
15	Running 90% for 25 minutes plus rehabilitation exercises	
16	Walking 90 minutes plus rehabilitation exercises	
17	Walking 90 minutes plus rehabilitation exercises	
18	Walking 90 minutes plus rehabilitation exercises	
19	Running 90% for 25 minutes plus rehabilitation exercises	
20	Walking 90 minutes plus rehabilitation exercises	
21	Walking 90 minutes plus rehabilitation exercises	

rehabilitation program. This is discussed even if the athlete is not ready to start the return-to-sport phase. Educating the athlete in the theory behind the program is important for compliance and for having an open communication about the process. All patients complete daily training diaries, in which they report their rehabilitation exercises, other activities, and pain levels (in the morning, during activity, and in the evening). The clinician consistently reviews this information and discusses progress with the patient.

Step 2 is the initiation of the program when the athlete meets the requirement of performing activities of daily living with pain no higher than 2/10. At this step, an important task is to determine and classify specific activities as light, medium, or high level, based on pain rating during and after the activity, and the athlete's perceived Achilles tendon exertion (**TABLE 5**).[11] This is done together by the clinician, athlete, and coach. Here, the clinician's knowledge on how to progress loading on the Achilles tendon is of great importance, along with an understanding of the athlete's sport. For example, if the athlete is a runner, the initial running activity can be of a slow speed on a flat surface and possibly utilizing more of a rearfoot-strike pattern to lower the Achilles tendon loading.

In **TABLE 5**, the criteria for each activity level are provided. An activity is considered light if the pain is no more than 2/10, either during the activity or the next day, and if the athlete perceives the activity as very weak (1/10) on the RPE scale. A medium-level activity corresponds to a pain level of 2/10 to 3/10 during the activity and up to 4/10 the next day, and the athlete should rate the perceived exertion to be no more than somewhat strong (4/10) on the RPE scale. A high-level activity corresponds to a pain level of 4/10 to 5/10 during the activity and up to 6/10 the next day, and the athlete rates the perceived exertion to be 5/10 or greater on the RPE scale. Several activities can be identified for each activity level. Subsequently, a specific training schedule for approximately 2 to 3 weeks is planned for the athlete.

Light-level activity can be performed daily. After a medium-level activity, 2 days of recovery are needed, during which the athlete cannot perform activity of the same or higher level. High-level activities require 3 days of recovery after medium- and/or high-level activities. When the athlete improves (ie, the pain level and the perceived exertion level decrease), a new activity classification is performed. Usually, the classification is revisited every 3 weeks. A previous medium-level activity might then become light, and a new activity can be added on the high list. In **TABLES 5** through **7**, examples of how the return-to-sport program may look for a runner and how it may progress over time are shown. The athlete is required to document pain and symptoms daily and to grade the perceived exertion after each activity. The pain and perceived exertion should agree with the guidelines in the classification scheme; otherwise, an adjustment of the activity should be made.

CONCLUSION

For athletes with Achilles tendinopathy, the extent of tendon injury, the age of the athlete, the amount of pain/symptoms, the extent of impairments, and the demands of the sport all need to be considered when planning for return to sports. In general, athletes with Achilles tendinopathy can be expected to

return to sport anywhere from 6 weeks to 1 year after the initial injury. However, the athlete is not considered completely recovered until he or she has participated for a full season without symptoms. The aim of the proposed return-to-sport program is to facilitate the decision-making process of how to progress sports participation in athletes with midportion Achilles tendinopathy, while minimizing the chance of recurrence of symptoms. Future research is needed to determine success rate and usefulness of the return-to-sport program for athletes in various sports.

REFERENCES

1. Abate M, Silbernagel KG, Siljeholm C, et al. Pathogenesis of tendinopathies: inflammation or degeneration? *Arthritis Res Ther*. 2009;11:235. http://dx.doi.org/10.1186/ar2723
2. Al-Abbad H, Simon JV. The effectiveness of extracorporeal shock wave therapy on chronic Achilles tendinopathy: a systematic review. *Foot Ankle Int*. 2013;34:33-41.
3. Alfredson H. Chronic midportion Achilles tendinopathy: an update on research and treatment. *Clin Sports Med*. 2003;22:727-741. http://dx.doi.org/10.1016/S0278-5919(03)00010-3
4. Alfredson H, Pietilä 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.
5. Alfredson H, Pietilä T, Öhberg L, Lorentzon R. Achilles tendinosis and calf muscle strength. The effect of short-term immobilization after surgical treatment. *Am J Sports Med*. 1998;26:166-171.
6. Almonroeder T, Willson JD, Kernozek TW. The effect of foot strike pattern on Achilles tendon load during running. *Ann Biomed Eng*. 2013;41:1758-1766. http://dx.doi.org/10.1007/s10439-013-0819-1
7. Arnoczky SP, Lavagnino M, Egerbacher M. The mechanobiological aetiopathogenesis of tendinopathy: is it the over-stimulation or the under-stimulation of tendon cells? *Int J Exp Pathol*. 2007;88:217-226. http://dx.doi.org/10.1111/j.1365-2613.2007.00548.x
8. Arya S, Kulig K. Tendinopathy alters mechanical and material properties of the Achilles tendon. *J Appl Physiol (1985)*. 2010;108:670-675. http://dx.doi.org/10.1152/japplphysiol.00259.2009
9. Aspenberg P. Stimulation of tendon repair: mechanical loading, GDFs and platelets. A mini-review. *Int Orthop*. 2007;31:783-789. http://dx.doi.org/10.1007/s00264-007-0398-6
10. Åström M, Rausing A. Chronic Achilles tendinopathy: a survey of surgical and histopathologic findings. *Clin Orthop Relat Res*. 1995:151-164.
11. Borg G. *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics; 1998.
12. Brandt M, Jakobsen MD, Thorborg K, Sundstrup E, Jay K, Andersen LL. Perceived loading and muscle activity during hip strengthening exercises: comparison of elastic resistance and machine exercises. *Int J Sports Phys Ther*. 2013;8:811-819.
13. 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. http://dx.doi.org/10.1136/bjsm.2005.021931
14. Butler DL, Grood ES, Noyes FR, Zernicke RF. Biomechanics of ligaments and tendons. *Exerc Sport Sci Rev*. 1978;6:125-181.
15. Calder JD, Karlsson J, Maffulli N, Thermann H, van Dijk CN. *Current Concepts in Achilles Tendinopathy*. Guildford, UK: DJO Publications; 2010.
16. Carcia CR, Martin RL, Houck J, Wukich DK. Achilles pain, stiffness, and muscle power deficits: Achilles tendinitis. *J Orthop Sports Phys Ther*. 2010;40:A1-A26. http://dx.doi.org/10.2519/jospt.2010.0305
17. Child S, Bryant AL, Clark RA, Crossley KM. Mechanical properties of the Achilles tendon aponeurosis are altered in athletes with Achilles tendinopathy. *Am J Sports Med*. 2010;38:1885-1893. http://dx.doi.org/10.1177/0363546510366234
18. Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. *Br J Sports Med*. 2009;43:409-416. http://dx.doi.org/10.1136/bjsm.2008.051193
19. Cook JL, Purdam CR. Rehabilitation of lower limb tendinopathies. *Clin Sports Med*. 2003;22:777-789. http://dx.doi.org/10.1016/S0278-5919(03)00007-3
20. de Jonge S, van den Berg C, de Vos RJ, et al. Incidence of midportion Achilles tendinopathy in the general population. *Br J Sports Med*. 2011;45:1026-1028. http://dx.doi.org/10.1136/bjsports-2011-090342
21. Freedman BR, Gordon JA, Soslowsky LJ. The Achilles tendon: fundamental properties and mechanisms governing healing. *Muscles Ligaments Tendons J*. 2014;4:245-255.
22. Fukashiro S, Komi PV, Järvinen M, Miyashita M. In vivo Achilles tendon loading during jumping in humans. *Eur J Appl Physiol Occup Physiol*. 1995;71:453-458. http://dx.doi.org/10.1007/BF00635880
23. Gajhede-Knudsen M, Ekstrand J, Magnusson H, Maffulli N. Recurrence of Achilles tendon injuries in elite male football players is more common after early return to play: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:763-768. http://dx.doi.org/10.1136/bjsports-2013-092271
24. Gross CE, Hsu AR, Chahal J, Holmes GB, Jr. Injectable treatments for noninsertional Achilles tendinosis: a systematic review. *Foot Ankle Int*. 2013;34:619-628. http://dx.doi.org/10.1177/1071100713475353
25. Hägglund M, Waldén M, Ekstrand J. Lower reinjury rate with a coach-controlled rehabilitation program in amateur male soccer: a randomized controlled trial. *Am J Sports Med*. 2007;35:1433-1442. http://dx.doi.org/10.1177/0363546507300063
26. Haglund-Åkerlind Y, Eriksson E. Range of motion, muscle torque and training habits in runners with and without Achilles tendon problems. *Knee Surg Sports Traumatol Arthrosc*. 1993;1:195-199. http://dx.doi.org/10.1007/BF01560205
27. Heales LJ, Lim EC, Hodges PW, Vicenzino B. Sensory and motor deficits exist on the non-injured side of patients with unilateral tendon pain and disability—implications for central nervous system involvement: a systematic review with meta-analysis. *Br J Sports Med*. 2014;48:1400-1406. http://dx.doi.org/10.1136/bjsports-2013-092535
28. Humble RN, Nugent LL. Achilles' tendonitis. An overview and reconditioning model. *Clin Podiatr Med Surg*. 2001;18:233-254.
29. Järvinen TA, Kannus P, Maffulli N, Khan KM. Achilles tendon disorders: etiology and epidemiology. *Foot Ankle Clin*. 2005;10:255-266. http://dx.doi.org/10.1016/j.fcl.2005.01.013
30. 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. http://dx.doi.org/10.1136/bjsm.36.4.239
31. Kannus P. Etiology and pathophysiology of chronic tendon disorders in sports. *Scand J Med Sci Sports*. 1997;7:78-85. http://dx.doi.org/10.1111/j.1600-0838.1997.tb00123.x
32. Kannus P, Józsa L, Natri A, Järvinen M. Effects of training, immobilization and remobilization on tendons. *Scand J Med Sci Sports*. 1997;7:67-71. http://dx.doi.org/10.1111/j.1600-0838.1997.tb00121.x
33. 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.
34. Khan KM, Cook JL, Bonar F, Harcourt P, Åstrom M. Histopathology of common tendinopathies. Update and implications for clinical management. *Sports Med*. 1999;27:393-408. http://dx.doi.org/10.2165/00007256-199927060-00004
35. Kingma JJ, de Knikker R, Wittink HM, Takken T. Eccentric overload training in patients with chronic Achilles tendinopathy: a systematic review. *Br J Sports Med*. 2007;41:e3. http://dx.doi.org/10.1136/bjsm.2006.030916
36. Kjaer M. Role of extracellular matrix in adaptation of tendon and skeletal muscle to mechanical loading. *Physiol Rev*. 2004;84:649-698. http://dx.doi.org/10.1152/physrev.00031.2003
37. Kjaer M, Langberg H, Miller BF, et al. Metabolic activity and collagen turnover in human tendon in response to physical activity. *J Musculoskelet Neuronal Interact*. 2005;5:41-52.
38. Komi PV, Fukashiro S, Järvinen M. Biomechanical loading of Achilles tendon during normal locomotion. *Clin Sports Med*. 1992;11:521-531.
39. Kvist M. Achilles tendon injuries in athletes. *Ann*

Chir Gynaecol. 1991;80:188-201.
40. Kvist M. Achilles tendon injuries in athletes. *Sports Med*. 1994;18:173-201. http://dx.doi.org/10.2165/00007256-199418030-00004
41. Langberg H, Rosendal L, Kjaer M. Training-induced changes in peritendinous type I collagen turnover determined by microdialysis in humans. *J Physiol*. 2001;534:297-302. http://dx.doi.org/10.1111/j.1469-7793.2001.00297.x
42. Langberg H, Skovgaard D, Petersen LJ, Bülow J, Kjaer M. Type I collagen synthesis and degradation in peritendinous tissue after exercise determined by microdialysis in humans. *J Physiol*. 1999;521 pt 1:299-306. http://dx.doi.org/10.1111/j.1469-7793.1999.00299.x
43. Leadbetter WB. Cell-matrix response in tendon injury. *Clin Sports Med*. 1992;11:533-578.
44. Longo UG, Ronga M, Maffulli N. Achilles tendinopathy. *Sports Med Arthrosc*. 2009;17:112-126. http://dx.doi.org/10.1097/JSA.0b013e3181a3d625
45. Lorimer AV, Hume PA. Achilles tendon injury risk factors associated with running. *Sports Med*. 2014;44:1459-1472. http://dx.doi.org/10.1007/s40279-014-0209-3
46. Maffulli N, Khan KM, Puddu G. Overuse tendon conditions: time to change a confusing terminology. *Arthroscopy*. 1998;14:840-843. http://dx.doi.org/10.1016/S0749-8063(98)70021-0
47. 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.
48. Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med*. 2009;19:54-64. http://dx.doi.org/10.1097/JSM.0b013e31818ef090
49. 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. http://dx.doi.org/10.1177/0363546505279918
50. Malliaras P, Barton CJ, Reeves ND, Langberg H. Achilles and patellar tendinopathy loading programmes: a systematic review comparing clinical outcomes and identifying potential mechanisms for effectiveness. *Sports Med*. 2013;43:267-286. http://dx.doi.org/10.1007/s40279-013-0019-z
51. Miller BF, Olesen JL, Hansen M, et al. Coordinated collagen and muscle protein synthesis in human patella tendon and quadriceps muscle after exercise. *J Physiol*. 2005;567:1021-1033. http://dx.doi.org/10.1113/jphysiol.2005.093690
52. Mokone GG, Schwellnus MP, Noakes TD, Collins M. The *COL5A1* gene and Achilles tendon pathology. *Scand J Med Sci Sports*. 2006;16:19-26. http://dx.doi.org/10.1111/j.1600-0838.2005.00439.x
53. Munteanu SE, Barton CJ. Lower limb biomechanics during running in individuals with Achilles tendinopathy: a systematic review. *J Foot Ankle Res*. 2011;4:15. http://dx.doi.org/10.1186/1757-1146-4-15
54. Murphy DF, Connolly DA, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med*. 2003;37:13-29. http://dx.doi.org/10.1136/bjsm.37.1.13
55. Niesen-Vertommen SL, Taunton JE, Clement DB, Mosher RE. The effect of eccentric versus concentric exercise in the management of Achilles tendonitis. *Clin J Sport Med*. 1992;2:109-113. http://dx.doi.org/10.1097/00042752-199204000-00006
56. Paavola M, Kannus P, Järvinen TA, Khan K, Józsa L, Järvinen M. Achilles tendinopathy. *J Bone Joint Surg Am*. 2002;84-A:2062-2076.
57. Pearce CJ, Carmichael J, Calder JD. Achilles tendinoscopy and plantaris tendon release and division in the treatment of non-insertional Achilles tendinopathy. *Foot Ankle Surg*. 2012;18:124-127. http://dx.doi.org/10.1016/j.fas.2011.04.008
58. Puddu G, Ippolito E, Postacchini F. A classification of Achilles tendon disease. *Am J Sports Med*. 1976;4:145-150.
59. 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. http://dx.doi.org/10.1136/bjsm.35.5.335
60. Roos EM, Engström M, Lagerquist A, Söderberg 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. http://dx.doi.org/10.1111/j.1600-0838.2004.378.x
61. Sayana MK, Maffulli N. Eccentric calf muscle training in non-athletic patients with Achilles tendinopathy. *J Sci Med Sport*. 2007;10:52-58. http://dx.doi.org/10.1016/j.jsams.2006.05.008
62. Silbernagel KG, Brorsson A, Lundberg M. The majority of patients with Achilles tendinopathy recover fully when treated with exercise alone: a 5-year follow-up. *Am J Sports Med*. 2011;39:607-613. http://dx.doi.org/10.1177/0363546510384789
63. Silbernagel KG, Gustavsson A, Thomeé R, Karlsson J. Evaluation of lower leg function in patients with Achilles tendinopathy. *Knee Surg Sports Traumatol Arthrosc*. 2006;14:1207-1217. http://dx.doi.org/10.1007/s00167-006-0150-6
64. Silbernagel KG, Thomeé R, Eriksson BI, Karlsson J. Continued sports activity, using a pain-monitoring model, during rehabilitation in patients with Achilles tendinopathy: a randomized controlled study. *Am J Sports Med*. 2007;35:897-906. http://dx.doi.org/10.1177/0363546506298279
65. Silbernagel KG, Thomeé 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. http://dx.doi.org/10.1136/bjsm.2006.033464
66. Silbernagel KG, Thomeé R, Thomeé 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. http://dx.doi.org/10.1034/j.1600-0838.2001.110402.x
67. Stanish WD, Curwin S, Mandell S. *Tendinitis: Its Etiology and Treatment*. Oxford, UK: Oxford University Press; 2000.
68. 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. http://dx.doi.org/10.1177/0363546507312165
69. Stevens M, Tan CW. Effectiveness of the Alfredson protocol compared with a lower repetition-volume protocol for midportion Achilles tendinopathy: a randomized controlled trial. *J Orthop Sports Phys Ther*. 2014;44:59-67. http://dx.doi.org/10.2519/jospt.2014.4720
70. Sussmilch-Leitch SP, Collins NJ, Bialocerkowski AE, Warden SJ, Crossley KM. Physical therapies for Achilles tendinopathy: systematic review and meta-analysis. *J Foot Ankle Res*. 2012;5:15. http://dx.doi.org/10.1186/1757-1146-5-15
71. Thomeé R. A comprehensive treatment approach for patellofemoral pain syndrome in young women. *Phys Ther*. 1997;77:1690-1703.
72. Visnes H, Hoksrud A, Cook J, Bahr R. No effect of eccentric training on jumper's knee in volleyball players during the competitive season: a randomized clinical trial. *Clin J Sport Med*. 2005;15:227-234.
73. Wang HK, Lin KH, Su SC, Shih TT, Huang YC. Effects of tendon viscoelasticity in Achilles tendinosis on explosive performance and clinical severity in athletes. *Scand J Med Sci Sports*. 2012;22:e147-e155. http://dx.doi.org/10.1111/j.1600-0838.2012.01511.x
74. Wilson JJ, Best TM. Common overuse tendon problems: a review and recommendations for treatment. *Am Fam Physician*. 2005;72:811-818.