Thoughts and comments on long-distance training, injuries, and more

TUESDAY, NOVEMBER 19, 2013

Achilles tendonitis in runners: A degenerative overuse injury best treated with eccentric heel drops

Introduction

Achilles tendonitis is an extremely common injury, not just in running but in many sports. The severity of overuse injuries to the Achilles tendon can range from dull soreness that barely impacts your ability to run or play sports to chronic, debilitating pain that can last for months or years. Fortunately, due to its high incidence in athletes, Achilles tendonitis is a fairly well-studied injury.

The majority of Achilles tendonitis cases occur at the midpoint of the Achilles, a few inches above the heel. But a minority of cases—between 20 and 24%, according to a few studies[1, 2]—occur where the Achilles tendon flattens out and inserts at the ankle. This is called **insertional Achilles tendonitis**. While the majority of studies focus on **midpoint Achilles tendonitis**, and as such it is the better-understood variant, there is nevertheless a good deal that can be learned about insertional Achilles tendonitis as well. This article deals specifically with midpoint Achilles tendonitis; if you are interested in insertional Achilles tendonitis, a detailed follow-up article is in the works, or you can read this article on insertional Achilles tendonitis that accompanied the original Achilles tendonitis post. Unless otherwise qualified in this article, "Achilles tendonitis" will refer specifically to midpoint Achilles overuse injury.

Terminology

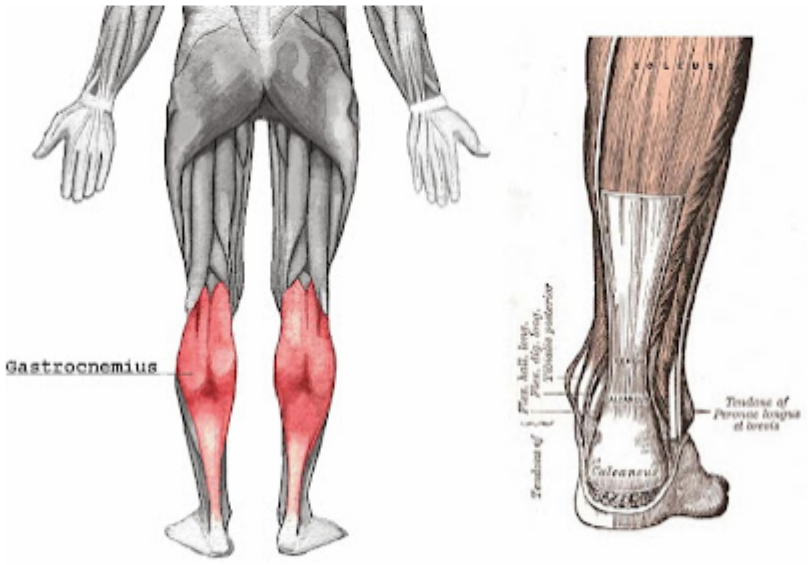
While "tendonitis" is by far the most common term used to refer to overuse injury to the Achilles tendon, it is not a strictly accurate term. The suffix "-itis" implies that the root cause or main feature of some condition is inflammation—as is the case in appendic**itis**, gingav**itis**, and so on. But, as we'll see in the research papers reviewed below, inflammation of the Achilles tendon or its surrounding tissues is *not* a common finding in athletes with overuse injuries to

the Achilles. Rather, their pain is caused by real, physical damage to and degradation of the small fibers that make up the Achilles tendon. Because of this, some doctors and researchers advocate renaming the injury "Achilles tendon**osis**" or "Achilles tendin**opathy**" to make it clear that degeneration of the tendon fibers is the root of the problem. Despite my support for this idea, I will use "tendonitis" in this article, as it is still the most common term for the injury.

In older literature, you might also see phrases like "Achilles tenosyndovitis" or "Achilles peritendinitis," terms which indicates that the source of the problem lies in the tissue that surrounds the Achilles tendon proper. Research on this is limited, so it is not clear to what extent (if any) injury to the sheath surrounding the Achilles plays a role in Achilles tendonitis.

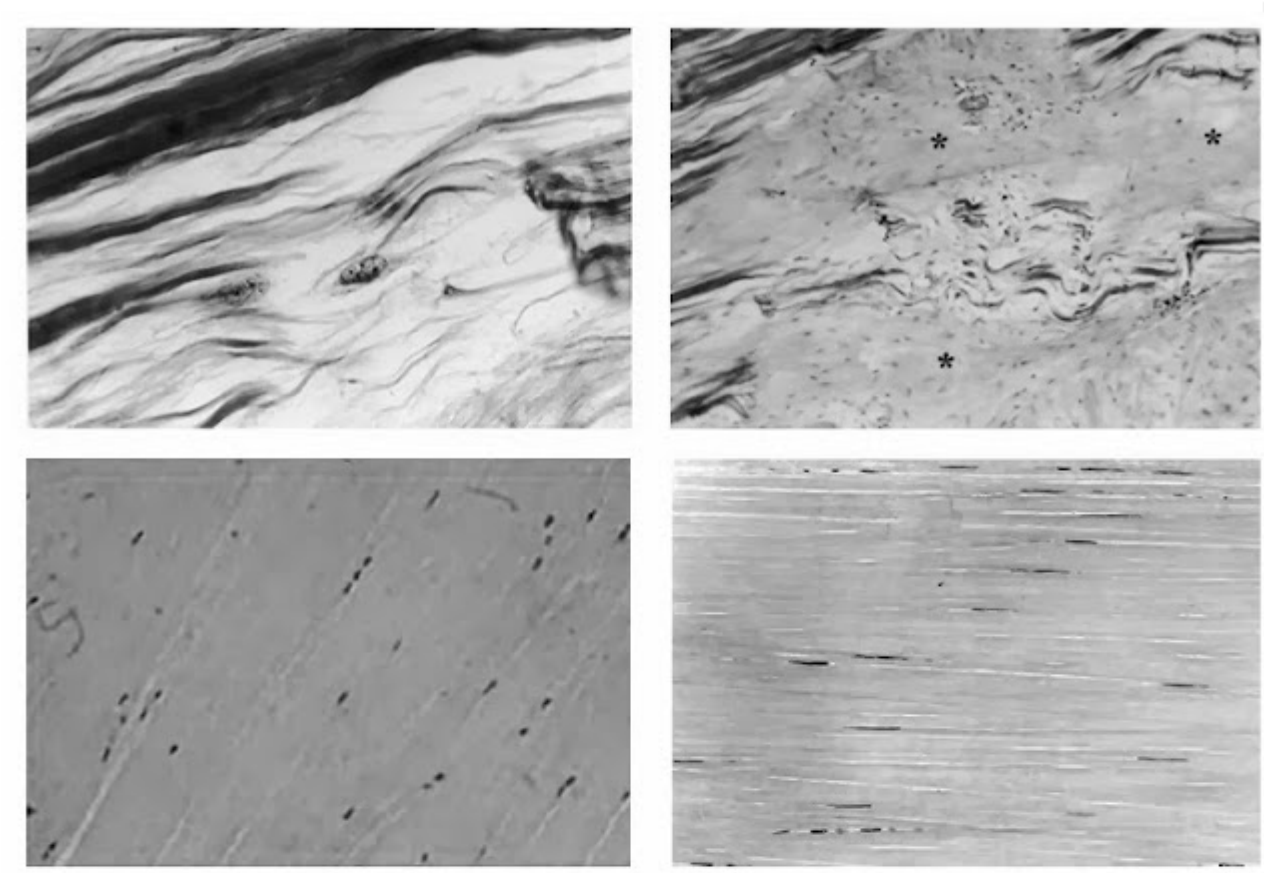
Anatomy

The Achilles tendon is the large, thick tendon at the back of your ankle. It connects the calf muscles to the base of your heel, and comes under very high tension both during impact with the ground, where the Achilles and calf help absorb the shock of landing, and during the "push-off" phase of running, when the calf and Achilles extend the ankle, propelling you off the ground. Though the Achilles tendon is "flexible" in the mechanical sense, its stiffness is more in line with that of a car's suspension spring than a rubber band—it would take around 900 pounds of force to stretch your Achilles by an inch![3] The incredible stiffness of the Achilles tendon allows it to store a large amount of energy, contributing to a quick and efficient running stride. Unfortunately, the magnitude of the forces that the Achilles handles during running and jumping are also probably responsible for its tendency to get injured.



The Achilles tendon connects the calf muscles--both the gastrocnemius and the soleus--to the heel. Some doctors and researchers refer to both muscles as one unit: the triceps surae.

Like all tendons, the Achilles is made up of **collagen**, a long-stranded protein that makes up much of the tough, fibrous material in your body: your skin, joint cartilage, ligaments, and tendons. In tendons, collagen is neatly arranged in a smooth, wavy pattern as shown below.[4]



Adapted from Paavola et al., Maffulli et al., and Skjong, Meininger, and Ho.

Healthy collagen fibers are parallel, wavy structures at the microscopic level (bottom left and bottom right). In an injured tendon, the collagen fibers appear disorganized, damaged, and degraded (top left and top right).

As with most parts of your musculoskeletal system, tendons repair themselves after normal stresses that occur during exercise and become stronger over time. But when the cumulative stress on a tendon becomes too great for the body to repair fully, overuse injury occurs.

The injury process

When the Achilles tendon becomes injured, the structure of the collagen near the injury site becomes disrupted. Initially, this disruption to normal tendon structure is minor, but if the injury worsens—as is often does when runners continue to run and race on an aching Achilles tendon—the structure of the collagen at the site of the injury becomes more and more deteriorated. Once chronic Achilles tendonitis (or rather, tendon*osis*, a true degeneration of the tendon) sets in, the collagen fibers at the site of the injury look more like a plate of spaghetti than the neatly-combed parallel strands in healthy tendons.[5]

Historically, Achilles tendonitis was thought to be primarily an inflammatory problem, hence the -itis suffix. But a good body of research has found that inflammation plays little or no role in the injury process in the Achilles tendon.[5] Inflammatory cells are not found when chronically injured or ruptured Achilles tendons have been examined under a microscope. Rather, the tissue samples of the tendon—usually taken from a patient during surgery for chronic Achilles

tendonitis or an Achilles tendon rupture—show marked signs of degeneration. The formerly-neat rows of collagen become a tangled mess replete with fibrous buildups. Further, when viewing multiple tissue samples, it becomes evident that the degeneration occurs gradually over time and without any concurrent inflammation.[6]

Though this rules out any role of inflammation in the chronic stages of Achilles tendonitis, there is still the possibility that there may be an initial "acute inflammatory stage" to Achilles tendonitis. Since few athletes with a minor Achilles injury only a few days old are willing to have their tendons sliced open in the name of science, the best we can do to investigate this is to look at animal studies. As J. D. Rees et al. write in a 2006 review article, there is conflicting evidence—two studies using rats suggest that there is no inflammatory phase at the beginning of a tendon injury, while another study of horses found that an inflammatory phase existed for the first two weeks after an overuse injury to a tendon.[7] But even if there *is* an inflammatory stage to tendon injury, there's still no evidence that treating it (with ice, compression, elevation, or nonsteroidal anti-inflammatory drugs like Advil) would help! Some research even suggests than anti-inflammatory drugs can *inhibit* tendon healing.[8, 9] So until there's more research on the subject, the role of inflammation in the initial stages of Achilles tendon injury is more of an academic interest than a practical one.

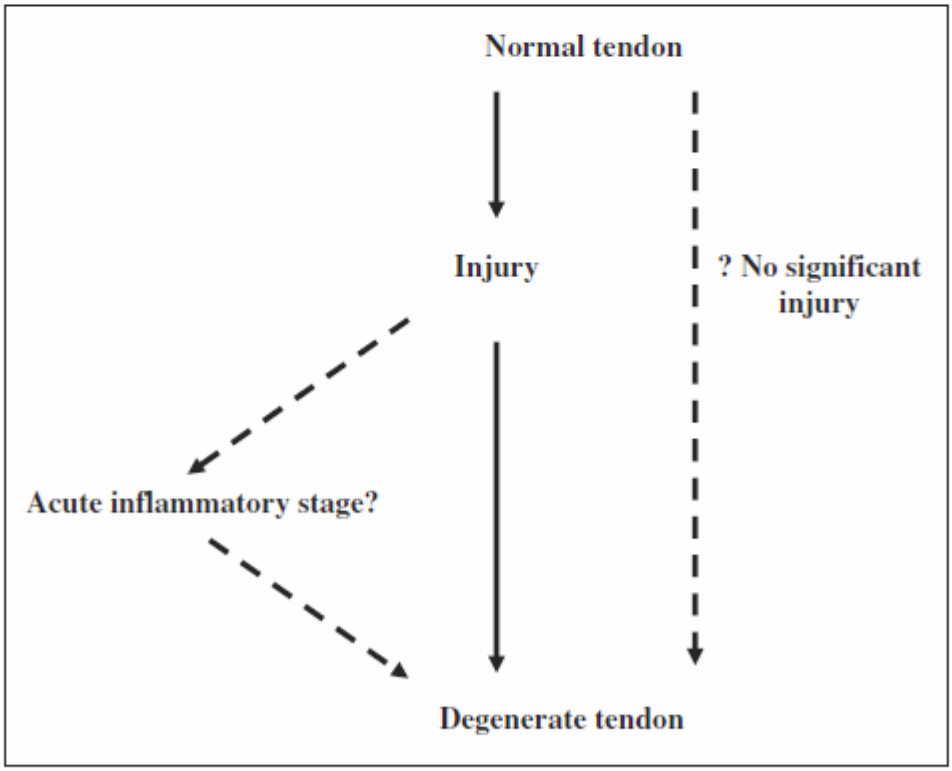


FIG. 2. Schematic representation of the process from initial injury to degenerative tendinopathy, highlighting the potential lack of either a significant inflammatory stage or discernible injury.

A schematic in Rees et al. illustrates two major unknowns about the injury process in Achilles tendonitis: 1) Is there an "acute inflammatory stage" that lasts for a few hours, days, or weeks following injury to the tendon? 2) Is it possible for continuous stress on the tendon to lead to a degenerated collagen structure without any overt injury?

Ultimately, all evidence points towards Achilles tendonitis being predominantly a degenerative injury without inflammation. Chronic overuse causes damage to the collagen fibers that make up the tendon; in a healthy tendon, the response would be remodeling and strengthening of the tendon fibers, but sometimes, either because of the degree of loading on the tendon (i.e. training too much) or because the healing process becomes somehow disrupted, the stressed collagen is not repaired correctly. As a result, collagen fibers become disorganized, and further stress results in more strain and damage to the tendon. This same degeneration process has been found in Achilles tendons which have ruptured, which is exactly what it sounds like—a macroscopic tear in the tendon which usually causes severe pain and an inability to use the tendon at all.[10] Given what we know about other running injuries, this degenerative process shouldn't be a surprise; it is quite similar to what is observed in plantar fasciitis and patellar tendonitis.

Symptoms and diagnosis

Achilles tendonitis manifests as an aching, painful sensation in the Achilles tendon. In midpoint Achilles tendonitis, the most common variant, the pain is worst in an area along the tendon between one and three inches from the base of the heel. There is pain and stiffness during running, hopping, or jumping, and there may also be stiffness in the tendon after getting out of bed in the morning. If you've had Achilles tendon pain for several weeks, you might be able to see or feel a thickening of the tendon in response to the localized tendon fiber damage. Hard nodules or lumps along your Achilles can also appear; these are the result of granules of fibrous tissue accumulating along the tendon.[5-6] It's also fairly common to have pain in *both* of your Achilles tendons; this is termed **bilateral** Achilles tendonitis and has a few implications for rehabilitation.

Insertional Achilles tendonitis is characterized by a similar aching, painful sensation, but it is very near where the tendon attaches to the base of the heel, and sometimes can extend into the bottom of your foot. For more on this injury, see this article on flat eccentric heel drops for insertional Achilles tendonitis.

Fortunately, diagnosis of Achilles tendonitis is fairly straightforward. An orthopedist or podiatrist can usually identify both midpoint and insertional Achilles tendonitis without any advanced imaging. However, imaging techniques like ultrasound or MRI might be useful to determine the severity of the injury or to check for partial tears in the tendon in particularly bad cases. The appearance of the Achilles tendon on diagnostic ultrasound is not directly linked to pain,[11] but can nevertheless sometimes be useful to gather information about the state of degradation in the tendon. MRI is not a particularly reliable diagnostic tool, but can predict the pace of recovery based on the severity of the abnormalities observed in the scan.[12]

Young runners, especially boys between the ages of 12-15, should be aware of a condition called **Sever's disease** or **calcaneal apophysitis**. Sever's disease is a somewhat murkily-defined overuse injury that causes heel pain and is associate with tight calves, so it can masquerade as Achilles tendonitis. Because its cause is rooted in the anatomy of the still-growing heelbone, it is not clear if any of the treatments below are useful for Sever's disease.[13] And unfortunately, because patients tend to recover within a few months,[14] there is hardly any research on treatment!

Causes and risk factors

The prevalence of Achilles tendonitis in jumping, running, and explosive sports indicates that it is "eccentric loading and explosive plyometric contractions" that are primarily responsible for the degeneration of the tendon, as described by Hess in an article on Achilles tendon degeneration and rupture.[15] Nevertheless, there are a number of factors which influence the prevalence of Achilles injuries in different populations of athletes.

Prevalence among men and women

Unlike the most common shin and knee injuries, Achilles tendonitis is not more common in women than men. Achilles tendonitis is at least as prevalent in men as it is in women—some studies[16] (though not all)[17] have found that men are *more* likely to sustain Achilles injuries. The reasons for this are not clear; women appear to suffer more from IT band syndrome and patellofemoral pain syndrome because of sex differences in hip mechanics, for example,[18] but there's no easy explanation for why men might get Achilles injuries more often than women. It may have to do with the fact that men tend to be heavier and run faster, both of which would increase the forces across the major load-carrying tendons and fascias of the body. Incidentally, some research has found that the patellar tendon and plantar fascia are *also* more commonly injured in men.[16] This, however, is only a conjecture.

Confusingly, research also indicates that women have a naturally lower rate of tendon repair after exercise.[19] The rate of tendon collagen synthesis can be further diminished by oral contraceptive use, perhaps leaving women who use them more vulnerable to tendon injury.[20] However, the natural variation in estrogen levels does not seem to affect tendon strain.[21] I was only able to find one study that connected oral contraceptive use with an increased risk for Achilles tendonitis, but it was incredibly weak. It was a study of sedentary, mostly middle-aged people, and used no direct control group—only population averages were referred to. Though the finding that eight of fifteen women who developed Achilles tendonitis were on an oral contraceptive was "statistically significant" in the study, the significance of this in the real world is very dubious.[22]

Given the prevalence of female athletes taking oral contraceptives (circa 50%),[23] whether for personal or health reasons, we would expect to see a slew of studies connecting contraceptive use and tendon injury, or at least a higher rate of tendon injuries in women than in men. Because these are both lacking in the literature, I don't think there is enough evidence yet to conclude that oral contraceptive use in athletes plays any significant role in the incidence of tendon injuries in female athletes.

Younger male runners are at a lower risk for developing Achilles tendonitis. One large study of injured runners found that being younger than 34 confers a protective effect for men, but not women;[16] an earlier study found that patients with Achilles tendonitis are, on average, four years older than patients with other sports injuries, though it did not differentiate between male and female athletes.[1]

Middle distance runners put more stress on their Achilles when running fast and while using spikes. This should lead to a greater risk of Achilles tendonitis, but research on this topic has been limited.

Theoretically speaking, middle distance runners as well as forefoot strikers should be at a higher risk for developing Achilles tendonitis, as high-speed running and forefoot striking both put increased stress on the Achilles tendon. Relatively little research has been published on this, however. One study of NCAA runners at Harvard University found a higher risk for Achilles tendonitis in female forefoot strikers, but not male ones.[24] In masters track and field athletes, it appears that event choice has no effect on the risk of developing Achilles tendonitis.[17] A 1987 study by Jack Lysholm and Jorgen Wiklander in Sweden noted that "hamstring strain and tendonitis" were more common in sprinters than in middle or long distance runners, but they did not specifically note in the abstract what type of tendonitis (this is one of the few articles I don't have full access to).[25]

The impact of how you run, beyond just footstrike style, is of particular interest to us, as this is one of the things you might be able to actively modify to decrease your risk of injury. In the case of other injuries, like IT band syndrome, investigating biomechanical risks for injury has illuminated useful treatments, so this is a good topic to investigate in detail for Achilles tendonitis, too.

Biomechanical factors: Prospective studies

The ideal way to detect gait-related risk factors for an injury is with a **prospective study**: one which gathers a group of healthy runners, measures a range of biomechanical factors, then follows the runners for a long period of time to see who gets injured. Unfortunately, prospective studies on Achilles tendonitis are limited, despite its prevalence among runners and among athletes in general.

However, a few have been published. A 2006 study of military recruits by N. N. Mahieu and other researchers at Ghent University in Belgium followed the 69 male recruits for their six-week military boot camp.[26] Those who developed Achilles tendonitis had demonstrated poor calf strength and increased ankle dorsiflexion range of motion at the outset of the study.

A 2009 study by many of the same researchers examined force distribution parameters among a group of 129 novice runners before they started a ten-week training program. Van Ginckel et al. found that the ten runners who developed Achilles tendonitis during the study displayed a decrease in "posterior-anterior displacement of the Center Of Force" and a more lateral

position of the center of force along the forefoot.[27] In layman's terms, this means that the runners who would go on to develop Achilles tendonitis had a weaker "push" off the ground and put more weight on the outside of their foot during the middle of the stance phase of running.

Biomechanically speaking, the results of both of these studies do not conflict with each other: poor calf strength could surely cause a runner to have a weaker push off the ground at the end of the stance phase. The connection between ankle dorsiflexion range of motion and the findings of Van Ginckel et al. are less clear—could this also cause less forward force transfer or more lateral loading of the forefoot? My biomechanical knowledge isn't detailed enough to answer that question.

Biomechanical factors: Retrospective studies

Having worked our way through the only two prospective studies that I'm aware of, we are now forced to turn to retrospective studies to try to uncover more risk factors for Achilles tendonitis. A **retrospective study** is one that takes its measurements in subjects who are *already* injured. The drawbacks of this are obvious: a biomechanical study, for example, might detect gait abnormalities brought on *because* of the injury, not ones which *caused* it. More simply, a limp or compensation to take pain off of the injured area could be misidentified as a causal factor. However, it is vastly easier to conduct a retrospective study, especially one with a lot of subjects, so there are several worth looking at.

The first is a 1991 study of 455 patients with Achilles tendonitis at the Turku Sports medical Research Unit in Finland.[1] Martti Kvist, the author, categorized the patients by several factors, reporting that the athletes with Achilles injures, who primarily consisted of runners and tennis players, tended to be about four years older than general sports injury patients and often displayed forefoot varus and poor range of motion at both the subtalar joint and in dorsiflexion of the ankle joint.

Forefoot varus is a "tilt" of the metatarsal heads where the outside of your forefoot naturally rests lower than the inside. The subtalar joint is the main controller of the pronation and supination of your foot—an inward roll (eversion) at the subtalar joint is exactly what a regular runner would call "pronation." Likewise, an outward roll (inversion) would cause supination.

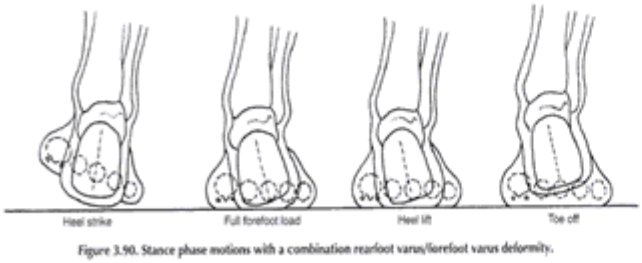


Figure 3.90. Stance phase motions with a combination rearfoot varus/forefoot varus deformity.

Forefoot varus coupled with pronation on impact

Another retrospective study which focused on the structure of the foot was conducted by Michael Ryan and others at the University of British Columbia.[28] This study examined 27 men with Achilles tendonitis and 21 healthy control subjects. Biomechanical analysis found that the injured men pronated more at their subtalar joint by two degrees (13° vs. 11° on average—a small difference, but statistically significant in the data analysis), and trended towards having lower ankle dorsiflexion speed and more overall ankle joint range of motion.

A third paper, published in 1999 by Jean L. McCrory et al., also indicates that runners with Achilles tendonitis tend to pronate more after impact.[29] Their study, which included 58 healthy

runners and 31 injured ones, was designed very similarly to Ryan et al.'s study. In the authors' words, "the injured group was more inverted at touchdown, had more pronation, a shorter time to maximum pronation, and a greater maximum pronation velocity."

Additionally, McCrory et al. found that the injured runners had weaker calf muscles than the healthy athletes, both on their injured leg and on the uninjured side. This continues to build the case for calf weakness as a biomechanical cause of Achilles tendonitis.

Also of interest was the lack of discernible differences in the impact forces or active forces between the two groups, a finding supported by other work.[17] Though impact forces or loading rates appear to be related to some common running injuries like plantar fasciitis and tibial stress fractures, Achilles tendonitis does not appear to be one of them.

The proposed "whipping motion" of pronation

Pronation has been thought to play a role in the development of Achilles tendonitis since at least 1978, when James, Bates, and Osternig proposed that rearfoot eversion caused a "whipping motion" along the tendon during the stance phase, subjecting it to additional stress and torsion.[6] Though this idea has support from retrospective studies and is widely espoused in review articles, the conspicuous absence of excessive rearfoot eversion in Van Ginkel et al.'s prospective study should give us some pause when considering pronation as a major causative factor of Achilles tendonitis. Van Ginkel et al. had only ten athletes develop injury, so this does not rule out pronation as a significant contributor to Achilles tendonitis, but it does suggest that other factors—like poor push-off from the ground and increased force on the lateral forefoot during the stance phase—play an important role instead of or in addition to pronation.

Pronation, along with forefoot varus, are the most common causal factors for Achilles tendonitis cited in review articles and medical textbooks. Though it is supported by several retrospective studies, pronation is not thought of as the boogeyman it used to be, and further, treatments attempting to *control* pronation (like custom orthotics or medially-posted shoes) have had, at best, minimal and unpredictable success. There is currently a large-scale study underway at La Trobe University on whether a custom orthotic can help people recover from Achilles tendonitis, but the results have not yet been released.[30]

Though forefoot varus is often cited as a cause, all review articles I have seen that mention it only cite Kvist's 1991 study. Later work, like a 2002 review by Mohsen Razeghi and Mark Edward Batt at Queen's Medical Centre in the UK, question the validity of "static" measurements of foot structure.[31] That being said, Van Ginkel et al.'s study rekindled the possibility that increased pressure on the lateral forefoot plays a role in Achilles tendonitis as well—this may well be due to forefoot varus, but research linking the two is still lacking.

Fluoroquinolones: An additional risk factor

One underreported risk factor for developing Achilles tendonitis is taking fluoroquinolone antibiotics. These are a special category of antibiotic that is highly effective against many dangerous bacterial infections, but is also sometimes used to treat more mundane illnesses like ear infections. Fluoroquinolone use is also associated with an increased risk of developing tendonitis or a tendon rupture in the Achilles.[32, 33, 34] Though the risk is lower for younger people, the implications of increased stress on the tendon brought on by exercise are not known. Hard numbers on the risk of developing tendonitis are difficult to come by, but one study pegged the risk of a tendon *rupture* at 1 in 6000—quite small for an individual, but still worth asking your doctor about if you are prescribed a fluoroquinolone antibiotic.[35]

Summary of risk factors

Unfortunately, there's no clear causal narrative to follow with Achilles tendonitis. No one biomechanical factor dominates the etiology of the injury, and the injury process is still not well-understood. Poor calf muscle strength is the only factor supported in both prospective and retrospective studies. Pronation and forefoot varus may play a role, but larger prospective studies will be needed to confirm this. Excessive ankle dorsiflexion range of motion has emerged as a potential risk factor as well, but it is not known to what extent this affects strain on the Achilles tendon.

Being older and being male are both established risk factors, although there's not much you can do about these. Unfortunately, the reason why older men suffer Achilles tendonitis at a higher rate isn't clear either.

From a logical perspective, hill workouts, high-speed running, and forefoot striking should all be risk factors as well, since they put considerable stress on the Achilles. Of these, only forefoot striking has been positively identified as a risk factor in published studies, and only in women.

When evaluating possible treatments, we'll have to use more general principles about reducing stress and healing tendon injuries when we consider how to treat and prevent Achilles tendonitis.

Treatment and prevention

Traditionally, Achilles tendonitis was treated much in the same way that other allegedly-inflammatory overuse injuries were treated: rest, ice, compression, anti-inflammatory drugs, and other measures designed to cut down on inflammation. But given that Achilles tendonitis is primarily a degenerative condition, we should view these classical treatments with suspicion. Indeed, there is no scientific evidence supporting *any* of them (except rest, of course). Instead, we'll have to look for ways to reverse the root causes of Achilles tendonitis, including damage to the tendon structure, possible biomechanical faults, and excessive stress on the tendon.

Mainstream treatments

Eccentric exercise: The gold standard

Strengthening and repairing the Achilles tendon should be the ultimate goal of any rehabilitation program. Fortunately, targeted **eccentric exercises** have emerged in the past twenty years as an ideal way to accomplish this.

You might need a quick primer on concentric and eccentric muscle contractions. **Concentric** contractions occur when the joint movement is in the same direction as the muscle's contraction. Using your biceps to curl a barbell up towards your shoulders is a concentric contraction. In contrast, an eccentric contraction is when a muscle is working to *oppose* the motion of a joint. Slowly lowering the barbell you've curled up to your shoulder is an **eccentric** motion. Most "down" motions are eccentric contractions working to oppose gravity: the down phase of a pushup, lowering a barbell down towards your chest while doing a bench press, and the down phase of a squat all involve eccentric muscle contractions. While muscles can support more weight with eccentric contractions than they can with concentric ones, eccentric work is also more damaging to your muscles. One sure-fire way to induce muscle soreness is to do a lot of eccentric work—that's why running *down* a long hill several times will usually leave your quads a lot more sore than if you had only run *up*.

Eccentric exercise was first examined as a possible treatment for Achilles tendonitis in 1992, but the value of an eccentric exercise rehab program didn't make waves in the scientific community until a landmark 1998 study by Håkan Alfredson and other researchers in Sweden.[36] Alfredson et al. used thirty recreational runners who had been suffering from chronic Achilles tendonitis for at least several months (and in one subject, over *eight years!*), all of whom had tried rest, nonsteroidal anti-inflammatory drugs, physical therapy, and footwear/orthotic intervention to no avail. Fifteen were assigned a rigorous eccentric calf strengthening routine and fifteen underwent surgical repair of the Achilles tendon.

The eccentric strength protocol consisted of two exercises: **straight-knee heel drops** and **bent-knee heel drops**. These exercises were performed twice a day, every day for twelve weeks, and done **slowly**. Alfredson et al. describe the exercises as follows:

> From an upright body position and standing with all body weight on the forefoot and the ankle joint in plantar flexion, the calf muscle was loaded by having the patient lower the heel beneath the forefoot (Fig. 1). They were only loading the calf muscle eccentrically, no following concentric loading was done. Instead, the noninjured leg was used to get back to the start position. The patients were told to go ahead with the exercise even if they experienced pain. However, they were told to stop the exercise if the pain became disabling. When they could perform the eccentric loading exercise without experiencing any minor pain or discomfort, they were instructed to increase the load by adding weight. This could easily be done by using a backpack that was successively loaded with weight.[36]

A straight-knee heel drop, as the name suggests, involves keeping the knee locked straight throughout the exercise. A bent-knee heel drop involves keeping the knee bent upon descent (thereby strengthening the soleus muscle), as illustrated below. If the patients progressed to very heavy weight, they were instructed to use a weight machine. For patients with Achilles

tendonitis in both legs, Alfredson et al. advise using your arms to raise yourself back to the starting position so that neither leg is loaded concentrically. During the twelve-week rehab program, Alfredson et al. mandated that the participants not run unless they could do so with only mild discomfort and no pain.

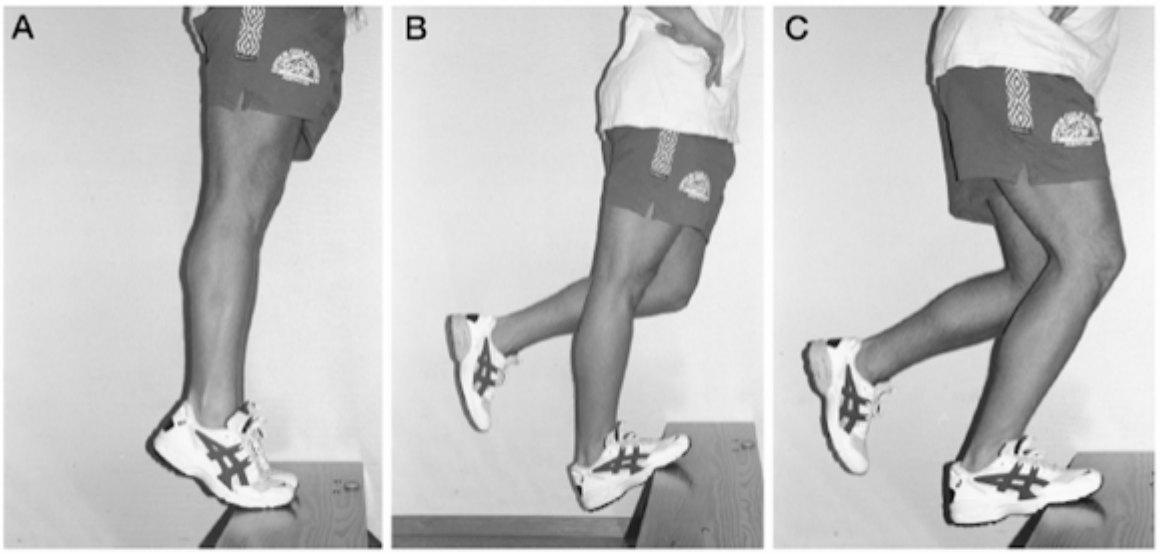


Figure 1. From an upright body position and standing with all body weight on the forefoot and the ankle joint in plantar flexion lifted by the noninjured leg (A), the calf muscle was loaded eccentrically by having the patient lower the heel with the knee straight (B) and with the knee bent (C).

Alfredson's eccentric heel drop exercises. Note that the motion of A → B and C denote two separate exercises, the straight-knee and bent-knee eccentric heel drop. From Alfredson et al.

Figure 2. Increasing the load by adding weight in a backpack.

Figure 3. Increasing the load by adding weight with a weight machine.

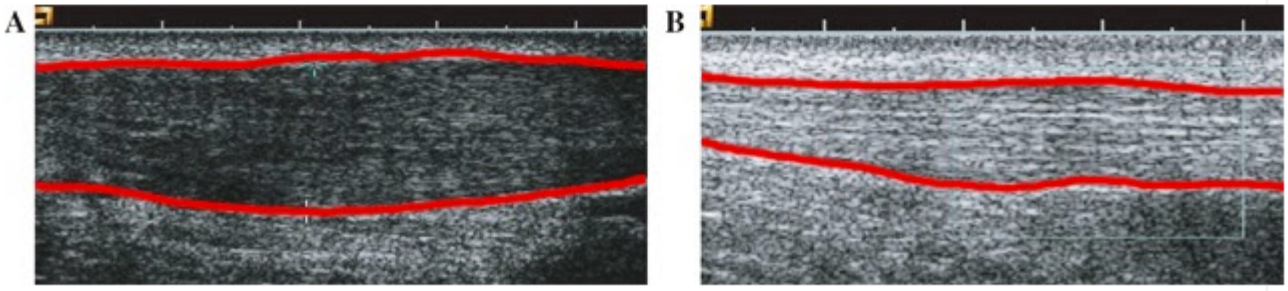
Once the heel drops are not painful anymore, weight should be added either using a backpack (left) or a weight machine (right). Adapted from Alfredson et al.

After 12 weeks of eccentric exercise, the results were impressive. Fully 100% of the subjects in the eccentric exercise group were able to return to their pre-injury running level. Their

average reported pain during activity, reported on a 100-point scale (the visual analogue scale, or VAS, decreased from **81.2** to ***4.8 (***± 6.5***).*** They also showed a marked increase in strength on their injured side. But perhaps even more significant is how the eccentric exercise group compared to the control group who underwent surgery. All 15 of the surgery group members were eventually allowed to return to running, but their VAS pain scores, which averaged 71.8 pre-surgery, only dropped to 21.2 (±11.4) after 24 weeks post-surgery (recall that the eccentric exercise group was scored after **12 weeks**). Thus, the eccentric exercise protocol was superior to surgery in every respect—it had better results in less time without any risks that surgery entail.

What is it about the eccentric exercise protocol that enabled such drastic improvements, even in subjects who had been injured for many years and not responded to any conventional treatment? A later study by the same group ruled out a simple increase in strength—in that study, 44 subjects were assigned either a concentric (calf raise, going "up" only) or eccentric (heel drop, going "down" only) protocol. Eighteen of the 22 members in the eccentric exercise group were able to return to their previous activity level, while only eight of the 22 members in the concentric strength group were able to do so.[37] An earlier study by a different research group also found that eccentric strength exercises were superior to concentric strength exercises in treating Achilles tendonitis.[38] So there is more at play than just muscular strength. And later work showed that the results of the initial Alfredson et al. study were more than just a fluke—a larger but similarly-designed study found that, among 78 patients and 101 tendons (some patients having tendonitis on both sides), the same eccentric exercise program allowed 89% of the patients to return to their previous activity levels, and VAS pain scores dropped from 68.3 to 13.3.[39] Similar studies done by researchers both inside[40] and outside[41, 42] of Sweden have also been able to reproduce Alfredson et al.'s results, and long-term follow-ups confirm that the benefits of eccentric heel drops are not merely temporary.[43] Further, the benefits are also evident in non-athletic patients with Achilles tendonitis too.[44] Unfortunately, one study found that women do not benefit quite as much as men do from eccentric heel drops for Achilles tendonitis.[45]

The reason why the eccentric exercise program boasts such impressive results is linked to how it affects tendon structure. Ultrasound imaging and MRIs of tendons before and after the eccentric exercise program show a reduction in abnormalities, a reduction in tendon thickening, and a return to normal tendon structure.[40, 46] Exactly *how* this is accomplished is not yet clear, but J.D. Rees et al. propose that eccentric loading puts unique stresses on the tendon not found in concentric loading which encourage tendon healing.[47]



Ultrasound image of a tendon before (A) and after (B) eccentric exercise protocol. Thickness is markedly decreased and structure is normalized, as emphasized by the red outline of the tendon (added). Adopted from Rees et al.

Eccentric exercise has the added benefit of strengthening the calf muscles, which addresses one of the biomechanical faults (poor ankle plantarflexion strength) we identified earlier, but given that concentric strength is much less effective at rehabbing Achilles tendonitis, calf

strength can't be the only benefit. The progressive eccentric program likely induces beneficial mechanical changes in the tendon itself, leading to a healthier tendon structure.

I suspect that three factors were crucial to the success of the Alfredson et al. rehabilitation program: the emphasis on ***eccentric*** strength, the ***progressive*** nature of the exercise (accomplished by adding weight), and the requirement to continue the exercise ***even when in moderate pain***. These all indicate that the mechanism at work is direct but controlled stress on the Achilles tendon, leading to breakdown and remodeling of collagen fibers. While this is only my hypothesis, some research already indicates that eccentric exercise increases collagen synthesis in injured athletes.[48]

A paper by Ewa Roos and others at Lund University Hospital in Sweden notes that patients should be aware that significant calf muscle soreness is an expected side effect.[43] Heavy-load eccentric exercise is a *very* good way to induce soreness in any muscle, so it's no surprise that Alfredson's program can cause calf soreness as a side effect.

If you are looking for a solid, reliable treatment for Achilles tendonitis, **you can stop reading the treatments section here**. Alfredson's eccentric exercise protocol is far and away the best treatment for Achilles tendonitis; all of the treatments below are supplemental or second-line at best. Since the only well-established biomechanical factor associated with Achilles tendonitis is weak calf muscles—something addressed by the eccentric exercise program anyways—we can't even infer any useful additional exercises. However, if you are looking for ways to speed your recovery, or you want to know which treatments to *avoid*, feel free to continue reading.

Other mainstream treatments

Though Alfredson et al.'s eccentric heel drop program boasts very good results, twelve weeks is an awfully long time for a runner in training. Additionally, around ten to thirty percent of athletes who complete the eccentric heel drop program still aren't able to return to their previous levels of activity. For these reasons, we should also investigate other treatments, keeping in mind the general principles of recovery: encouraging tendon healing, taking stress off the tendon, and fixing or mitigating any possible biomechanical faults. Rest, obviously, is a great way to encourage healing and take stress off the Achilles. But you wouldn't have read this far to be satisfied with only taking time off.

Because of Achilles tendonitis was thought of as an inflammatory injury for a long time, **nonsteroidal anti-inflammatory drugs** or **NSAIDS** like Aleve (naproxen) and Advil (ibuprofen) are a popular and often-recommended treatment. However, the scientific evidence is fairly clear about NSAIDs: they are not an effective way to manage Achilles tendonitis. As noted above, Achilles tendonitis is not an inflammatory condition. And worse, a Swedish study of 70 patients with Achilles tendonitis found no benefit when comparing a prescription-strength NSAID drug to a placebo.[49] Two papers by two different pairs of renowned physicians demonstrate how the research and medical communities are moving away from using anti-inflammatory drugs to treat tendon injuries. Steven Stovitz and Robert Johnson at the University of Minnesota cite the absence of inflammation in most overuse injuries and the absence of evidence supporting the efficacy of NSAIDs.[50] Stovitz and Johnson also believe that inflammation is a necessary part of the healing process, so treating an injury by cutting down on inflammation could actually *hinder* recovery—something demonstrated in rat tendons

by Scott Ferry and others at the University of North Carolina.[8] Merzesh Magra and Nicola Maffulli at Keele University in the UK write:

> Can the continued use of NSAIDs for the treatment of tendinopathies be justified? The available literature would suggest that in the absence of an overt inflammatory process, there is no rational basis for the use of NSAIDs in chronic tendinopathy, because they are unlikely to change its still ill-defined natural history. [...] There is no biologic basis for NSAID effectiveness in treating this condition, and no evidence of any benefit. NSAIDs appear to be effective, to some extent, for pain control. This causes patients to ignore early symptoms, and thus may lead to further damage of the tendon and delay definitive healing. Early NSAIDs administration after an injury may have a deleterious effect on long-term tendon healing.[51]

From the above evidence, it appears that NSAIDs like Advil or Aleve should not be used to treat Achilles tendonitis, especially considering the possible side effects, including gastrointestinal problems and stomach ulcers.

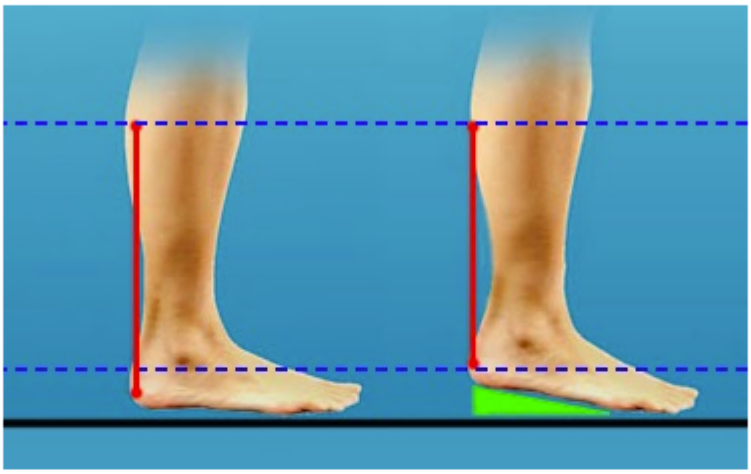
In the same vein, injections of **corticosteroids** like cortisone were popular in the past as an anti-inflammatory treatment for tendonitis. But, like with NSAIDs, newer research is questioning the use of corticosteroids. Case reports of athletes experiencing a ruptured Achilles tendon following corticosteroid injections began to trickle in during the 1980s,[52] spurring more research into the effects of corticosteroid drugs on tendon health. As discussed in a 1992 review article by F. Mahler and D. Fritschy,[53] animal studies have conclusively demonstrated that direct injections of corticosteroids into tendons result in damage and impaired strength in the tendon.

Whether corticosteroids injected *near* the tendon are hazardous is still controversial. U. Fredberg argues that there is no reliable proof that injections near the tendon are directly linked to tendon rupture,[54] but other researchers, like Ronald Hugate, Jason Pennypacker, Marnie Saunders, and Paul Juliano at Penn State University, argue that injections near the tendon can still damage it.[55] Hugate et al. published a 2004 study that demonstrated damage to rabbit tendons when corticosteroids were injected into the retrocalcaneal bursa, a fluid-filled sac adjacent to the Achilles tendon (a structure which exists both in humans and in rabbits).

Regardless, as described by C.A. Speed in a 2001 review article,[56] there is no good evidence supporting the use of corticosteroid injections for tendon injuries. As an example, one clinical trial conducted in 1988 found that a corticosteroid injection provided no benefit after twelve weeks when compared to a sham injection of a local anesthetic.[57] Given the non-inflammatory nature of Achilles tendonitis and the worrying reports of tendon ruptures, corticosteroids seem like a poor avenue of treatment for runners with Achilles tendonitis. While one study suggests that iontophoresis, a method of transporting medicine across the skin via electrical currents, may be able to deliver corticosteroids to the tendon without the damage associated with injections,[58] more evidence is needed before supporting iontophoresis delivery of corticosteroids.

Though **icing** is an extremely common method of treating overuse injuries like Achilles

tendonitis, there is virtually no research in humans on its efficacy as a treatment method in athletic injuries.[59] Though icing is, in theory, a treatment designed to battle inflammation, the limited research on it to date has indicated that many of the effects of icing, even relatively aggressively (3x10 minute sessions), wear off fairly quickly after you remove the ice.[60] Because of this, combined with the collective wisdom of a whole lot of runners, I posit that icing, at the very least, does no harm. However, there's zero research on whether or not it makes an effective treatment—a glaring gap in research that's hopefully rectified in the near future.



This exaggerated image illustrates how a heel lift reduces the range of motion of the Achilles and the ankle during the "stance" phase of walking and running.

Heel lifts, along with shoe modifications (i.e. wearing a shoe with a higher heel to toe drop), are a very common treatment method. The logic is fairly simple—by providing a rigid or semi-rigid wedge underneath your heel when it sits in your shoe, your Achilles will not be stretched as much when your foot is on the ground. This is very reasonable in a biomechanical sense; people with Achilles tendon problems tend to find that running uphill, running fast, and running in low-heeled shoes like racing flats and spikes all aggravate their Achilles. Surprisingly, though, there is relatively little scientific research on the efficacy of heel lifts for treating Achilles tendonitis. One study confirmed that walking with a heel lift reduces calf muscle activity and correspondingly increases shin muscle activity, just as we would expect.[61] However, this study used some extremely aggressive heel lift heights: 19, 38, and 57 mm— that's ¾, 1½, and 2 ¼ inches! But a more recent study using more realistic heel lift sizes of 6 mm and 9 mm did not find any reductions in calf muscle activity while walking in shoes with heel lifts.[62] When it comes to the mechanics of using a heel lift while actually running, a 2002 paper by Sharon Dixon and David Kerwin at the University of Exeter and the University of Bath, respectively, found that heel lifts resulted in modest reductions in the loading rate of the Achilles tendon while running on a treadmill, but the peak force in the Achilles tendon was subject-specific; some of the subjects experienced decreased peak force in their tendon while using heel lifts, while others had the opposite.[63] The only clinical trial I'm aware of that actually tested heel lifts as a treatment, a 1984 study of 33 athletes with Achilles tendonitis, did not find any benefit to adding the use of heel lifts to a standard rehab program.[64] Some people have expressed concern about using heel lifts indefinitely—wouldn't using a heel lift prevent the Achilles from ever re-adapting to being used through its full range of motion? This is at least a reasonable hypothesis, given that other research has found that women who wear high heels have shortened calf muscles and stiffer Achilles tendons.[65] For competitive runners, heel lifts don't offer a permanent solution: eventually, they will need to be able to sprint, wear spikes or racing flats, and run up steep hills.

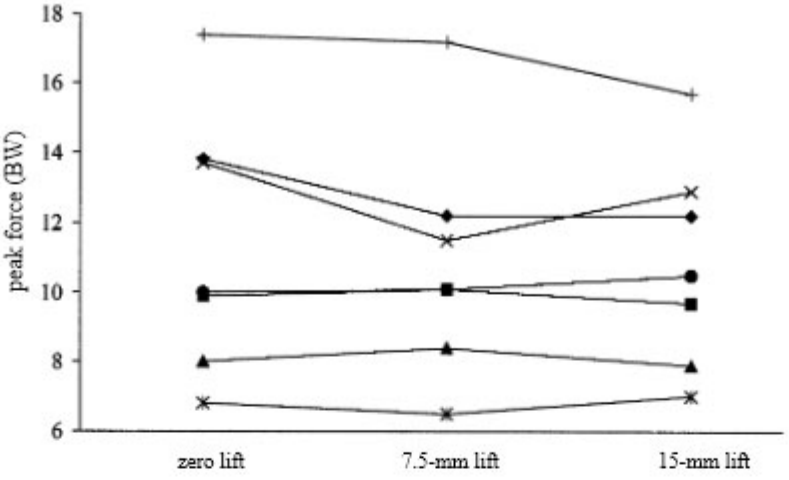


Figure 3 — Peak Achilles tendon force values for individual runners for each heel lift condition. Key: ∪ Participant 1; ∨ Participant 2; σ Participant 3; 5 Participant 4; § Participant 5; λ Participant 6; + Participant 7.

The effects of heel lifts in runners is very subject-specific, meaning individuals respond differently. This image from Dixon and Kerwin demonstrates how the peak force in the Achilles tendon varies when the seven subjects wear heel lifts. Some runners experience drops in overall force as the heel lift height increases from zero to 7.5 to 15 mm, while others have no effect—some even experience an increase in peak force!

A typical custom orthotic. From Roos et al.

Almost all **orthotics**, whether custom or over-the-counter, also elevate the heel more than the standard insole that comes with your shoes. With regards to the efficacy of orthotics in treating Achilles tendonitis, there are no quality studies. This problem was described in a 2009 study protocol published by Shannon Munteanu and others at La Trobe University in Australia.[30] They are currently conducting a large, randomized clinical study of custom orthotics for treating Achilles tendonitis, but the study is not yet complete. Once published, its findings should provide strong evidence for whether custom orthotics are of any use when treating Achilles tendonitis. Until then, support for custom orthotics is anecdotal at best. Pronation and forefoot varus—the two proposed biomechanical factors which could be correctable by a custom orthotic—are only tenuously connected to Achilles tendonitis, so there isn't enough evidence to broadly recommended as a treatment option.

Calf stretching is widely recommended as a treatment for Achilles tendonitis, and makes sense in theory—looser calf muscles would mean less stress on the Achilles. However, no studies have investigated it as a treatment option, and since the eccentric heel drop protocol *already* provides a stretch to the calf muscles, doing any additional stretching doesn't make a lot of sense in the absence of research supporting it.

Personally and nonscientifically speaking, I am not a fan of stretching an already-injured area, so calf stretches are not something I would do for Achilles tendonitis. If you want to loosen up your calves without stretching them, two easy ways to do so are to roll them with a foam roller or rolling tool like The Stick or the Tiger Tail, and heating your calves (not the tendon!) with hot water packs.

Various night splint devices.

Likewise, some people have suggested that wearing a **night splint** to keep your ankle in dorsiflexion while you sleep would aid healing with Achilles tendonitis by keeping your calves stretched and keeping tension on your Achilles tendon. This idea likely cropped up in response to studies which found success using night splint devices like the Strassburg Sock to treat plantar fasciitis.[66, 67] However, there are two problems with using night splints for Achilles tendonitis. First, a standard night splint, whether it is a rigid brace like a protective "boot" or a soft splint like the Strassburg Sock, only puts significant tension on the soleus muscle. A brace that puts tension on the gastrocnemius (the other muscle in your calves) would have to lock your knee in extension. Second, and more importantly, the two studies conducted on the use of night splints both had poor results: one paper found no benefit when a night splint was used in addition to Alfredson et al.'s eccentric heel drop protocol,[68] and another study actually found that use of a night splint *decreased the effectiveness* of eccentric heel drops![43] Because of these studies, night splints like the Strassburg Sock should not be used to treat Achilles tendonitis.

Alternative and anecdotal treatments

Since Achilles tendonitis is so common in the running community, there are a lot of treatments passed around among veteran runners who've had the injury multiple times. Other "alternative" treatments have been popularized by trainers or physical therapists who believe in their usefulness; in either case, these types of treatments aren't supported by much research, but are worth a look nevertheless.

Active Release Technique (ART) and **Graston Technique** are two soft-tissue manipulation therapies which are very popular among runners and triathletes. Both are known for being somewhat painful; the reasoning behind these and other deep-tissue massage-like therapies is that strong forces or friction need to be applied to the tendon or muscle to break down scar tissue and adhesions. While it's a nice idea, and many runners have reported finding ART or Graston useful, the only research on these techniques to date is limited to case studies, usually published in chiropractic journals. Given this, it's hard to recommend these as serious treatment options. On the bright side, though, they don't have nearly as many downsides as

more mainstream treatments—either that or they just haven't been documented yet. Hopefully, more research will investigate ART, Graston, and other soft tissue therapies in the near future. As described in a review article by Brett Andres and George Murrell, the only scientific studies on soft tissue manipulation have looked at generic deep friction massage, and none found any benefit vs. traditional physical therapy.[69]

While **therapeutic ultrasound** is favored by trainers and physical therapists, the evidence for its usefulness is scant. As described in a pair of review studies by Valma Robertson and Kerry Baker, most well-designed studies find no benefit from therapeutic ultrasound,[70] and most of the claimed effects of ultrasound are not substantiated by high-quality studies.[71]

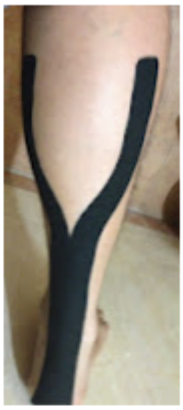
Low-level laser therapy attempts to encourage recovery by stimulating tissue healing and is another favorite of some podiatrists and physical therapists. A low-energy laser, usually in the red or infrared light spectrum, is directed at the Achilles tendon for the duration of the treatment. Although there's some basic biology that supports its use, published research and review studies are conflicting. One 2012 review by Samuel Sussmilch-Leitch and others at the University of Melbourne found a small benefit after 12 weeks when laser therapy was added to an eccentric exercise program,[72] but a 2008 review by Brett Andres and George Murrell at St. George Hospital, also in Australia, found that seven out of twelve studies of laser therapy found no benefit over a sham treatment, and cited four other review studies recommending against the use of low-level laser therapy.[69]

Running barefoot or in flats/spikes will put more stress on the Achilles

Because of the popularity of the minimalist/barefoot movement, some runners advocate using **minimalist shoes** or **running barefoot** as a way to treat or prevent Achilles injuries. Their reasoning is that the lower heel puts a stress on the tendon, inducing recovery. Of course, there's no evidence to support this, and I suspect that abruptly transitioning to low-heeled footwear would *aggravate* an Achilles injury, not heal it. But more to the point, we already have a very good way to put controlled stress on the Achilles tendon through eccentric heel drops. I do, however, think there is a role for barefoot running/low-heeled shoes in preventing Achilles tendonitis, at least among runners who plan on doing some racing in spikes or racing flats. Avoiding *any* running in minimalist shoes, racing flats, spikes, or barefoot is a poor idea for competitive runners, since their racing season is going to mandate some high-intensity running in shoes that put a lot of

stress on the Achilles tendon. Doing some easy running or strides barefoot or in low-heeled shoes might prevent problems later, but it isn't a good idea once you've already got an Achilles injury.

Kinesiology tapes like Kinesiotape or KT tape are becoming more popular among elite athletes, since the stretchy, elastic tape is easy to put on and doesn't inhibit normal motion like traditional stiff athletic tape. The limited evidence to date indicates that the small benefits, if any, of kinesiology taping are mostly because it provides some tactile feedback on the skin.[73, 74] Benefits attributed to **compression wear** like calf sleeves or compression socks likely also operate on this principle. Because it's inexpensive and pretty much risk-free, it's hard to frown too much on kinesiology tape. Just don't rely on it as a miracle cure.



Typical Kinesiotaping for Achilles tendonitis

Emerging treatments

Most of the cutting-edge research being published on Achilles tendonitis is focused on what you might call "biological treatments"—medical procedures intended to repair or regenerate the damaged tissue in the Achilles tendon that is causing pain. While several of these treatments show flashes of potential, they have all only been tested in at most one or two large, well-designed scientific studies. In time, some will certainly turn out to be useless treatments overhyped by doctors and medical device manufacturers to turn a profit, but the next breakthrough in treating Achilles tendonitis is almost sure to come from a treatment that attacks the biological basis of the injury.

Extracorporeal shockwave therapy

Perhaps the best-researched and most well-known of these is **extracorporeal shockwave therapy**, sometimes abbreviated as ESWT. Originally developed to treat kidney stones, shockwave therapy involves using an ultrasound-like device to pulse shockwaves directly into injured tissue like the Achilles tendon. In theory, these shockwaves cause a controlled amount of damage to the tissue, restarting the healing process. As with all emerging treatments, evidence is conflicting and large, well-designed studies are limited. Some high-quality studies have supported the use of extracorporeal shockwave therapy,[75, 76] leading to some review studies to recommend it as a possible supplemental treatment to eccentric exercise.[77, 72] Other authors, like Andres and Murrell, cite some well-designed studies that found no benefit.[69] Andres and Murrell also express some concern over one study that reported two cases of tendon rupture in the experimental group, and a case study from Taiwan describes a rupture in a 49-year-old female—albeit one who had been treated with surgery, anti-inflammatories, *and* corticosteroid injections previously.[78]

Figure 1. Directional application of extracorporeal shockwave therapy in neutral position of the ankle joint.

Figure 2. Directional application of extracorporeal shockwave therapy in dorsiflexion position of the ankle joint.

Extracorporeal shockwave therapy or ESWT involves using an ultrasound transducer to apply shockwaves to the Achilles tendon, creating a controlled amount of damage and encouraging repair of the tendon fibers. Image from Fridman et al.

Given that ESWT has been recommended by review studies as a safe and effective treatment for plantar fasciitis in runners,[79] we should be hopeful that similar success will eventually be demonstrated in Achilles tendonitis with successive large, high-quality studies. Until then, however, it is somewhat of a gamble. The studies supporting it are not only conflicting, but they don't even agree on methodology: different practitioners use different machines, varying levels of shockwave intensity, different numbers of pulses, different conductive mediums, and so on, so two different doctors might provide two very different kinds of shockwave therapy. Additionally, there's little in the way of long-term follow-up studies which can determine if there are any long-lasting effects (good or bad) from shockwave therapy.

Platelet-rich plasma

Another increasingly popular emerging treatment is **platelet-rich plasma** or PRP. Sometimes also referred to as an **autologous blood injection**, this treatment involves a doctor drawing some of your own blood, spinning it in a centrifuge to isolate and concentrate the platelets, then injecting it into the site of the injury—in this case, your Achilles tendon. Like with shockwave therapy, the goal with platelet-rich plasma injection is to restart the healing process. Though the biology of tendon healing is not fully understood, platelets, growth factors, and other agents present in plasma appear to play a significant role. Platelet-rich plasma has attracted a lot of attention, but studies on its use for Achilles tendonitis are extremely limited and not particularly promising. Two papers from 2010 and 2012 describe successfully treating a series of patients with PRP, but neither of them include a control group.[80, 81] Robert J. de Vos and other researchers in The Netherlands published a very thorough series of papers on a group of 54 patients with Achilles tendonitis who were treated either with eccentric exercises and a PRP injection or eccentric exercises and a placebo injection. Though both groups improved, those who received the PRP injection fared no better at 24 weeks[82] or one year[83] out from the injection, and ultrasound scans found no differences in tendon structure between the two groups.[84] Another study by a group in Oregon found that the "MRI appearance of diseased Achilles tendons remained largely unchanged following PRP injection."[85] Given the poor results from well-designed studies, PRP can't be considered as a viable treatment for Achilles tendonitis as of right now.

Other injectable treatments

Additional emerging therapies focus on other injectable agents. **Sclerosing injections** (also called sclerotherapy) are designed to destroy blood vessels and nerve endings in the tendon, while **prolotherapy** also attempts to damage the tendon, restarting the healing process. But these techniques have even less solid research backing them than PRP or cortisone shots. Considering the risks involved with injecting untested medication or chemicals into one of the most important tendons in your body, it is not possible to recommend any of these injection-based therapies for Achilles tendonitis barring further research.

Topical nitroglycerin

Nitroglycerin patches, typically used for controlling chest pain in people with heart disease, have recently been tested as a possible avenue for treatment of Achilles tendonitis. Basic biological research into tendon healing has indicated that a small molecule called **nitric oxide** plays an important role in tendon healing following injury. Though nitric oxide—the molecule formed when nitroglycerin is metabolized by your body—is largely absent in healthy tendons, it is rapidly synthesized following tendon injury. Additionally, when nitric oxide production in rats is artificially *inhibited*, tendon healing is reduced, and when nitric oxide production is artificially *increased*, tendon healing increases as well. [86] Since nitroglycerin is easily transported through the skin and converted to nitric oxide inside the body, nitroglycerin patches are a convenient method to deliver nitric acid to a particular location.

Most studies on nitroglycerin patches to date have used sections cut from circular nitroglycerin patches for chest pain, which are applied directly over the most painful area of the tendon. Image from Skjong et al.

The biological support for producing nitric oxide has been followed by strong but not unanimous support from studies using nitroglycerin patches to treat tendon problems. Ali Bokhari and George Murrell at St. George Hospital conducted three high-quality placebo-controlled studies that demonstrated significant tendon improvements during a six-month treatment with nitroglycerin patches, and one of these studies focused specifically on patients with Achilles tendonitis.[86] Bokhari and Murrell followed their patients for several years after the conclusions of the initial studies, finding long-lasting benefits of the six-month nitroglycerin patch treatment in the patients with Achilles tendonitis, but no significant benefit five years out in the group with lateral epicondylitis (tennis elbow).

In contrast, a 2008 paper by Timothy Kane, Muhammad Ismail, and James Calder in the UK followed a similar protocol—application of a nitroglycerin patch directly over the most painful area of the Achilles tendon every day for six months—but found no added benefits compared to a control group who received only standard physical therapy.[87] The patients who failed to improve underwent surgery, and afterwards, the researchers inspected samples of the tendons of the patients treated with nitroglycerin. Unlike in studies of rats, they found no evidence for increased activity of nitric oxide.

Despite this disappointing study, most review articles look favorably upon nitroglycerin treatment. A 2010 meta-analysis by Ephraim Gambito and others at the University of Santo Tomas in the Philippines commented on the use of nitroglycerin patches in cases of chronic tendonitis:

> "There is strong evidence for NTG [nitroglycerin patches] in relieving pain during activities of daily living, and increasing tendon strength. Further studies are needed to explore the role of this promising intervention in all phases of tendinopathies."[88]

Christian Skjong, Alexander Meininger, and Sherwin Ho opine in a 2011 article that the evidence strongly supports the use of nitroglycerin patches for short-term pain relief, though adding that long-term benefits are still uncertain.[77] Andres and Murrell also recommend nitroglycerin patches as a second-line treatment when eccentric exercises fail.[69]

Thanks to its history in treating heart disease, the effects of nitroglycerin patches on the body are relatively well-known; when used to treat tendonitis, the only major side effect appears to be headaches due to nitroglycerin's potent vasodilating properties. It should be noted that some patients find these headaches severe enough to cease using the nitroglycerin patches. Despite this, nitroglycerin is one of the few emerging treatments to show real promise in treating Achilles tendonitis, so additional research is undoubtedly underway. For now, treatment of tendonitis remains an off-label use of nitroglycerin patches and as such is not particularly common.

Summary of treatments

Far and away the **best** treatment for Achilles tendonitis in runners is Alfredson's eccentric heel drop protocol. Three sets of 15 heel drops, both with a straight knee and a bent knee, twice a day for twelve weeks, pushing into mild or moderate pain. When you become able to do the exercises without pain, you should progressively add weight by wearing a backpack with dumbbells, textbooks, or other heavy objects. The eccentric heel drop program is the only treatment method that has widespread scientific support, and the magnitude of the difference it makes in improvement is enormous. No responsible rehab program for Achilles tendonitis should exclude the progressive twice-daily 3x15 eccentric exercises.

Most other traditional treatments fail to hold up to scientific scrutiny. In theory, **heel lifts** might be useful in the short term to take some stress off the Achilles, but the little experimental evidence that exists doesn't support their use. In any case, they aren't a long-term solution for competitive runners.

Non-steroidal anti-inflammatory drugs like Advil or Aleve aren't supported by research, and their use doesn't make much sense anyways considering what we know about the degenerative, non-inflammatory nature of Achilles tendonitis. While some researchers still support using **corticosteroid injections**, there are serious questions surrounding their role in tendon ruptures. The only placebo-controlled randomized trial I'm aware of found no effect of corticosteroids on Achilles tendonitis, so we can't say that corticosteroid injections are scientifically supported either.

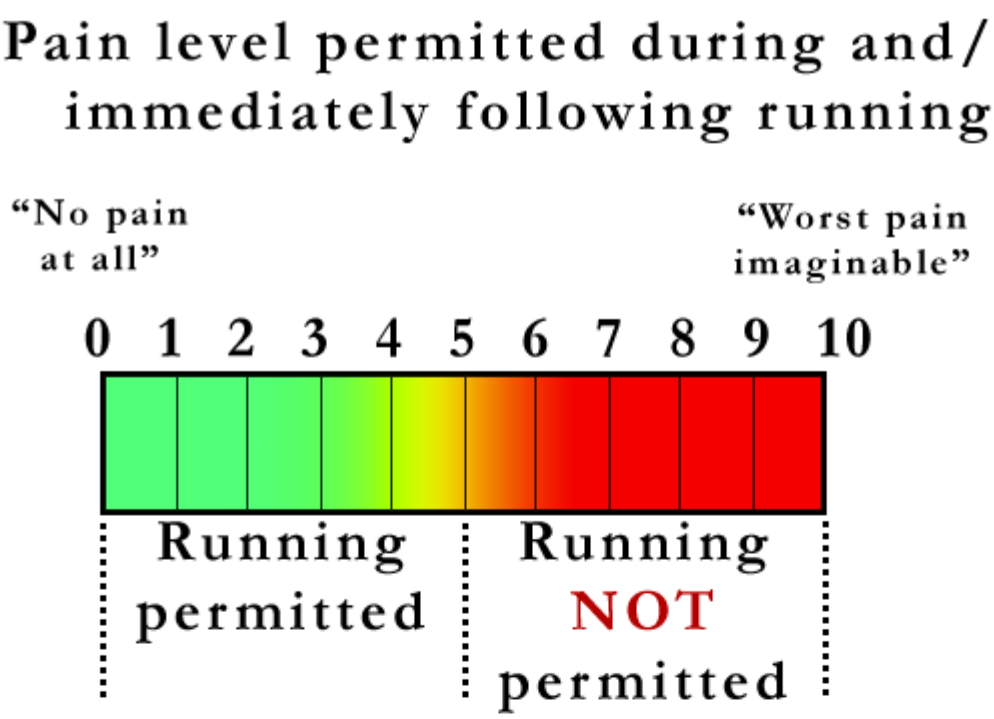
Calf stretching, **orthotics**, and **soft-tissue techniques** like ART and Graston are completely untested. This doesn't mean they have no benefit, but they can't be considered serious treatments with such a paucity of research supporting them. **Night splints** like the Strassburg Sock should be avoided, as one study found no benefit and another actually found them detrimental.

Ultrasound, **low-level lasers**, **and platelet-rich plasma** (PRP) all have poor evidence supporting their use for Achilles tendonitis. Other **injectable treatments** like sclerotherapy and prolotherapy have basically zero support from quality research. None of these should be considered viable treatments for Achilles tendonitis unless additional research shows a true benefit.

Among emerging treatments, the two which show some promise are **extracorporeal shockwave therapy** (ESWT) and topical **nitroglycerin patches**. Shockwave therapy has conflicting evidence, but some well-designed studies support its use, as do authors of multiple review papers. However, it is not yet a mature treatment, so protocols covering the specifics of the shockwave treatment are not yet standardized. Nitroglycerin patches have showed significant promise in a few high-quality studies, leading several review papers to recommend its use as a second-line treatment for stubborn cases of Achilles tendonitis, but support is not unanimous.

Return to running

As with most soft-tissue injuries, how you return to running after suffering Achilles tendonitis is highly individual. There's no set timeframe for tendon healing, and much of how long you'll have to take off is dictated by how seriously your tendon is hurt. Usually, this is as far as I can go with my advice—I'm not a doctor, after all. But fortunately, a group of researchers in Sweden led by Karin Grävare Silbernagel published a very creative study which demonstrated that you can safely continue some activity—like running—during an Achilles tendon rehab program.[89] They divided 38 patients into two groups during the course of a twelve-week rehab program modeled partially after Alfredson's eccentric heel drop protocol. The first group was instructed to avoid all activity that aggravated the Achilles, taking part only in nonimpact "active recovery" exercise like aquajogging, cycling, and swimming for the first six weeks. The second group was allowed to continue with running and jumping, but only under certain criteria. Their pain during or after exercise was not allowed to rise to over 5/10 on the pain scale—zero being "no pain at all" and ten being "worst pain imaginable." Pain was also not permitted to persist the morning following exercise, and Achilles pain and stiffness were not allowed to get worse from week to week. The second group was able to continue to train as long as they limited their workouts so their pain was within the constraints of the pain-monitoring model.



In the researchers' analysis, the group doing only nonimpact exercise during rehab fared no better than the exercising group at any point during the study's year-long follow-up, despite the fact that they avoided all pain-inducing exercise (outside of their rehab program, presumably). In their own words, "No negative effects could be demonstrated from continuing Achilles tendon loading activity, such as running and jumping, with the use of a pain-monitoring model during treatment."[89]

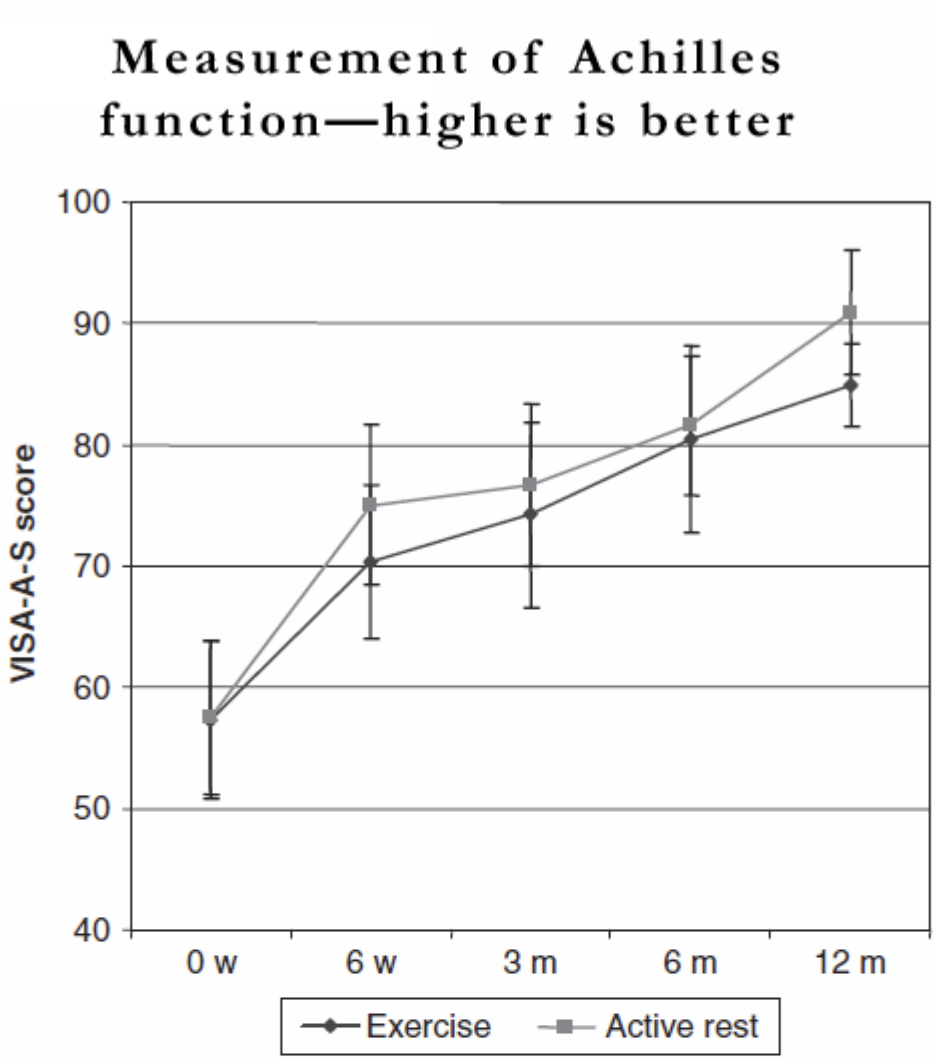


Figure 1. Mean VISA-A-S scores with 95% confidence interval, at 0 and 6 weeks and at 3-, 6-, and 12-month evaluations. VISA-A-S, Swedish version of the Victorian Institute of Sports Assessment–Achilles questionnaire.

Adapted from Silbernagel et al.

In Silbernagel et al., subjects who did not run at all for six weeks while rehabbing from Achilles tendonitis fared no better than those who used a pain-monitoring model which allowed them to run as long as their pain was mild or moderate.

This is very good news for runners who don't want to completely lose fitness because of an Achilles tendon injury. However, this also **should not** be taken as a green light to try to "run through" Achilles tendonitis! As outlined by Silbernagel et al., your pain should be improving over time, not regressing. Silbernagel et al.'s study isn't perfect—they used a pared-down rehab program, not the complete Alfredson protocol. It is possible that the full load of the Alfredson protocol (3x15 reps twice a day of both exercises) would be too much stress to support running on, at least initially. One study of volleyball players with patellar tendonitis allowed the athletes to continue to play and compete while completing an eccentric training program and did not have success;[90] Silbernagel et al. point out that they did not use a pain-monitoring program to limit activity that is excessively painful. This might have resulted in too much stress on the tendons, which did not allow healing. Ultimately, if you are wondering whether and how much you should run during your rehab, you should talk to your doctor or physical therapist.

Conclusion

Unlike some of the other injuries we've reviewed in the Injury Series, Achilles tendonitis has poorly understood biomechanical roots but fairly well-researched treatment options. Being male and being older both increase your risk of developing Achilles tendonitis, as does being a female forefoot striker, but well-established causal factors are limited: poor calf strength is the only risk factor identified in both prospective and retrospective studies. Because of the lack of evidence for the biomechanical causes for Achilles tendonitis, we can't infer too much in terms of changes to running form that can reduce your risk of developing Achilles problems.

When it comes to preventing Achilles tendonitis, there aren't any solidly vetted techniques, but we can infer some logical preventative measures from what we've learned about the injury. Doing calf strength exercises like Alfredson's eccentric heel drops might help, as poor calf strength has been identified as a risk factor by both prospective and retrospective studies. Additionally, *continuing* to do eccentric heel drops after you've completed the 12-week program is also a good idea from a prevention standpoint. Gradually phasing in hill work, high-speed running, and usage of low-heeled shoes like spikes and racing flats also makes sense, as all three of these probably put more strain on your Achilles. Beyond this, there isn't much you can do about most risk factors. If you are an older male runner, for example, you'll just have to accept that you're at a higher risk for Achilles injury and plan your training accordingly.

The first-line treatment for Achilles tendonitis should be Alfredson's eccentric heel drop protocol. Traditionally, running is not permitted during the rehab period, but new research suggests that it is okay to run as long as your pain remains below 5/10 on the pain scale, does not persist the next morning, and improves from week to week. Most other common treatments, including anti-inflammatories, orthotics, heel lifts, ultrasound, and various injectable treatments, have little or no evidence supporting their efficacy. When the eccentric heel drop protocol fails, research suggests that extracorporeal shockwave therapy and topical nitroglycerin patches are the two emerging treatments with the highest chance of success.

In terms of the injury itself, it is very important to remember that Achilles tendonitis is **not** an inflammatory injury. Some scientists have suggested that an "acute" inflammation phase exists for a few days or weeks following the initial injury to the tendon, but all evidence indicates that chronic Achilles tendonitis has no inflammatory component. The sore, aching pain in the Achilles tendon that is characteristic of Achilles tendonitis is due to degeneration of the collagen fibers that make up the tendon, not simple inflammation of the tendon or its sheath. This drastically changes what treatments are likely to succeed. However, this deeper understanding of the injury process has identified strong treatment options, most notably the eccentric heel drop protocol. Further research will better illuminate which new treatments are worth pursuing and which should be discarded.

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