by Joshua Dubin, DC, CSCS

Athletes strain to avoid Achilles tendon problems

The Achilles tendon, which runs from the top of the heel to the back of the calf, is a strong, nonelastic, fibrous tissue that attaches the gastrocnemius and the soleus muscles (Figure 1) to the heel bone/calcaneus.[1] Another name for the muscle group sharing the Achilles tendon is the "triceps surae." The Achilles tendon can effectively absorb large forces associated with running, forces that can approach six to eight times body weight with an average of 800 foot strikes per mile.[2,3] Injury to the Achilles tendon or its surrounding sheath, the paratenon, can be the result of overuse, improper training, gait abnormalities, age-related degenerative changes, or improper footwear.[1,2,4-8]

Recreational runners who prematurely increase the intensity, duration, and frequency of their training sessions are prone to developing Achilles tendon injuries because their Achilles tendons do not have time to adapt to the increased demand.[9] Improper training techniques, such as abrupt increases in mileage, may lead to microtears and degenerative changes to the Achilles tendon or the surrounding paratenon, weakening the tendon and predisposing it to further injury. Achilles tendon injuries usually occur gradually, increasing in severity if the athlete declines proper treatment and training modifications. Symptoms of Achilles tendon injuries can include one or more of the following:

- diffuse or localized swelling and tenderness around the tendon;
- pain with the first few steps after getting out of bed in the morning; and
- exacerbation of the injury upon walking uphill.[1,4,5,10,11]

Conservative therapy can aid in the normal reparative processes of Achilles tendon healing, thereby allowing for a quicker return of athletes to their sport.[5,9]

Three classifications of Achilles tendon injuries will be discussed here: tendinosis, tendinitis, and paratenonitis. Achilles tendinosis is a noninflammatory, asymptomatic condition that may lead to structural degenerative changes such as a thickening of the tendon. These degenerative changes compromise the strength and function of the Achilles tendon, predisposing it to further injury. Achilles tendinitis and paratenonitis are painful, inflammatory conditions that involve the Achilles tendon and surrounding paratenon, respectively.[1,10-12]

Understanding the biomechanics of the ankle joint, the function of the triceps surae

The incidence of these injuries can be reduced if athletes follow a properly progressed training program.

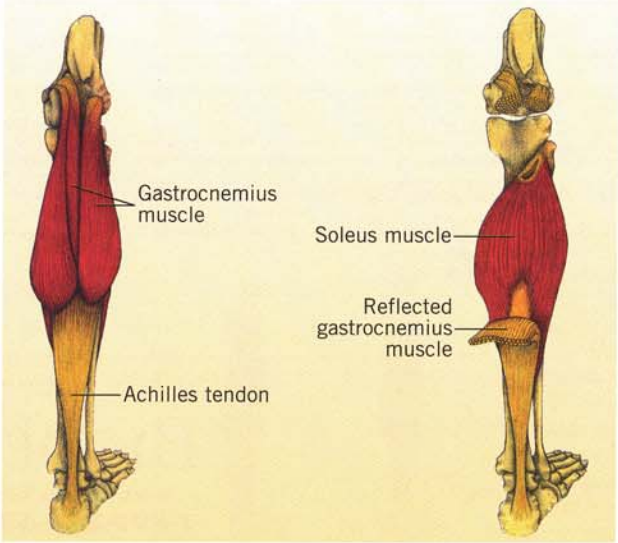

Figure 1. Attachments and origins of the calf muscles and the Achilles tendon.

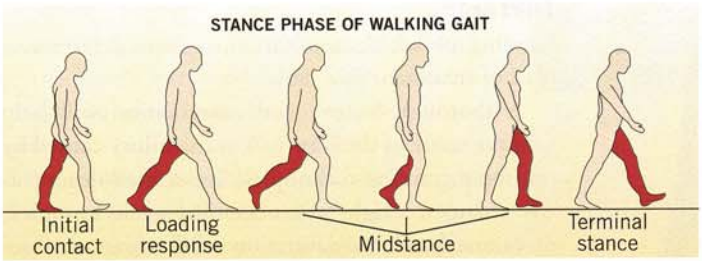

Figure 2. Light leg indicates stance phase.

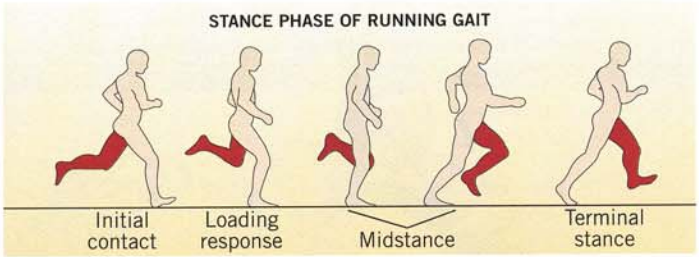

Figure 3. Light leg indicates stance phase.

and Achilles tendon during a normal running gait, and conditions that predispose the Achilles tendon to injury are all important in aiding practitioners to develop an effective treatment protocol.

Lower leg biomechanics while running

Gait can be separated into two phases: the stance and swing phases. During the stance phase, the foot contacts and adapts to the ground surface; during the swing phase, the leg accelerates forward and prepares for ground contact. The stance phase of gait consists of initial contact, loading response, midstance, and terminal stance subphases (Figure 2). The midstance phase starts when the contralateral foot lifts from the ground surface and ends as the forward momentum of the swing leg and the tension on the triceps surae musculature of the stance leg cause the stance leg heel to lift. The terminal stance phase begins when the stance leg heel lifts from the ground surface and ends when the swing leg contacts the ground surface. Stance phase in running differs from that of walking in that the stride is elongated, the cadence is increased, and double limb support is eliminated (Figure 3).[7,14,15]

The Achilles tendon is the strongest tendon in the body and normally can absorb the eccentric forces exerted on it during running or jumping activities without incurring injury.[1] However, tight calf muscles, certain gait abnormalities, improper training techniques, and age-related changes can predispose the Achilles tendon to repetitive microtrauma and injury.[1,5,9,11,16]

The talocrural joint, one of the two joints that make up the ankle joint, is the articulation between the leg bones (tibia and fibula) and the talus (ankle bone) and allows both dorsiflexion and plantar flexion. Tight gastrocnemius and soleus muscles can limit dorsiflexion of the ankle joint and place excessive eccentric strain on the triceps surae musculature and the Achilles tendon throughout midstance, thereby predisposing the Achilles tendon and surrounding paratenon to injury.

Inversion and eversion

Certain foot abnormalities lead to biomechanical dysfunction, predisposing an individual to Achilles tendon injury. The second of the two ankle joints, the subtalar joint, consists of the articulation between the talus and the calcaneus. Two primary movements occur at the subtalar joint: inversion and eversion (Figure 4). During initial contact the calcaneus is normally in 2° to 3° of inversion.[5] Excessive inversion of the calcaneus during initial contact is termed rearfoot varus. To compensate for the increased inclination of the calcaneus during initial contact the subtalar joint pronates excessively and at a faster speed than normal, allowing the calcaneus to contact and adapt to the ground surface throughout the loading response and the beginning of midstance. However, this movement places an increased eccentric load on the Achilles tendon, predisposing it to injury.

After the beginning of midstance and into terminal stance, the subtalar joint should be resupinating, changing the foot into a rigid lever for toe-off (Figure 5). Forefoot varus is a structural irregularity in which the forefoot has an abnormal inversion tilt compared to the rearfoot. Forefoot varus will lead to prolonged pronation throughout midstance and into terminal stance to allow the inside of the forefoot to contact the ground surface. Rapid resupination of the subtalar joint, a compensatory reaction to prolonged pronation through the beginning of midstance, creates a bowstring effect on the Achilles tendon and places an increased eccentric load on the medial side of the tendon. Also, the knee extending in preparation for toe-off and the subtalar joint pronating throughout midstance will place a double eccentric strain on the Achilles tendon, exposing it to excessive forces that may lead to a repetitive strain injury.[3,6,17,18]

The subtalar joint in a runner with a flat medial arch, or pes planus, will tend to overpronate, increasing the eccentric strain on the Achilles tendon. Pronation of the subtalar joint in a runner with a rigid high medial arch, or pes cavus, will be limited with poor shock-absorbing capabilities, leading to transmission of higher forces through the Achilles tendon and other adjacent structures.

Runners in their 30s and 40s are more disposed to developing tendon injuries than are younger athletes because the collagen matrix of the Achilles tendon and the triceps surae musculature begins to degrade as we age.[19] These tissues take longer to heal between bouts of exercise, predisposing them to injury if not given adequate time to rest. The older athlete should train on softer surfaces[4] and cross train with exercises such as cycling, swimming, cross country skiing, rollerblading, and an elliptical machine.

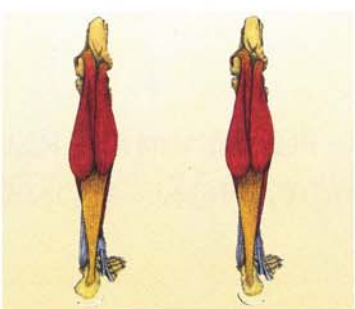
Figure 4. Inversion of the calcaneus (subtalar joint inversion, left) occurs during the initial contact phase to prepare for ground contact, and in terminal stance to provide a rigid platform for toe-off. Eversion of the calcaneus (subtalar joint eversion, right) occurs during the loading response and the beginning of midstance, as the foot and ankle change from a rigid lever into a mobile shock absorber and adaptor to the ground surface.

Figure 5. A supinated position of the foot (left) as it strikes the ground surface maintains ankle joint stability. After initial contact, the ankle pronates; the talocrural joint dorsiflexes, the subtalar joint everts, and the forefoot abducts (toes point away from the midline).

Factors predisposing an athlete to developing Achilles tendinitis include tight gastrocnemius and soleus muscles, overpronation, and increased velocity of pronation of the foot and ankle from initial contact through the beginning of midstance, prolonged pronation during midstance, age-related degeneration of the Achilles tendon, and training programs that do not allow the Achilles tendon to adapt. Such training programs may encourage too much activity before a proper base is established, incorporate too many hills on training routes, and/or include high-intensity interval training.

Therapies

Grading an Achilles tendon injury helps determine a plan of treatment (see table).

A thorough history and examination will help find the cause of the injury. Was the injury caused by improper training techniques, age-related degenerative changes, a tight gastrocnemius-soleus complex, or biomechanical dysfunction of the rear- or forefoot? Initial goals of therapy are to reduce swelling and inflammation of the tendon and paratenon to alleviate acute tendon injury or chronic flare-ups so the patient can perform the activities of daily living with less pain. Pain-free modified training can then be implemented to improve strength and flexibility of the gastrocnemius-soleus/Achilles tendon complex, as well as cardiovascular fitness. The end goal is to return the athlete to a pain-free running routine. However, even if the pain symptoms dissipate, the athlete should be made aware that it takes time for the Achilles tendon to regain full strength and function. Tendons have fewer blood vessels than muscles, limiting the oxygen and nutrient supply to these tissues. Faced with this shortage of blood supply, tendons take a longer time to heal than muscles.

The phases of repair are reactive, regenerative, and remodeling. The reactive phase is the initial inflammatory response to microtrauma. Vasodilation of the vessels surrounding the injured tendon or muscle causes swelling, pain, and loss of function. To limit the immobilizing effects of the reactive phase, RICE (rest, ice, compression, and elevation) should be applied to the injured region. During the regenerative phase, dead cells are cleared out, tiny blood vessels are restructured to help supply oxygen to the damaged tissue, and collagen is laid down for repair. Collagen, the connective tissue that replaces the damaged tendon or muscle, is initially weak, but with time its strength improves. Damaged muscle regains approximately 50% of its strength after seven to 14 days; tendons may take longer. During the remodeling phase, the collagen tissue matures. After completing a proper medical treatment program and complying with a home strength training and flexibility routine, the athlete should regain 100% of his or her strength. The remodeling phase can take up to six months for muscle repair and even longer for tendon repair, depending on the severity of the injury.[13,20,21]

GRADES OF ACHILLES TENDON INJURIES AND PHASES OF TISSUE REPAIR AND TREATMENT

Grade 1	Pain does not occur during normal activity, but generalized pain is felt about 1 to 3 hours after sport-specific training has ended. Tenderness usually resolves within 24 hours without intervention.
Grade 2	Minimal pain is present towards the end of the sport-specific training session; performance is not affected. Appropriate treatment may be necessary to prevent a grade 3 injury.
Grade 3	Pain is present at the onset of training, and interferes with the speed and duration of a training session. Treatment and training modification are necessary to prevent a grade 3 injury from progressing to a grade 4 injury.
Grade 4	Pain restricts training and is also noticeable during activities of daily living; the athlete can no longer continue sport-specific training. Low-impact training, such as swimming and biking, can be implemented for cardiovascular fitness and aggressive musculoskeletal therapy can reduce the severity of the injury. The goal of therapy is to restore structural integrity of the tissues allowing for the athlete to return to pain-free sport-specific training.
Grade 5	Pain interferes with training as well as activities of daily living. The Achilles tendon becomes deformed and there is a loss of function of the triceps surae. Aggressive therapy is required and surgery may be necessary.

Source: Ref #6

Appropriate treatment of a grade 1 or grade 2 Achilles tendon injury would consist of:

- Manual adjustments to the ankle and foot to free up joint motion.[22]
- Deep tissue procedures, such as the Graston Technique

(developed around use of specially designed devices) and Active Release Technique (a patented manual therapy technique), to break up scar tissue in the affected tendon or paratenon and restore soft tissue motion and glide.[16]

- Ultrasound and electric muscle stimulation combination therapy to restore normal muscle tone, help in the healing process, and reduce pain.[20,23] Iontophoresis with dexamethasone is also a useful modality to decrease inflammation.
- Inflammation reduction by icing the Achilles tendon for 20 minutes on/one hour off, repeated throughout the day, and taking nonsteroidal anti-inflamatory drugs per primary doctor recommendation.
- A strength training program for the gastrocnemius and soleus, including standing and seated calf raises. Studies have indicated that emphasizing eccentric strength training of the triceps surae has been beneficial in treating and preventing future Achilles tendon injuries.[24,25] Dorsiflexion strengthening exercises should also be implemented. Strengthening exercises should be progressed with no or little discomfort.
- Stretching of the triceps surae and Achilles tendon can be conducted on a step or a slant board. Using a resistive band can also improve dorsiflexor and evertor strength and hamstring and calf muscle flexibility.
- A recommendation to replace running shoes after 250 to 500 miles of use, at which point the shoe loses 40% of its shock absorption capability.[20]
- A recommendation to use appropriate arch supports as necessary. A runner with pes planus will usually overpronate, placing an increased strain on the Achilles tendon. A good sneaker with a firm heel counter and an inside arch support will help correct overpronation and prevent Achilles tendon injury. If the runner continues to have Achilles tendon problems, a semirigid orthosis with a medial arch support no higher than 5/8 inch is a useful tool in preventing Achilles tendinitis. A temporary 1/8-inch heel lift can also be added to the orthosis to limit dorsiflexion of the foot; this would take pressure off the injured Achilles tendon. A runner with pes cavus has limited pronation and poor shock-absorption capabilities. The high-arch runner should get a sneaker with good cushioning; if necessary a semirigid orthosis or cushioned liner can be added.[4,5,9,15,26]
- A night splint maintaining the ankle and foot in slight dorsiflexion can help to alleviate morning stiffness in the Achilles tendon.[3] For more advanced cases of Achilles tendinitis a walking splint can be useful in alleviating stress on the slowly healing tendon.
- Recommendations for appropriate training limits. For marathon runners, initially a training base of four miles at 65% to 75% maximum heart rate needs to be established. Later, a progressive training schedule should be followed. A proper warm-up consisting of a slow jog will increase the blood supply to the muscles and tendons, making them more efficient in absorbing loads. Hill training should be added gradually because uphill running will increase the eccentric load on the Achilles tendon.

Early therapy and intervention (as above) are important to prevent a grade 3 tendon injury from progressing to a grade 4 or a grade 5 injury. In the early stages of a grade 3 tendon injury, one week of activity modified from the offending training regimen is recommended, as well as treatment procedures similar to those used to treat a grade 1 or a grade 2 tendon injury. Modified activity with swimming, running in the pool, bicycling, or an elliptical machine would be useful in maintaining aerobic fitness and in allowing the Achilles tendon and triceps surae to heal properly before resuming training. Treating a more advanced grade 3 or grade 4 tendon injury will involve a longer bout of modified activity and rest from the offending activity, and a slower progression of weight training and stretching.[4,5,21]

Chronic Achilles tendinitis injuries may not always resolve with conservative therapy. Initially, microscopic tears in the Achilles tendon or paratenon are repaired with type III collagen.[21] Type III collagen is immature scar tissue that has a disorganized arrangement of fibers and functions to create a temporary bond between the damaged tendon fibers.[21] Type III collagen is eventually replaced by type I collagen, mature scar tissue that has a parallel arrangement of fibers similar to that of normal tendon tissue.[21,27] With time and a properly progressed rehabilitation program, the type I collagen scar regains the tensile strength of normal tendon tissue. However, sometimes the type III collagen is not replaced by type I collagen in the later stages of healing. The immature scar tissue of a tendinosis with tendinitis/paratenonitis remains a chronically inflamed and weakened structure that may be palpated as a tender nodule, usually located on the medial side of the Achilles tendon. The degenerative scar tissue may be resistant to conservative care and attempting to train on the injured tendon may cause further injury.

An athlete who wants to return to running may need to consider surgery to regain the ability to train without pain. Magnetic resonance imaging has been shown to be extremely sensitive to pathological changes that occur in the Achilles tendon and may be a useful tool for the treating surgeon in discovering degenerative tissue that needs debridement.[3] Surgery usually involves excision of the degenerative intratendinous lesion, followed by rehabilitation. In cases of chronic paratenonitis, brisement of the paratenon-tendon interface may help to resolve it.[3,27-29]

Conclusion

Achilles tendinitis is a common overuse injury among athletes participating in sports involving repetitive jumping and running activities. The incidence of Achilles tendon injuries can be reduced if

athletes follow a properly progressed training program that allows for adaptation of the Achilles tendon to increased eccentric loads.[24,25] Certain biomechanical dysfunctions, such as rearfoot varus, forefoot varus, pes cavus, tight and weak triceps surae and Achilles tendon complex, and age-related degenerative changes, may predispose an athlete to developing an Achilles tendon injury. To prevent injury these athletes should incorporate proper footwear, semirigid orthoses as necessary, a lower body flexibility and strength training routine, and cross training into their workouts.

Achilles tendon injuries can usually be treated successfully with a conservative rehabilitation program that includes modified training and incorporates an eccentric strength training program of the gastrocnemius-soleus/Achilles tendon complex. The athlete must be made aware that it takes time for the Achilles tendon to heal even with rehabilitation. After the Achilles tendon regains function and becomes pain free, the athlete should progress his or her training program carefully to prevent reinjury. Sometimes Achilles tendon injuries are resistant to conservative therapy and surgery may be necessary to remove the degenerative tissue from the tendon or paratenon to encourage proper healing and restoration of strength and function with rehabilitation.

Joshua C. Dubin, DC, CSCS, is the owner of Dubin Chiropractic in Quincy, MA. He has been a member of the Team USA Triathlon/Duathlon International Triathlon Union medical staff since 1996.

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