Evidence-Based Treatment of Foot and Ankle Injuries in Runners

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Foot injuries

Epidemiology

Forty to 50% of all running injuries occur below the knee. Between 10% and 20% of all running injuries are foot injuries. Foot problems are the most common injuries that are reported by long distance and marathon runners [1,2]. There are several reasons why foot injuries are so common. One is the high prevalence of foot pain in the general population, not just runners. The incidence of foot problems is as high as 80% in the general population [3]. The other reason is the great biomechanical stress that is placed on the foot during running.

The foot is the only structure of the body that regularly contacts the ground. It consists of bones, tendons, and ligaments, without prominent muscle mass, so it is different from other areas that usually are addressed in sports medicine, and different rehabilitation principles apply. This bony and ligamentous structure must withstand ground reaction forces during running that are equal to three to four times normal body weight [4]. In addition to the increase in the amount of force during running, there is increased demand for this to occur efficiently and with optimal neuromuscular coordination. During running, the stance phase of gait changes from about 60% of the gait cycle to as little as 30%. During this shortened stance phase there is increased demands on the foot because it must change rapidly from a rigid structure at initial contact with the ground to prevent buckling of the knee, to the planted foot which needs to be flexible to accommodate uneven surfaces and allow the forces to be dispersed over a broader surface.
area, and then back to a rigid structure to transfer forces during push off [5]. The unique structure of the foot allows it to accommodate to these increasing demands; however, common training errors, such as rapid increase in mileage or training intensity, poor footwear, and functional or structural faults, can lead to injury of a variety of structures.

Anatomy and biomechanics of the foot

The foot has a complex structure. For clinical discussions, it usually is divided into three distinct regions: (1) the rearfoot, which consists of the calcaneus and talus and related soft tissue structures; (2) the midfoot, which consists of the cuneiforms, the navicular, and the cuboid and related soft tissue structures; and (3) the forefoot, which consists of the metatarsals and phalanges [6].

The rearfoot is involved with the tibiofibular joint and the talocrural joint (see later discussion) and the subtalar joint, between the calcaneus and talus, which is a key structure that is critical to function of the rearfoot. The subtalar joint has three degrees of freedom and allows motion in several planes at once. This allows the foot to adapt to sloping and uneven terrain and to transmit forces efficiently. At heel strike, the subtalar joint is in supination which allows the hind and midfoot to be in a locked position, and therefore, act more like a rigid lever. The subtalar joint moves into pronation to assist the ankle and knee with impact shock absorption and to adapt better to ground surfaces. This allows the foot to be a mobile, adaptive structure. Then, as the body crosses over the foot, the joint moves back into supination to increase the rigidity of the structure for push off. Excessive or delayed motion at this joint is believed to be a major factor in running injuries of the lower limb [4,5,7].

The midfoot makes the “keystones” of the foot arches. The medially-located navicular bone provides stability for the medial longitudinal arch. The laterally-located cuboid provides stability for the lateral longitudinal arch, and the cuneiforms in the middle make up the transverse arch. In isolation, these midfoot joints allow only minimal movement; however, taken together, they allow for significant movement to enable the foot to adapt to many different positions. Together, the joints in this area are known as Chopart’s joints. These joints also move from a rigid phase to an unlocked phase during the gait cycle. Common running injuries in this area are due to stress fractures and injuries to the many ligaments that attach in this region of the foot.

The forefoot begins at the tarsometatarsal joints, which also are known as Lisfranc’s joints [3]. The first, second, and third metatarsals articulate with their associated cuneiform. The shape of the most medial cuneiform determines the mobility of the first ray, which many investigators believe is an important contributor to running injuries of the foot. The base of the second metatarsal is in a recessed position as it articulates with the second
cuneiform; this makes it inherently more rigid than its neighbors, and thus, is more susceptible to stress fractures in runners. The fourth metatarsal also is stable. The fifth metatarsal is more mobile [7], and so is a less common site of stress fractures; however; when fractures do occur, healing may be delayed and close attention is necessary because of the increased mobility in this area [6]. At the end of the stance phase, the metatarsal phalangeal joints are extended fully. This creates tautness of the plantar fascia and elevation and rigidity of the longitudinal arch. This is called the windlass mechanism and stabilizes the foot during push off [5].

Foot injuries

Common foot injuries in runners include tendinopathies, stress fractures, and a variety of soft tissue injuries. Injuries to be aware of are nerve entrapments and other neurologic injuries, and manifestations of systemic diseases. A regional approach to the differential diagnosis of running injuries of the foot is outlined below. Evidence-based medicine is discussed when it is available, and the rehabilitation approach to treatment is detailed.

Rearfoot pain

Plantar fasciitis

Plantar fasciitis is the most common cause of rearfoot pain in runners. The diagnosis usually is made clinically. Patients present with gradual onset of pain in the inferior heel, which is worse in the first few steps in the morning or after rest. It also may worsen by the end of the day or after a run because of fatigue. Like other overuse injuries, symptoms usually are preceded by training errors [8]. On physical examination, there is point tenderness over the anteromedial aspect of the heel at the medial process of the calcaneal tuberosity. A less painful, but still tender, area is along the plantar fascia, particularly the medial part. Symptoms usually worsen with passive dorsiflexion of the toes. Limited foot dorsiflexion usually is seen. A study of 50 consecutive patients who were referred to physical therapy for plantar fasciitis compared risk factors of the patients with a group of age-matched controls; limited dorsiflexion on the involved side significantly increased the risk for plantar fasciitis. This relationship was exponential. Ankle dorsiflexion of 6° to 10° had an odds ratio of 2.9, whereas those who had 0° or less of dorsiflexion had an odds ratio of 23.3. Increased body mass index also increased the risk for plantar fasciitis [9]. In a large study of runners who had injuries, older age and heavier weight were associated with plantar fasciitis [2]. Regarding foot structure, excessive pronation and supination have been blamed as causes of plantar fasciitis [7].

The rest of the physical examination rules out competing diagnoses for heel pain. Enthesopathies and heel pain is a common complaint in patients who have spondyloarthropathies, so this should not be missed. Other common diagnoses that are seen in runners are discussed below.
Imaging is not needed, except to rule out other diagnoses. Often, a heel spur is seen on radiograph which most likely is a result of increased forces that are caused by the tight fascia and abnormal biomechanics, and is not a cause of the pain [6].

Treatment usually is successful with a combination of symptom control and improving biomechanics. Pain almost always is controlled by decreasing running, ice to the fascia, nonsteroidal anti-inflammatory drugs (NSAIDs), and cross-friction massage. The main biomechanical problem is decreased dorsiflexion, so stretching of the gastroc-soleus complex is key. Stretching of the plantar fascia by dorsiflexing the toes and the foot at the same time also is indicated. A prospective randomized study of 100 patients who had chronic plantar fasciitis of at least 10 months duration compared a group performing standard weight-bearing Achilles stretching with a group that stretched the plantar fascia by manually applying overpressure to their dorsiflexed toes and ankles while sitting. Both groups received an over-the-counter soft shoe insert and took NSAIDs for 3 weeks. Both groups had an improvement in pain and function, but the group that did the plantar fascia stretching improved more [10]. The second most common biomechanical problem is weakness of the plantar flexors. Failure in eccentric loading allows increased forces to be transmitted to the insertion of the fascia. Therefore, strengthening, especially eccentric strengthening, is important. The other common deficits that are seen include poor balance and gluteus medius weakness, which can be addressed with a proper exercise program [11].

If symptoms do not improve with physical therapy and medication, orthotics and heel pads often are prescribed. In a study of 236 patients, all of whom received stretching exercises, four different shoe inserts were compared: a silicone heel pad, a rubber insert, a felt pad, and a custom orthosis. Those with the silicone insert improved the most, whereas those with the custom orthoses improved the least. The group that had the custom orthoses did worse than the group that did stretching alone [12]. Other studies that used heel pads and soft-molded orthoses found them to be helpful as well [13]. Magnetic insoles did not have any benefit over regular cushioned insoles [14].

For resistant cases, some have advocated night splints that dorsiflex the ankle at bedtime and provide a prolonged stretch. Several small, randomized controlled trials showed superior outcomes with this treatment in patients who complied with wearing the splints [15], but other studies did not find them to be effective [8].

Shock wave therapy for chronic plantar fasciitis also has been the subject of several recent randomized controlled trials. This is indicated only if the patient has failed the above outlined treatments. There is no consensus at this time as to whether repeated low-energy shock wave therapy, which does not require anesthesia, or single high-energy shock waves, which requires local or regional anesthesia (usually an ankle block), is superior. In a study of runners who had plantar fasciitis who ran at least 30 miles per week
before injury and in whom conservative treatment had failed, low-energy extracorporeal shock wave therapy was compared with sham therapy. They found a significant reduction of pain first thing in the morning; pain ratings decreased from an average of 7 to 2 in the treatment group and 7 to 5 in the sham group at 6 months. Sixty percent of the treatment group versus 27% of the sham group had greater than 50% improvement at 6 months [16]. Similarly positive results have been found with high-energy shock wave treatments [17].

Corticosteroid injection into the most tender area of the plantar fascia also is a common treatment for this condition. A study that evaluated this treatment was limited by low follow-up responses, but revealed significant pain relief at 1 month, but no difference at 3 to 6 months. Clinicians worry that steroid injections weaken the fascia and could result in increased risk for rupture, but this has not been proven in the literature [8].

**Fat pad contusions and pain**

Fat pad contusions and atrophy are another common cause of heel pain. It has not been as well studied as plantar fasciitis. A heel cushion is the usual treatment.

**Calcaneal and talar stress fractures**

These are not nearly as common as mid- and forefoot stress fractures (see later discussion). Little research has been done in this area. Patients present with heel pain with running or walking that is relieved with nonweightbearing. Imaging with bone scan, CT, or MRI confirms the diagnosis. Treatment is the same as outlined below for other stress fractures.

**Tarsal tunnel syndrome**

This is entrapment of the tibial nerve as it passes behind the medial malleolus. It is much more likely to occur after trauma to the ankle than spontaneously or with overuse, but these can be mechanisms of injury as well, especially in runners who pronate excessively. Any or all of the branches of the tibial nerve in the foot may be involved. Patients present with deep aching pain and paresthesias in the plantar surface of the foot. Symptoms may worsen with running or at night. On physical examination, a Tinel’s sign at the area of entrapment may be positive. Pain may be provoked by forceful active pronation or by sustained passive eversion, because both of these stress the area [6,18]. It is rare to find true neurologic loss, such as intrinsic foot muscle wasting or weakness or dense sensory loss. Neurologic examination should rule out competing diagnoses, such as peripheral neuropathy or radiculopathy. Electrodiagnostic studies will confirm the diagnosis. Treatment includes correcting biomechanical problems and ankle rehabilitation, such as Achilles stretching and proprioceptive training. If this is not successful, steroid injections and surgery are other modes of treatment [19].
Midfoot pain

Navicular stress fractures
This is a common stress fracture in runners, so it should be ruled out in any runner who presents with vague midfoot pain. The differential diagnosis includes extensor tendinopathy, which usually is more tender to palpation on the plantar surface and with resisted foot dorsiflexion, and midtarsal joint sprains, which usually are associated with a discrete event, such as twisting the foot or tripping. With a navicular stress fracture, physical examination is remarkable for tenderness directly over the bone when the proximal dorsal surface is palpated (often called the “N spot”). Pain is made worse by hopping. It is diagnosed definitively by bone scan, MRI, or CT. There can be a long recovery with prolonged time off from running. Treatment begins with 6 weeks of nonweightbearing, with gradual return to sport.

Posterior tibial tendinopathy
The posterior tibial tendon passes behind the medial malleolus and inserts on the navicular bone. Injury of this tendon can cause ankle and midfoot pain. It is a common overuse injury that is seen with rapid increases in training intensity or poor footwear because of the eccentric forces that occur as the posterior tibial muscle resists descent of the medial longitudinal arch. Runners present with tenderness along the tendon from the ankle to the midfoot and pain with resisted foot inversion. On physical examination, excessive pronation and a tight posterior tibialis muscle usually are found. Rehabilitation consists of addressing these issues, potentially with an orthosis, as well as the usual care of tendon disorders.

Peroneal tendinopathy
The peroneal tendons pass behind the lateral malleolus, where they can be a source of pain, and then diverge so that the peroneus brevis tendon can insert on the base of the fifth metatarsal; the peroneus longus runs deep across the foot through a groove in the cuboid to insert onto the base of the first metatarsal and medial cuneiform [20]. The tendon can be a source of pain anywhere along this course, and symptoms are aggravated by resisted eversion and plantarflexion. It is associated with excessive pronation at toe off, and weak plantarflexion, so these should be addressed in the treatment phase [7].

Anterior tarsal tunnel syndrome
This is entrapment of the deep peroneal nerve as it passes under the extensor retinaculum. Patients present with aching and numbness on the dorsum of the midfoot, which can extend to the first web space. It is believed to be caused most commonly by poor fitting shoes, so may respond to changes in footwear. Other treatments that are used often include corticosteroid injections, ankle rehabilitation, and surgical release.
Forefoot pain

Metatarsal stress fractures

Stress fractures are common overuse injuries in runners, with a prevalence as high as 9% in collegiate runners. They are more common in women. A retrospective study that examined 10 years of injuries to collegiate athletes in several sports found that distance runners were most likely to sustain a stress fracture. Foot stress fractures were the most common type that were seen in runners in this study; they were divided equally between navicular and metatarsal fractures [21]. Other studies of running injuries found high percentages of stress fractures of the foot [22,23], especially metatarsal fractures that involved the second and third metatarsals. The second metatarsal is particularly vulnerable because the proximal head is tucked between the medial and lateral cuneiforms and is immobile [5]. Fifth metatarsal stress fractures are uncommon in runners, but may be more difficult to treat. If the fracture occurs at the diaphysis, it is known as a Jones fracture, and requires prolonged nonweightbearing; it may require surgery if nonunion occurs [6].

Biomechanical risk factors for foot fractures have been examined. In a Finnish study of elite runners who had recurrent stress fractures, a relationship between a high longitudinal arch and cavus-type foot and stress fractures was found. Similar results were found in other studies, particularly studies of military recruits who suffered stress fractures of the foot. This is believed to be secondary to the more rigid, reduced shock absorbency of this type of foot [5,24]. Other investigators believe that a pes planus foot is more at risk because of increased pronation, and therefore, muscular fatigue, which causes increased forces to be transmitted to the bone [1,7,24]. Other commonly cited risk factors are high mileage, sudden escalation of mileage, training on hard surfaces, and nonmenstruation in women [1,21,24].

Patients usually present with foot pain that is worse with running and better with rest. At first, symptoms may be intermittent, but begin to occur with all activity. They often present 4 to 5 weeks after a sudden training increase. The most common physical examination finding is point tenderness over the fracture. Imaging confirms the diagnosis. Plain films can remain normal for 3 to 6 weeks after symptoms develop. The first change seen is subperiosteal bone formation. Sometimes changes are never seen on plain films [7]. Bone scans will be positive in 20% to 40% of cases in which clinical suspicion is high but plain films are normal [21]. MRI also is sensitive in showing stress fractures. Some investigators believe that MRI is too sensitive, because it sometimes shows bony reaction in asymptomatic athletes. Grading scales have been developed for MRI changes that correlate with prognosis [21].

There are no good randomized controlled trials that evaluated treatment for stress fractures of the metatarsals. Generally, treatment begins with
reducing activity to a pain-free level; therefore, if walking is painful, the
patient should be made nonweightbearing, but if walking is not painful, it is
permitted. Rehabilitation begins with swimming or pool running so that
aerobic fitness can be maintained. Muscle imbalances and inflexibilities of
the lower extremities are addressed, depending on the individual needs of
the patient. After they can do the activity pain-free, patients may progress
to nonpounding upright activity, such as cycling, elliptical training, or
Stairmaster machines, and lower extremity weight training. Gradually,
running and sports drills are added and then time and distance is increased
gradually as long as the patient remains asymptomatic. Orthotics may be
prescribed to accommodate a less than ideal foot structure. In female
athletes, general bone health and hormonal issues may need to be explored.

Return to full running is variable, depending on the grade of the fracture
and the patient’s healing capacity. In a study of collegiate athletes in a wide
variety of sports who had various stress fractures, the average return to
sport was 8.4 weeks [21].

**Metatarsalgia**

This is a common condition in runners to consider after metatarsal stress
fractures are ruled out. Patients complain of pain on the plantar surface of
the metatarsal heads that is worse with running and better at rest.
Tenderness in this area is found on physical examination. Often, an
overpronated foot is seen. This is because the first and second metatarsal
heads may accept increased force at impact because of the excessive
pronation [5]. It is treated by a metatarsal pad that is placed proximal to the
painful area to relieve pressure on the metatarsals and spread forces over
a larger area, or a custom orthosis that can provide the same function along
with a cut-out for the painful metatarsal head to relieve pressure further.

**Extensor and flexor tendonitis**

Forefoot tendonitis, especially extensor tendonitis, is common in runners.
Running hills is believed to be a risk factor because of the challenge to toe
dorsiflexion range of motion (ROM) when running uphill, and the challenge
of a prolonged eccentric contraction when running downhill [7]. Treatment
is the same as for other tendon injuries—relieve pressure to the area by not
overtightening shoe laces, decrease pain with NSAIDs and ice, and address
strength and flexibility deficits of the foot and ankle.

**First metatarsal phalangeal conditions**

Running can aggravate common conditions of the first metatarsal
phalangeal, such as hallux rigidis and hallux valgus. Generally, these are
managed with activity modification and orthoses in runners who want to
pursue conservative care and continue to run. Hallucis sesamoids also can
be aggravated by running, especially sprinting. Patients have pain with
weight bearing and walking. Physical examination reveals tenderness and
swelling in the area. Often, it is difficult to differentiate stress fractures of the sesamoid from sesamoiditis, which is pain and swelling of the tendon around the sesamoids. These injuries are difficult to treat and may require prolonged rest and unweighting the area with orthoses or padding [6].

**Interdigital neuromas**

Symptoms are caused by swelling of the nerves and scar tissue around the nerves. This is believed to be secondary to repetitive toe dorsiflexion that occurs at push off during running and excessive foot pronation. Patients complain of numbness and pain in the toes that is worse with tight shoes and when weight is placed through the forefoot. The third intermetatarsal space is affected most commonly, so the third and fourth toes are numb most commonly [18]. Treatment is usually with metatarsal pads, widened footwear, and strengthening of foot intrinsics. In some cases, surgery is necessary to relieve symptoms.

**Ankle injuries**

**Epidemiology**

The ankle is another area that is injured commonly in running, and in sports that require running. Ankle injuries account for approximately 15% of all sports injuries [25]. Like foot injuries, ankle injuries can be divided into overuse injuries and traumatic injuries. Overuse injuries in the ankle usually are tendon injuries, the most common of which is Achilles tendinopathy. By far, the most common traumatic injury is a lateral ankle sprain. Other, less common injuries of the ankle also are discussed below.

**Anatomy and biomechanics of the ankle**

The ankle consists of the talocrural joint and the distal tibiofibular joint. The talocrural articulation is a hinged synovial joint that is located between the distal tibia and fibula and the superior portion of the talus. The distal tibiofibular articulation is a fibrous joint, or syndesmosis. A strong interosseous ligament forms the principle connection between the tibia and fibula at this joint. The anterior and posterior tibiofibular ligaments provide further supports to this joint.

The superior surface of the talus, or trochlea, is pulley-shaped and bears the weight of the body that is transmitted by way of the tibia. The body of the talus has three continuous facets for articulations superiorly with the tibia, laterally with the medial malleolus, and medially with the lateral malleolus. The inferior surface of the talus articulates with the calcaneus. Posteriorly, the talus has medial and lateral tubercles that form a groove in between for the flexor hallucis longus tendon to pass into the foot. During ossification, the lateral tubercle may fail to unite with the body of the talus;
this results in an extra bone, the os trigonum. Finally, the talus articulates anteriorly with the navicular.

Dorsiflexion and plantarflexion are the primary movements of the talocrural joint. During plantarflexion, some rotation and abduction/adduction can occur. In dorsiflexion and the neutral position, the ankle is stable given its bony articulations which are supported by powerful ligaments and are crossed by several tendons which are bound tightly down by a retinaculum, or thickened deep fascia. During plantarflexion, however, the trochlea of the talus moves anteriorly in the tibial mortise; this lessens bony stability and creates more reliance on the ligamentous contribution.

The fibrous capsule of the talocrural joint is reinforced medially by the deltoid ligament and laterally by the lateral ligaments. The deltoid ligament attaches the medial malleolus to the talus, navicular, and calcaneus. It also helps to support the medial longitudinal arch. This ligamentous complex consists of four parts: tibionavicular, anterior and posterior tibiotalar, and tibiocalcaneal ligaments. The ligaments rarely are injured because the complex is strong and eversion injuries are less common.

The three lateral ligaments, which are not as strong as the deltoid ligament, attach the lateral malleolus to the talus and calcaneus. They are named the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and posterior talofibular ligament (PTFL). The ATFL primarily prevents anterior translation of the talus on the tibial mortise; however, in plantarflexion, the ligament’s orientation allows it to prevent inversion. It is the weakest of the lateral ligaments, and thus, is the one that is injured most commonly. The CFL prevents inversion at the talocrural and the subtalar (talocalcaneal) joints. The PTFL prevents posterior talar translation on the tibia. It is the strongest of the lateral ligaments and is taut only in extreme dorsiflexion; therefore, it is only injured in severe ankle sprains.

Regarding the muscles that act on the ankle, the main dorsiflexors are the tibialis anterior and extensor digitorum longus, although the extensor hallucis longus and peroneus tertius can assist. The chief plantarflexors include the gastrocnemius and soleus, but are assisted by the plantaris, tibialis posterior, flexor hallucis longus, and flexor digitorum longus.

**Ankle injuries**

Common ankle injuries in runners primarily include tendinopathies and ligamentous sprains; however, osteochondral injuries, nerve entrapments, and other neurologic injuries must remain on the differential diagnosis when evaluating a runner who has an ankle injury. Differentiating the far more common overuse, insidious injuries from acute, traumatic injuries also is important. A regional approach to the differential diagnosis of ankle injuries in runners is outlined below. Evidence-based treatment with a focus on
rehabilitation is highlighted. Lateral ankle ligamentous sprains and Achilles tendinopathy are paid specific attention as prototypes of treatment protocols for ankle injuries in runners.

**Lateral ankle pain**

**Ligamentous sprains**

Although more insidious/overuse injuries are more common in runners, they also can sustain acute trauma. Lateral ankle sprains are one of the most common sports-related injuries; cross-country running probably is the most risky for the runner [26]. More than 40% of ankle sprains can progress to chronic problems [27]. In runners, ankle sprains occur more commonly in adolescents. Inversion injuries are most common, thus straining the lateral ligaments. These are more common because the lateral malleolus projects more distally (than the medial) which creates a bony block to significant eversion.

Because the typical mechanism of injury is inversion, supination, and plantarflexion of the foot while the tibia rotates externally, there is a predictable sequence of ligamentous tears [27]. The ATFL is damaged before the CFL. The PTFL is damaged only in severe injuries and frequently is associated with a fracture. The ATFL is an intracapsular structure, and thus, if torn, hemarthrosis can result. Ligament injuries are graded in severity from I to III. A grade I injury involves ligamentous stretching but no gross tears. A grade II injury involves partial ligamentous tearing, whereas a grade III injury involves a complete ligamentous rupture. It is important to grade these injuries correctly because it aids in prognosis and determining the appropriate rehabilitation. Eighty-six percent of ankle ligament tears are midsubstance, and thus, only 14% are avulsion injuries [27]. Sixty-five percent of grade III sprains are solely ATFL tears and 20% include the ATFL and the CFL [27].

When taking a history of a runner who has ankle pain, it is important to understand the mechanism of injury, which can clue the practitioner to the injured structures. The locations of pain and swelling also help to determine the site of injury. Determining the onset of pain is helpful in that a runner who can bear weight immediately following the injury and then develops pain and swelling as he continues to run suggests a ligamentous injury over a fracture and also can help to indicate the severity of injury; continuing to run is an indication that little to no instability is present.

The examination of the runner who has a suspected ankle sprain begins with observation that specifically looks for swelling, ecchymosis, and any deformity while standing (if possible) and supine. Palpating for the exact location of tenderness can help to establish if the injury is solely ligamentous or if a fracture may be involved. Be certain to palpate the ligaments, malleoli, talus, distal and proximal fibula, base of the fifth metatarsal, and the peroneal tendon. Assess active and passive ankle ROM. Plantarflexion
typically exacerbates pain by stressing the ATFL. Assess the runner’s neurovascular status by palpatting the pedal arteries and testing sensation in the sural and peroneal nerves’ distribution.

Provocative maneuvers include the anterior drawer and talar tilt tests. The anterior drawer estimates ATFL stability [28]. The examiner attempts to translate the foot anterior to the tibia while gripping the heal. The runner’s knee should be flexed to relax the gastrocnemius. Test reliability, however, is poor, partially because of patient guarding secondary to pain.

The talar tilt, or inversion, test estimates CFL integrity [29]. The ankle is grasped and moved into inversion to assess the motion of the talus and calcaneus on the tibia and fibula. This test is difficult when examining an acute injury because of pain and swelling. van Dijk et al [30] recommended that the physical examination be delayed for 4 to 5 days after the initial injury to improve its sensitivity and specificity.

Radiography in evaluating ankle sprains is guided by the Ottawa Ankle Rules [31]. These state that ankle films should be taken if there is bony tenderness in the posterior half of the lower 6 cm of the tibia or fibula or an inability to bear weight immediately after injury and during the clinical assessment. Foot radiographs are indicated if the athlete has bony tenderness over the fifth metatarsal or navicular or if there is an inability to bear weight immediately after injury and during the clinical assessment. If the athlete presents within 10 days of injury, no significant fracture has been missed with these guidelines. Standard ankle films include antero-posterior (AP), lateral, and mortise views. The mortise projection is an AP view with the leg internally rotated 20° to allow the beam to be perpendicular to the intermalleolar line. Stress radiography is not used commonly because it does not detect an injury reliably [32]. MRI is used rarely in the setting of acute ankle sprains; however, it can be helpful in the evaluation of chronic ankle sprains or ankle pain that is not relieved with regular conservative measures to evaluate for talar dome lesions, other osteochondral injuries, or peroneal tendon involvement. Injuries to the talar dome occur in 7% to 22% of ankle sprains and are missed commonly on initial evaluation [33].

Initial management of an ankle sprain involves controlling pain and swelling and maintaining ROM. PRICE (protection, rest, ice, compression, and elevation) is appropriate to start. Cryotherapy helps to reduce effusion and potentially decreases metabolism which may limit secondary hypoxic injury [34]. Hocutt [35] et al demonstrated better outcomes in patients who started cryotherapy within 36 hours of injury. Wrapping the acutely injured ankle with an elastic bandage, distal to proximal, also can minimize effusion. Use of electrical stimulation and ultrasound have not demonstrated a definite reduction in swelling with human subjects, although they may be helpful for adjuvant pain control.

Functional, removable braces (eg, air splints) that control inversion/eversion, but allow dorsiflexion and plantarflexion, generally are recommended over rigid immobilization, although there is no strong data to
recommend one form of immobilization over another [36]. With rigid immobilization (eg, walking boot), maximal dorsiflexion allows the least capsular distention, and thus, decreases effusion and allows for close approximation of the torn ligaments ends in grade III sprains and reduces tension on the injured ligaments in grades I and II sprains [37]. Grade III injuries may require more support than a typical air splint can offer. Remember that more extensive immobilization likely will prolong the rehabilitation period, although it may increase patient mobility earlier. Overall, early motion is an important goal in treatment. If no associated fractures are present, weight bearing as tolerated is encouraged and can be assisted temporarily with crutches or a cane. Reinforcing a normal gait pattern as soon as possible can limit stress on other tissues/joints that are proximal in the kinetic chain. The use of an assistive device for ambulation can be continued until the runner has a pain-free uncompensated gait.

Rehabilitation after an ankle sprain cannot be overemphasized. The overlying goal of any rehabilitation program is to restore normal mechanics to the ankle and improve joint stability to allow the athlete to return to safe running and decrease the risk for a recurrent sprain. Rehabilitation protocols progress in a step-wise fashion, beginning with ROM and progressing to restoring neuromuscular control, strengthening, proprioceptive training, and functional training before return to regular running.

Maintaining ROM is part of the initial management of acute ankle sprains and is the first step in rehabilitation. Passive and active assisted ROM in dorsiflexion and plantarflexion should be started as early as pain permits. Stretching with a towel for passive dorsiflexion is important to prevent Achilles tendon tightening. This can progress to standing on an incline after weight bearing is tolerated. During this early phase, low-grade mobilizations of the talocrural, subtalar, and midtarsal joints may be performed to decrease any potential restrictions, improve biomechanics, and thus, facilitate proper stretching.

Similar to vastus medialis inhibition in knee pain and serratus anterior inhibition in shoulder pain, the peroneal musculature is affected after an acute ankle sprain; thus, regaining neuromuscular control is the next step in rehabilitation [38]. Retraining the peroneals and other supporting musculature through strengthening and proprioception exercises facilitates normalizing neuromuscular control. Strength training should begin with isometrics and progress to the use of resistance bands/tubing, and finally, to closed-chain loading with toe raises and squats. The runner can progress strengthening from stress-free positions (where the ankle is neutral or in some dorsiflexion) to more stressful positions (ankle plantarflexion and inversion) and in multiple planes. More focus should be placed on the eccentric phase of contraction.

Proprioceptive training is important to recover balance and postural control, and it is hoped that it will prevent reinjury. Use of a wobble board is a common method of proprioceptive training and has demonstrated
effectiveness [39]. Early on, the runner can be seated with his feet on the wobble board then progress to standing, and later, standing with closed eyes to create a further challenge for advanced proprioceptive training.

After the runner is pain-free, has full ROM, strength of more than 75% of the noninjured leg, and adequate proprioception and balance, rehabilitation that progresses to functional training can begin with the goal of increasing power and improving neuromuscular control (at the ankle and more proximally up the kinetic chain of the limb) in multiple planes of motion. Plyometrics, agility drills, and closed-chain single-leg stance exercises are part of this functional program.

Return to running is allowed when these functional exercises are performed without pain. The length of time that the athlete was in rehabilitation (and not running) will determine how quickly he or she will get back to the previous level of running. To lessen deconditioning during rehabilitation, the runner should be encouraged to stationary cycle or participate in deep-water running.

Surgical treatment rarely is the initial step, even for complete (grade III) ligament ruptures. All athletes who have an ankle sprain (grades I–III) should trial conservative treatment as discussed above. If the athlete who has a grade III tear fails this conservative approach, then consideration of surgical reconstruction is indicated after other causes for persistent pain have been evaluated fully with appropriate imaging. A delay in surgery (even years after the initial injury) does not prevent good operative results; thus, surgery should be considered only after rehabilitation has failed [40].

**Lateral soft tissue impingement**

Sometimes after a severe lateral ankle sprain or repeated minor strains, scarring of the soft tissues and synovium in the area create chronic lateral ankle pain and a feeling of catching and giving-way in the ankle. Initial treatment is the same as for chronic ankle sprains. Steroid injections into the joint can relieve symptoms. If these treatments are not helpful, then surgery can be considered to remove scar tissue.

**Peroneal tendinopathy**

This is a common overuse cause of lateral ankle pain and should be considered, especially if the runner has not suffered ankle sprains. Biomechanically, it is believed to be due to excessive pronation and eversion of the foot. Physical examination reveals tenderness over the tendon and pain with resisted eversion. Rehabilitation is the same as for other tendon problems: alternative training (eg, swimming, cycling) until running is asymptomatic, modalities, correction of muscular imbalances and foot biomechanics (potentially with an orthotic device), and eccentric strengthening of the involved muscles after it can be accomplished pain-free.

Subluxation of the peroneal tendon is an uncommon cause of lateral ankle pain in runners but can occur after an acute dorsiflexion-eversion
stress. The peroneal retinaculum can tear, and thus allow the peroneal tendon to sublux anterior to the lateral malleolus. Treatment of an acute injury is a nonweight-bearing cast for 6 weeks. Chronic instability may be served better by surgical reconstruction because of the likelihood of recurrent subluxation.

**Sinus tarsi syndrome or subtalar ligament sprain**

The sinus tarsi is a canal that runs from the anterior inferior lateral malleolus posteromedially to just posterior to the medial malleolus. It is believed that with poor foot and ankle biomechanics (commonly excessive pronation), microtrauma can occur to this area. This injures the subtalar ligaments and connective tissue that are housed within this bony canal and cause poorly localized pain, but often just anterior to the lateral malleolus. The physical examination is nonspecific, except for pain in the area with palpation, and typically, the subtalar joint is notably stiff. It is difficult to differentiate pain that arises from the sinus tarsi from pain that is related to a lateral ligament sprain. An injection of lidocaine into the sinus tarsi that relieves symptoms may help with diagnosis. Rehabilitation is the same as for chronic ankle strains. In addition, many practitioners believe that manual mobilization of the subtalar joint is important [41].

**Osteochondral talus injuries**

The articular surface of the talus typically is disrupted by trauma and lateral lesions are associated with severe lateral ankle sprains. Typically, they are not diagnosed until further evaluation is performed in the runner who is unable to rehabilitate effectively after a lateral ankle sprain. Plain films with a mortise view of the ankle are indicated first. If negative, a bone scan that is followed by CT or MRI alone will help to demonstrate the anatomic morphology of a lesion. Conservative management, generally with nonweight-bearing immobilization, is tried first for small lesions that are still attached to the talus. Some practitioners believe that joint motion without significant loading may be better to stimulate articular cartilage healing. If the lesion is large, a loose body, or did not respond to conservative management, surgery should be considered.

**Anterior ankle pain**

The most common cause of anterior ankle pain that is seen in runners is anterior tibialis tendonitis. Physical examination reveals tenderness and swelling over the tendon, and pain with resisted dorsiflexion. Rehabilitation is the same as for other tendon injuries discussed above. Most other causes of anterior ankle pain have a traumatic etiology. Tibia–fibula syndesmosis sprains usually are not seen in isolation and generally are associated with fractures or lateral ligament injuries. Partial tears are difficult to diagnosis. Complete tears usually show up as widening of the space between the medial
malleolus and talar dome and search for an associated fracture is indicated. Treatment of partial tears is similar to lateral ligament sprains, but grade III tears will need cast immobilization or surgical management.

**Medial ankle pain**

A common cause of medial ankle pain in runners is posterior tibial tendonitis, which is discussed in the midfoot pain section because pain occurs over the entire course of the tendon. Other causes are tarsal tunnel syndrome (also discussed above); flexor hallucis longus tendonitis, which is more common in sprinters than in distance runners because of the forceful push off that is used during racing by sprinters; and ligamentous sprains. Medial (deltoid) ligament injuries are exceedingly less common than injury to the lateral ligaments and result from eversion stress or forced external rotation to the planted foot. Associated fractures are common. An isolated deltoid ligament injury generally is treated similarly to lateral ligament sprains, although commonly, much more time is invested before return to sport.

**Posterior ankle pain**

**Achilles tendinosis**

Posterior ankle pain is a common complaint in runners. The most common cause of this is Achilles tendon pain, which has an annual incidence of 7% to 9% in top level runners [42]. One study of orienteering runners found that the odds of developing Achilles problems was 10 times greater in runners than in age-adjusted controls [43]. The pathophysiology behind this disorder is not completely clear. Biopsies do not reveal inflammatory cells; therefore, the terms “tendinosis” or “tendinopathy” are used, rather than tendonitis. It is more common in older runners, and histologic studies reveal fiber degeneration and derangement of collagen fibers, so it seems to be a degenerative process. Hypoechoic regions on ultrasound that are indicative of fiber degeneration are seen in asymptomatic subjects, however, so there must be an additional unknown component to the factors that cause the development of pain. In an interesting study of elite soccer players, ultrasound imaging of asymptomatic Achilles tendons was performed at the beginning of the season. Ultrasound detected changes that are associated with tendinosis (eg, spindle-shaped thickening) in 11 of 96 asymptomatic tendons. At the end of the season, five of the subjects who had abnormal tendons (45%) had become symptomatic; only 1 of the 85 tendons that were normal at the beginning of the season developed tendinosis during the season. Four of the subjects who had abnormal tendons at the start of the season remained asymptomatic, and ultrasound at the end of the season revealed that the tendon changes had normalized. Two of the 11 subjects remained asymptomatic and still had changes on ultrasound [44]. Some scientists hypothesize that neovascularization may be the cause of pain in chronic tendinosis [45].
The history of Achilles tendinosis is similar to other tendon problems that are seen in runners; it is associated with excessive mileage, sudden increases in intensity, inadequate warm-up and stretching, and muscle imbalances. In military recruits, training in the cold is a risk factor, and is believed to be caused by increased viscosity of the mucopolysaccharides, which act as a lubricant to the paratendonous structures to allow for smooth gliding of the tendon. It is believed that this may be the mechanism behind the reason for “warming up” with light exercise and stretches to prevent tendon problems [46]. Commonly, the pain is intermittent and improves with a warm-up at first and later progresses to constant pain. Multiple physical examination signs have been described. Most commonly, the most tender area is 2 cm to 6 cm above the calcaneal insertion. One small study compared the physical examination of 10 athletes who were diagnosed with Achilles tendinosis with a control group of athletes from the same sports. The physical examination included:

- Sensitivity of the tendon to palpation
- Arc sign: painful or swollen area moves with dorsiflexion and plantarflexion of the foot
- Royal London Hospital Test: after the most tender point to palpation is identified, the area is palpated while the patient maximally dorsiflexes and plantarflexes. Pain is decreased or disappears with maximum dorsiflexion.

The outcomes were compared with ultrasound findings of tendon disease. All three tests had relatively good specificity (0.83–0.91), meaning that they were able to identify tendons that showed no changes on ultrasound fairly well; however, the sensitivity was not as good and ranged from 0.53 to 0.58 [47].

Studies of the biomechanical faults that are associated with Achilles tendinosis found that patients are more likely to have excessive pronation, limited mobility of the subtalar joint, and limited ankle dorsiflexion range. In addition, it is believed that gastroc-soleus weakness contributes to the condition because a weak or fatigued muscle lacks energy-absorbing capacity and the muscle can no longer protect the tendon from overload and strain [48].

Although the diagnosis usually is made clinically, MRI and ultrasound are able to show tendon changes. These imaging studies can be helpful to determine if it is solely tendonopathy or if a potential tear is contributing to the symptoms. If Achilles tendon rupture is suspected, Thompson’s test can be performed. The patient lies prone with the calf relaxed. The examiner squeezes the calf musculature. Normally, the foot plantarflexes. No movement is indicative of an Achilles tendon rupture.

Treatment of Achilles tendonopathy usually begins with symptom control by using ice, modifying activity, and NSAIDs, although one study showed that NSAIDs were not helpful in chronic tendinosis [48]. The use of
peritendinous corticosteroid injections to treat Achilles tendon problems is controversial. Many experts believe that these should be avoided because of the risk for weakening the tendon and causing rupture; however, this has not been proven in human or animal studies. In a study of 43 patients who were followed for greater than 2 years after fluoroscopically-guided corticosteroid injections into the space surrounding the Achilles tendon, no patient suffered tendon rupture [48]. Although a third of orthopedic surgeons who were surveyed said that they use steroid injections to treat Achilles tendinosis, the efficacy of these injections is unclear. In the previously discussed study, 40% believed that the injection helped them, 53% believed that it did not change their condition, and 7% believed that they were worse [49]. A study that compared corticosteroids plus bupivicaine injection into the paratendinous sheath with bupivicaine alone found no difference between the groups at 6 weeks [50]. Injection directly into the tendon is contraindicated because this was shown to cause tissue damage in animal studies [49].

Rehabilitation focuses on correcting the biomechanical faults that were discussed above and eccentric strengthening of the gastroc-soleus complex. A study of runners who had chronic tendinosis that was severe enough to prevent running had weak calf muscle strength on the injured leg compared with the noninjured leg. All patients who were included in the study had not improved after being treated with rest from running, conventional physical therapy, shoe orthoses, and NSAIDs. Fifteen of these patients went on to have surgery, and 15 were taught eccentric calf strengthening exercises and were instructed to do them two times a day for 12 weeks. In the group that performed eccentric strengthening, all patients returned to running and believed that they were at their preinjury level by the end of the 12 weeks. Strength testing revealed that the side-to-side strength changes had resolved. The group who was waiting for surgery had no change in their symptoms during that same 12-week period. After surgery, all patients in that group also returned to running at their preinjury level, but recovery took 6 months. The investigators suggested several mechanisms by which the eccentric exercises could lead to improvement, including lengthening of the muscle tendon unit, increased muscle hypertrophy and strength, and increased tensile tendon strength [51]. Another study of eccentric calf strengthening in patients who had chronic Achilles tendinosis found that all but three of the patients improved clinically and that tendon structure normalized on ultrasound after training in 19 of 26 tendons [52].

Other causes of posterior heel pain

Retrocalcaneal bursitis can be confused with Achilles tendinosis, but the pain is localized more inferiorly. It also can coexist with Achilles tendon problems. Posterior impingement syndrome also causes posterior heel or ankle pain. It is caused by impingement of soft tissues between the talus and the tibia in extreme foot plantarflexion. It is much more common in
sprinters than in distance runners because of foot position in sprinting (ie, “toe running”).

**Summary**

Foot and ankle injuries are common in runners. Treatment is becoming more evidence-based for the most common of these conditions; however, further research is needed to determine the best treatments for injuries that are encountered less commonly.

**References**


