18

The Foot

Objectives

When you finish this chapter you should be able to

- Identify the major anatomical and functional features of the foot.
- Discuss how foot injuries may be prevented.
- Explain the process for evaluating injuries to the foot.
- Identify specific injuries that occur in the foot, and discuss plans for management.
- Design rehabilitation techniques for the injured foot.

Outline

Key Terms

stance phase
swing phase
metatarsalgia
neuroma
apophysitis
apophysis
exostosis
point tenderness

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- Clinical application scenarios covering evaluation of foot injuries, prevention of foot injuries, and management of foot injuries
- Click-and-drag questions covering anatomical features of the foot
- Multiple-choice questions covering injury evaluation, prevention of injury, and rehabilitation techniques for the foot
- Selection questions covering activities of the foot

Many activities involve some elements of walking, running, jumping, and changing direction. The foot is in direct contact with the ground, and the forces created by these athletic movements place a great deal of stress on the structures of the foot. Consequently, the foot has a high incidence of injury.[8,32,61]

The function of the foot is critical in walking, running, jumping, and changing direction. In one instant, the foot must act as a shock absorber to dissipate the ground reaction forces. In the next instant, it must become a rigid lever that propels the body forward, backward, or to the side.[17]

The foot forms the base for the entire kinetic chain, and different structural foot types can affect movement, stability, and the biomechanics throughout the kinetic chain.[25] Because of the stress that these movements place on the foot and because of the complex nature of the anatomical structures of this body part, recognition and management of injuries to the foot present a major challenge to the athletic trainer.

FOOT ANATOMY

Bones

The foot consists of 26 bones: 14 phalangeal, 5 metatarsal, and 7 tarsal (Figure 18–1). Additionally, there are two sesamoid bones beneath the first metatarsal.

Toes The toes are somewhat similar to the fingers in appearance but are much shorter and serve a different function. The toes are designed to give a wider base both for balance and for propelling the body forward. The first toe, or hallux, has two phalanges, and the other toes each have three phalanges.

Two sesamoid bones are located beneath the first metatarsophalangeal joint. Their functions are to assist in reducing pressure in weight bearing, increase the mechanical advantage of the flexor tendons of the great toe, and act as sliding pulleys for tendons.

Metatarsal Bones The metatarsals are the five bones that lie between and articulate with the tarsals and the phalanges, thus forming the semimovable tarsometatarsal and metatarsophalangeal joints. Although little movement is permitted, the ligamentous arrangement gives elasticity to the foot in weight bearing. The metatarsophalangeal joints permit hinge action of the phalanges, which is similar to the action between the hand and fingers. The first metatarsal is the largest and strongest and functions as the main weight-bearing support during walking and running.

The medial and lateral sesamoid bones are located on the plantar aspect of the metatarsophalangeal joint of the great toe within the flexor hallucis tendon: Their purposes are (1) to increase the mechanical efficiency of the tendon and (2) to decrease frictional stress as the tendon passes over bony prominances.

Tarsal Bones The foot has seven tarsal bones, which are located between the bones of the lower leg and the metatarsals. These bones are important for body support and locomotion. They consist of the calcaneus, talus, navicular, cuboid, and first, second, and third cuneiform bones.

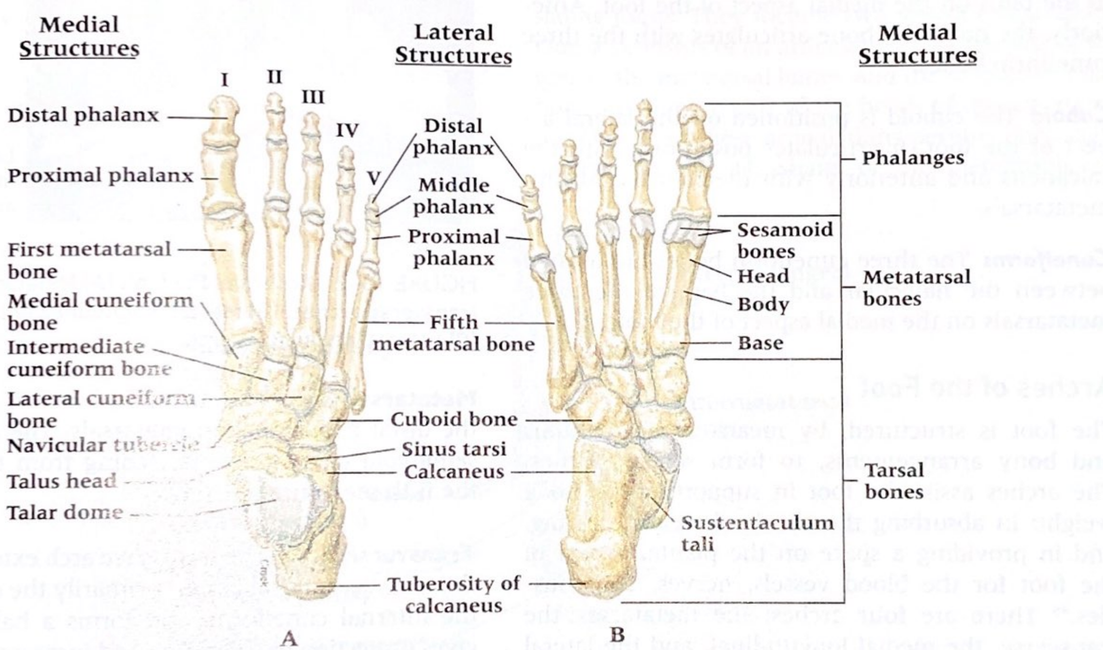


FIGURE 18–1 Bony structure of the foot. (A) Dorsal aspect. (B) Plantar aspect.

Calcaneus The calcaneus is the largest tarsal bone. It supports the talus and shapes the heel; its main functions are to convey the body weight to the ground and to serve as an attachment for both the Achilles tendon and several structures on the plantar surface of the foot.

The wider portion on the posterior calcaneus is called the tuberosity of the calcaneus. The medial and lateral tubercles are located on the inferior lateral and medial aspects and are the only parts of this bone that normally touch the ground.

Talus The irregularly shaped talus is the most superior of the tarsal bones. It is situated above the calcaneus over a bony projection called the sustentaculum tali. The talus consists of a body, neck, and head. The uppermost part of the talus is the trochlea, which articulates with the medial and lateral malleoli to form the ankle joint. The talus is broader anteriorly than posteriorly, thus preventing forward slipping of the tibia during locomotion.

Because the talus fits principally into the space formed by the malleoli, lateral movement is restricted by the stabilizing ligaments of the ankle. Because the uppermost articular surface of the talus is narrower posteriorly than anteriorly, dorsiflexion is limited. At a position of full dorsiflexion the anterior aspect of the medial collateral ligaments is taut, whereas in plantar flexion internal rotation occurs because of the shape of the talus. The average range of motion is 10 degrees in dorsiflexion and 23 degrees in plantar flexion.[68]

Navicular The navicular bone is positioned anterior to the talus on the medial aspect of the foot. Anteriorly, the navicular bone articulates with the three cuneiform bones.

Cuboid The cuboid is positioned on the lateral aspect of the foot. It articulates posteriorly with the calcaneus and anteriorly with the fourth and fifth metatarsals.

Cuneiforms The three cuneiform bones are located between the navicular and the base of the three metatarsals on the medial aspect of the foot.

Arches of the Foot

The foot is structured, by means of ligamentous and bony arrangements, to form several arches. The arches assist the foot in supporting the body weight; in absorbing the shock of weight bearing; and in providing a space on the plantar aspect of the foot for the blood vessels, nerves, and muscles.[49] There are four arches: the metatarsal, the transverse, the medial longitudinal, and the lateral longitudinal (Figure 18–2).

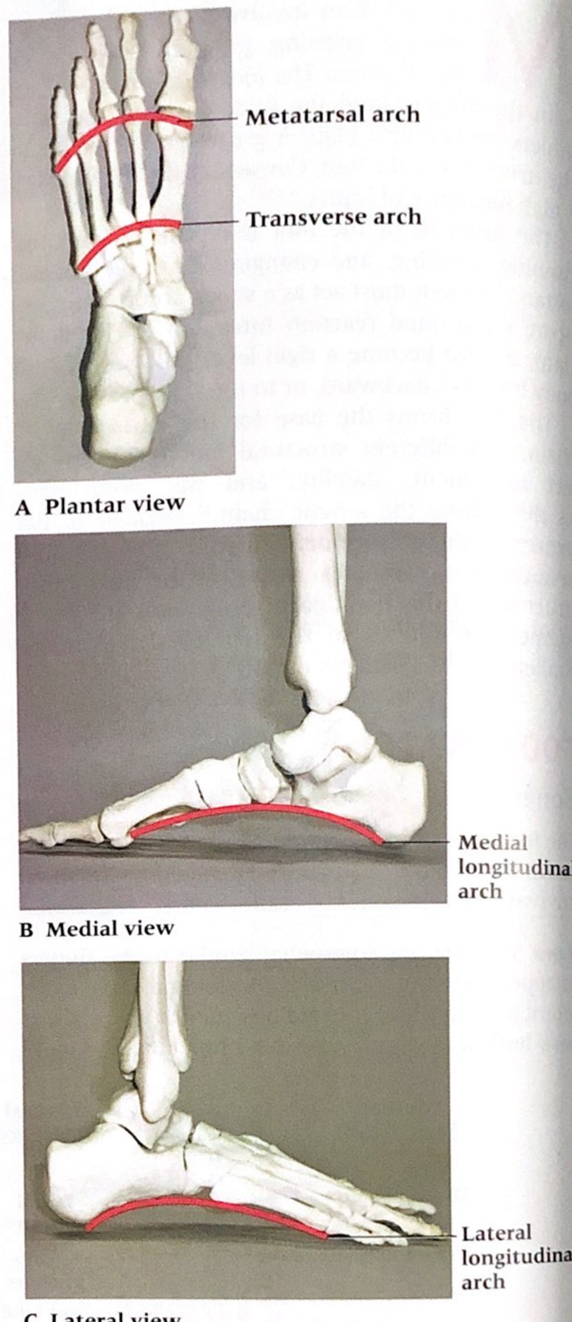


FIGURE 18–2 Arches of the foot. (A) Metatarsal and transverse arches. (B) Medial longitudinal arch. (C) Lateral longitudinal arch.

Metatarsal Arch The metatarsal arch is shaped by the distal heads of the metatarsals. The arch has a semiovoid appearance, stretching from the first to the fifth metatarsal.

Transverse Arch The transverse arch extends across the transverse tarsal bones, primarily the cuboid and the internal cuneiform, and forms a half-dome. It gives protection to soft tissue and increases the foot's mobility.

Medial Longitudinal Arch The medial longitudinal arch originates along the medial border of the calcaneus and extends forward to the distal head of the first metatarsal. Bony support is provided by the calcaneus, talus, navicular, first cuneiform, and first metatarsal. The main supporting ligament of the longitudinal arch is the plantar calcaneonavicular ligament, which acts as a spring by returning the arch to its normal position after it has been stretched. The tendon of the posterior tibialis muscle helps reinforce the plantar calcaneonavicular ligament.

Lateral Longitudinal Arch The lateral longitudinal arch is on the outer aspect of the foot and follows the same pattern as that of the medial longitudinal arch. It is formed by the calcaneus, cuboid, and fifth metatarsal bones. It is much lower and less flexible than the inner longitudinal arch.

Plantar Fascia (Plantar Aponeurosis)

The plantar fascia is a thick, white band of fibrous tissue originating from the medial tuberosity of the calcaneus and ending at the proximal heads of the metatarsals. Along with ligaments, the plantar fascia supports the foot against downward forces (Figure 18–3). The plantar fascia is a distal continuation of fascia that runs posteriorly from the muscles of the thigh to the muscles of the calf and continues under the calcaneus, where it thickens to become the plantar fascia. It is the most superficial layer on the plantar surface of the foot, lying just between the skin and the first layer of muscles.

Articulations

The articulations (joints) of the foot are categorized into five regions: interphalangeal, metatarsophalangeal, intermetatarsal, tarsometatarsal, subtalar, and midtarsal (Figure 18–4).

FIGURE 18–3 The Achilles tendon is continuous with the plantar fascia on the plantar surface of the foot.

Interphalangeal Joint The interphalangeal joints are located at the distal extremities of the proximal and middle phalanges at the bases of the adjacent middle and distal phalanges. These joints are designed only for flexion and extension. All interphalangeal joints have reinforcing collateral ligaments on their medial and lateral sides. Also located between the collateral ligaments on the plantar and dorsal surfaces are interphalangeal ligaments.

Metatarsophalangeal Joint The metatarsophalangeal joints are the condyloid type, which permits flexion, extension, adduction, and abduction. Each of these joints has collateral ligaments as well as plantar and dorsal metatarsophalangeal ligaments.

Intermetatarsal Joint The intermetatarsal joints are sliding joints. They include two sets of articulations. One set consists of an articulation on each side of the base of the metatarsal bones, and the second articulations are on each side of the heads of the metatarsal bone. Each of these articulations permits only slight gliding movements. Shafts of the metatarsals are

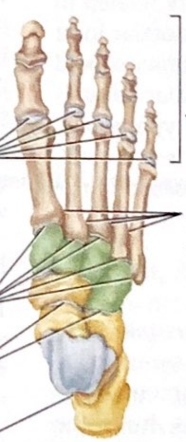


FIGURE 18–4 Articulations of the foot.

connected by interosseous ligaments. The bases are connected by plantar and dorsal ligaments, and the heads are attached by transverse metatarsal ligaments.

Tarsometatarsal Joint (Lisfranc's Joint) The tarsometatarsal joint is formed by the junction of the bases of the metatarsal bones with the cuboid and all three cuneiforms. The slight saddle shape of this joint allows for some gliding and thus for a restricted amount of flexion, extension, adduction, and abduction. Metatarsal bones are attached to the tarsal bones by the dorsal and plantar tarsometatarsal ligaments. Interosseous ligaments connect the three cuneiforms to the metatarsals. The tarsometatarsal joint is also known as Lisfranc's joint.

Subtalar Joint The subtalar joint is the articulation between the talus and the calcaneus. *Inversion, eversion, pronation,* and *supination* are normal movements that occur at the subtalar joint. Inversion is a movement of the calcaneus such that the sole of the foot turns inward, or medially. Eversion is a movement of the calcaneus such that the sole of the foot turns outward, or laterally.

In weight bearing, foot pronation is the combined movements of talar plantar flexion and adduction and calcaneal eversion. In contrast, foot supination is the combined movements of talar dorsiflexion and abduction and calcaneal inversion.[31] These movements, which occur at the subtalar joint, are triplanar movements—that is, movements that occur in all three planes simultaneously.[30] The movements of the talus during pronation and supination have profound effects on the lower extremity, both proximally and distally.

Midtarsal Joint (Chopart's Joint) The midtarsal joint, also referred to as Chopart's joint, consists of two distinct joints: the calcaneocuboid and the talonavicular joint. The midtarsal joint depends mainly on ligamentous and muscular tension to maintain position and integrity. Midtarsal joint stability is directly related to the position of the subtalar joint. If the subtalar joint is pronated, the talonavicular and calcaneocuboid joints become hypermobile. If the subtalar joint is supinated, the midtarsal joint becomes hypomobile. As the midtarsal joint becomes more or less mobile, it affects the distal portion of the foot because of the articulations at the tarsometatarsal joint.[31]

Stabilizing Ligaments

The subtalar ligaments are the interosseus talocalcaneal and the anterior, posterior, lateral, and medial talocalcaneal (Figure 18–5). A major ligament is the plantar calcaneonavicular, which passes from the medial longitudinal arch. Because of its relatively large number of elastic fibers and its primary purpose

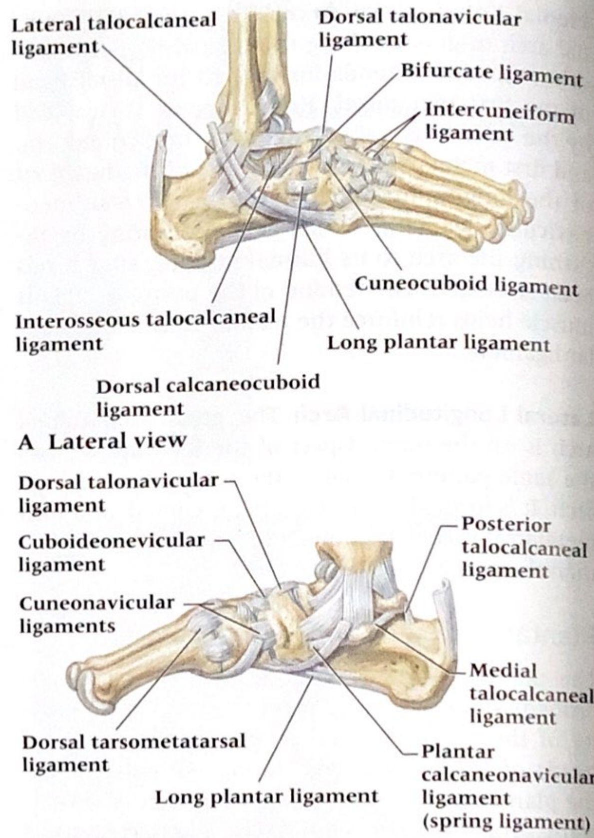


FIGURE 18–5 Ligaments of the foot. (A) Lateral. (B) Medial.

of providing shock absorption, the plantar calcaneonavicular is commonly called the spring ligament.

The primary ligaments of the midtarsal joint are the dorsal talonavicular, bifurcate, and dorsal calcaneocuboid. The midtarsal joint is given added strength in its plantar aspect by the long plantar ligaments.

Ligaments of the anterior tarsal joints are divided into those of the cuneonavicular, cuboideonavicular, intercuneiform, and cuneocuboid joints. Each of these joints has both dorsal and plantar ligaments. The intercuneiform ligaments have three transverse bands; one band connects the first cuneiform with the second and the second with the third. A ligament also connects the third cuneiform with the cuboid bone.

Muscles and Movement

The movements of the foot are produced by numerous muscles (Figures 18–6 and 18–7). Table 18–1 summarizes the intrinsic muscles of the foot and their actions.

Dorsiflexion and Plantar Flexion Dorsiflexion and plantar flexion of the foot take place at the ankle

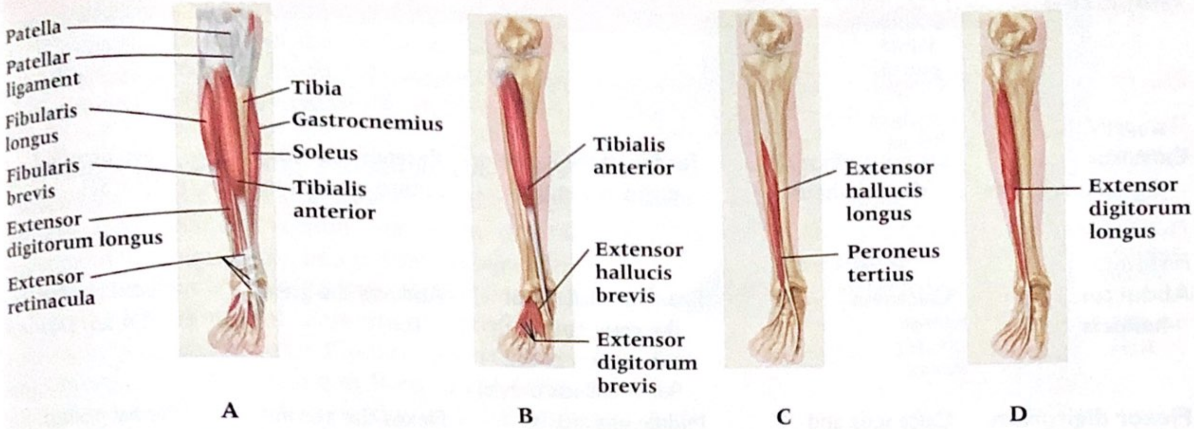


FIGURE 18–6 Muscles and tendons of the anterior aspect of the ankle and foot.

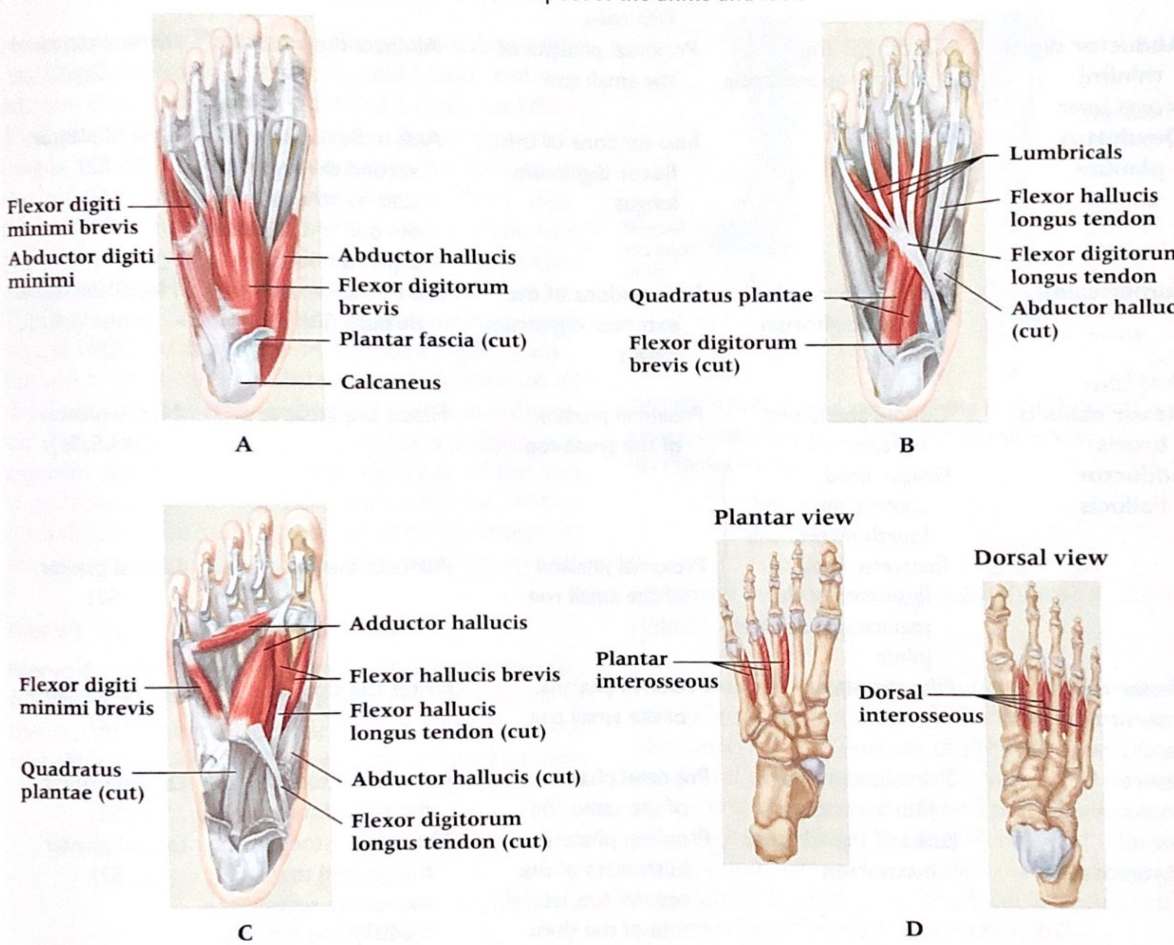


FIGURE 18–7 Intrinsic muscles of the foot. (A) First layer. (B) Second layer. (C) Third layer. (D) Fourth layer.

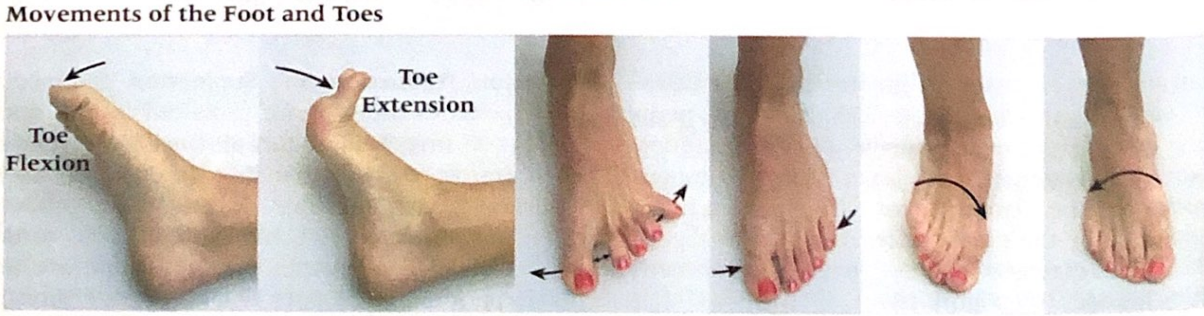
joint and are discussed in greater detail in Chapter 19. The gastrocnemius, soleus, plantaris, peroneus longus, peroneus brevis, tibialis posterior, flexor hallucis longus, and flexor digitorum longus muscles are the plantar flexors. Dorsiflexion is accomplished by the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius muscles (see Figure 18–6).

Inversion, Adduction, and Supination The medial movements of the foot are produced by the same muscles as inversion, adduction (medial movement of the forefoot), and supination (a combination of inversion and adduction). Muscles that produce these movements pass behind and in front of the medial malleolus. Muscles passing behind are the tibialis posterior (see Figure 19–5B), flexor digitorum

TABLE 18–1 Intrinsic Muscles of the Foot

Muscle	Origin	Insertion	Action	Nerve/ Nerve Root
Dorsal Muscle				
Extensor digitorum brevis	Lateral surface of the calcaneus	Tendon of the extensor digitorum longus	Extends the second through fifth toes	Deep peroneal (L5, S1)
Plantar Muscles				
First Layer				
Abductor hallucis	Calcaneus	Proximal phalanx of the great toe (with the tendon of the flexor hallucis brevis)	Abducts the great toe	Medial plantar (L4, L5, S1)
Flexor digitorum brevis	Calcaneus and plantar aponeurosis	Middle phalanx of the second through fifth toes	Flexes the second through fifth toes	Medial plantar (L4, L5, S1)
Abductor digiti minimi	Calcaneus and plantar aponeurosis	Proximal phalanx of the small toe	Abducts the small toe	Lateral plantar (S1, S2)
Second Layer				
Quadratus plantae	Calcaneus	Into tendons of the flexor digitorum longus	Aids in flexing the second through fifth toes by straightening the pull of the flexor digitorum longus	Lateral plantar (S1, S2)
Lumbricales	From tendons of the flexor digitorum longus	Into tendons of the extensor digitorum longus	Flexes the second through fifth toes	Medial and lateral plantar (L4, L5, S1, S2)
Third Layer				
Flexor hallucis brevis	Cuboid and lateral cuneiform	Proximal phalanx of the great toe	Flexes the great toe	Medial plantar (L4, L5, S1)
Adductor hallucis	*Oblique head:* second, third, and fourth metatarsals; *Transverse head:* ligaments of the metatarsophalangeal joints	Proximal phalanx of the small toe	Adducts the great toe	Lateral plantar (S1, S2)
Flexor digiti minimi brevis	Fifth metatarsal	Proximal phalanx of the small toe	Flexes the small toe	Lateral plantar (S1, S2)
Fourth Layer				
Plantar interossei	Third, fourth, and fifth metatarsals	Proximal phalanx of the same toe	Adducts the toes toward the second toe	Lateral plantar (S1, S2)
Dorsal interossei	Bases of the adjacent metatarsals	Proximal phalanges; both sides of the second toe; lateral side of the third and fourth toes	Abducts the toes from the second toe; moves the second toe medially and laterally	Lateral plantar (S1, S2)

Movements of the Foot and Toes



Toe Abduction | Toe Adduction | Foot Pronation | Foot Supination longus, and flexor hallucis longus (see Figure 19–5D). Muscles passing in front of the medial malleolus are the tibialis anterior (see Figure 19–5A) and the extensor hallucis longus (see Figure 18–6C).

Eversion, Abduction, and Pronation The lateral movements of the foot are caused by the same muscles that produce eversion, abduction (lateral movement of the forefoot), and pronation (a combination of eversion and abduction). Muscles passing behind the lateral malleolus are the fibularis longus (peroneus longus) and the fibularis brevis (peroneus brevis). Muscles passing in front of the lateral malleolus are the peroneus tertius and extensor digitorum longus (see Figure 18–6C&D).

Movement of the Phalanges The movements of the phalanges are flexion, extension, abduction, and adduction. Flexion of the second, third, fourth, and fifth distal phalanges is executed by the flexor digitorum longus and the quadratus plantar muscles. Flexion of the middle phalanges is performed by the flexor digitorum brevis, and flexion of the proximal phalanges is performed by the lumbricales and the interossei. The great toe is flexed by the flexor hallucis longus. The extension of all the middle phalanges is done by the abductor hallucis and abductor digiti quanti, the lumbricales, and the interossei. Extension of all distal phalanges is effected by the lumbricales, extensor digitorum longus, extensor hallucis longus, and extensor digitorum brevis. The adduction of the foot is performed by the interossei plantares and adductor hallucis; abduction is performed by the interossei dorsalis, abductor hallucis, and abductor digiti quanti.

Nerve Supply and Blood Supply

Nerve Supply The medial and lateral plantar nerves, which are branches of the tibial nerve, supply all of the intrinsic muscles on the plantar surface of the foot. The deep peroneal nerve supplies the extensor digitorum brevis on the dorsal suface of the foot (Figure 18–8).

FIGURE 18–8 Nerves of the foot.

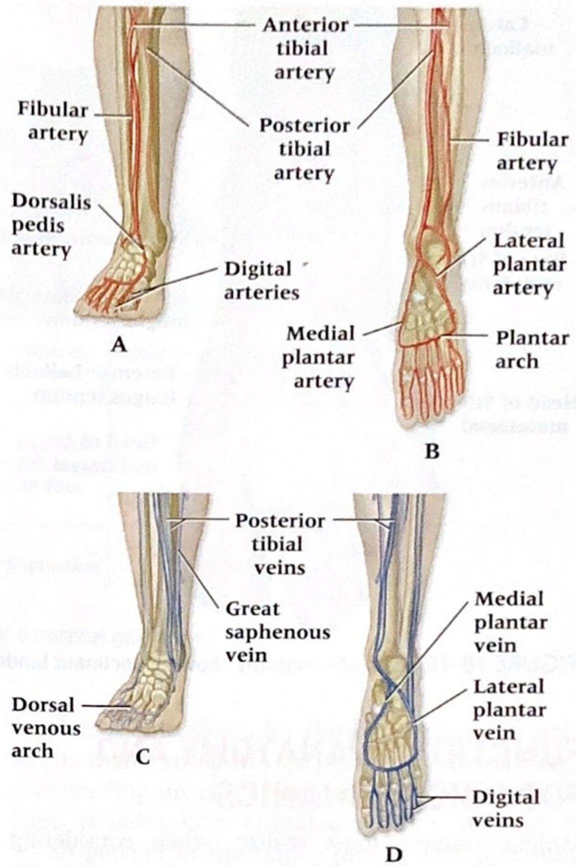


FIGURE 18–9 Blood supply of the foot. (A) Dorsal arteries. (B) Plantar arteries. (C) Dorsal veins. (D) Plantar veins.

Blood Supply The primary blood supply for the foot comes from the anterior tibial artery and posterior tibial arteries. The dorsum of the foot is supplied by the dorsal pedal artery and the dorsal metatarsal arteries, which branch from the anterior tibial artery. The plantar aspect of the foot is supplied by the lateral plantar artery, the medial plantar artery, and the plantar arterial arch, which all branch from the posterior tibial artery (Figure 18–9A&B).

The venous drainage from the plantar surface is through the medial and lateral plantar veins into the posterior tibial vein. The venous drainage on the dorsum of the foot is through the dorsal venous arch and dorsal pedal vein into the anterior tibial vein (Figure 18–9C&D).

Surface Anatomy

Figure 18–10A shows the pertinent surface anatomy for the dorsal surface of the foot, and Figure 18–10B shows the plantar surface of the foot.

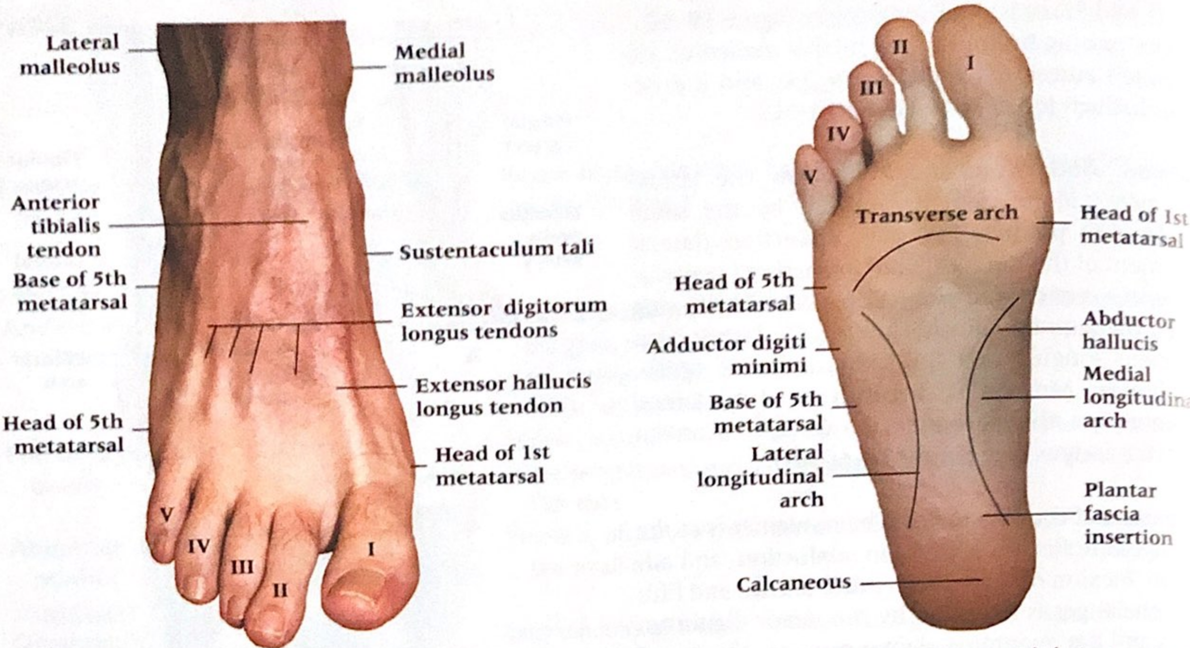


FIGURE 18–10 Surface anatomy showing pertinent landmarks of the foot from (A) dorsal view and (B) plantar view.

FUNCTIONAL ANATOMY AND FOOT BIOMECHANICS

Athletic trainers must realize, when considering foot, ankle, and leg injuries, that these segments are joined together to form a kinetic chain. Each movement of a body segment has a direct effect on proximal and distal body segments.[37] A study of lower-extremity chronic and overuse injuries related to sports participation must include some understanding of the biomechanics of the foot, especially in the act of walking and running. A number of biomechanical factors may be related to injuries of the lower-leg region.

Most people will develop foot problems at some time in their lives.

Normal Gait

The action of the lower extremity during a complete gait cycle in walking can be divided into two primary phases (Figure 18–11). The **stance phase** starts with initial contact of the heel on the ground and ends when the toe breaks contact with the ground (toe-off). This phase accounts for about 60 percent of the total gait cycle. The stance phase involves weight bearing in a closed kinetic chain. The stance phase can be further subdivided into five periods: *initial contact, loading response, midstance, terminal stance*, and *preswing*.

stance phase From initial contact to toe-off.

At midstance and terminal stance, the body is supported by a single limb, whereas at initial contact and in the early portion of the loading response period, there is double support with both feet on the ground.[54,70]

The time between toe-off and the subsequent initial contact is termed the **swing phase**, which is a period of non–weight bearing. The swing phase can be subdivided into three periods: *initial swing, midswing*, and *terminal swing*. In normal gait, while one leg is in the stance phase, the other is in the swing phase.

swing phase Period of non–weight bearing.

As in the walking gait, a running gait has both stance and swing phases. However, there are several differences. In running, the loading response and midstance periods occur more rapidly. There is also a period after toe-off in which neither foot is in contact with the ground and there is no time when both feet contact the ground simultaneously. In running, the stance phase accounts for only one-third of the gait cycle.

The foot's function during the stance phase of running is twofold. At heel strike, the foot acts as a shock absorber to the impact forces and then adapts to the uneven surfaces. At toe-off, the foot functions as a rigid lever to transmit the explosive force from the lower extremity to the running surface. In a heel-strike running gait, initial contact of the foot is on the lateral aspect of the calcaneus, with the subtalar joint in supination. It is estimated that 80 percent of distance runners use this heel-strike pattern, and the remainder are either midfoot or forefoot strikers.[68] Sprinters tend to be forefoot strikers, whereas a number of joggers are midfoot strikers.

At initial contact, the subtalar joint is supinated (Figure 18–12). Associated with this supination of

Stance Phase (60% of total)					Swing Phase		
Initial Contact (heel contact)	Loading Response	Midstance	Terminal Stance	Preswing (toe-off)	Initial Swing	Midswing	Terminal Swing
External Rotation of Tibia	Internal Rotation of Tibia			External Rotation of Tibia			
Supination	Pronation			Supination			

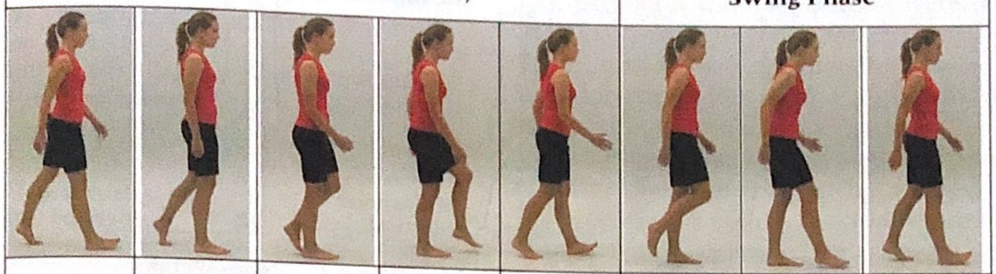


FIGURE 18–11 The stance and swing phases of a normal gait cycle.

the subtalar joint is an obligatory external rotation of the tibia.[54] As the foot is loaded, the subtalar joint moves into a pronated position until the forefoot is in contact with the running surface. The change in subtalar motion occurs between initial heel strike and 20 percent into the support phase of running.[54] As pronation occurs at the subtalar joint, there is obligatory internal rotation of the tibia. Transverse plane rotation occurs at the knee joint because of this tibial rotation. Pronation of the foot unlocks the midtarsal joint and allows the foot to assist in shock absorption and to adapt to uneven surfaces. It is important during initial impact to reduce the ground reaction forces and to distribute the load evenly on many different anatomical structures throughout the foot and leg. Pronation is normal and allows for this distribution of forces on as many structures as possible to avoid excessive loading on just a few structures. The subtalar joint remains in a pronated position through 55 to 85 percent of the stance phase, with maximum pronation being concurrent with the body's center of gravity passing over the base of support.[70]

The foot begins to resupinate and will approach the neutral subtalar position at 70 percent to 90 percent of the stance phase.[70] In supination, the midtarsal joints are locked, and the foot becomes stable and rigid to prepare for toe-off. This rigid position allows the foot to exert a great amount of force from the lower extremity to the running surface.

FIGURE 18–12 Foot bearing weight in walking as it moves from heel strike to toe-off.

Subtalar Joint Pronation and Supination Pronation and supination of the foot and subtalar joint are normal during the stance phase of running. However, excessive or prolonged pronation or supination often cause or contribute to overuse injuries. When structural or functional deformities exist in the foot or leg, compensation is likely to occur at the subtalar joint. The subtalar joint compensates in a manner that allows the foot to make stable contact with the ground and get into a

18–1 Clinical Application Exercise

An athletic trainer working in a sports medicine clinic observes a forefoot valgus deformity in a soccer player during a preseason screening.

? Why might this deformity be a problem? What can be done to manage this condition?

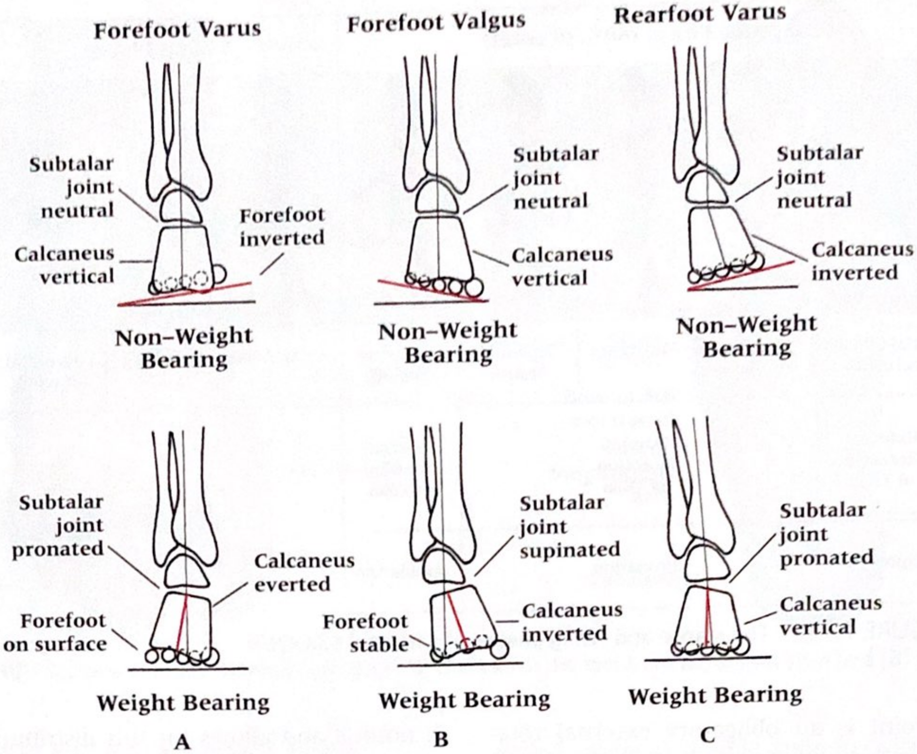


FIGURE 18–13 Structural foot deformities in non–weight bearing and compensations in weight bearing. (A) Forefoot varus. (B) Forefoot valgus. (C) Rearfoot varus.

weight-bearing position (Figure 18–13). This excessive motion compensates for an existing structural deformity.[31]

Structural Deformities The most typical structural deformities of the foot that produce excessive pronation or supination include forefoot varus, forefoot valgus, and rearfoot varus (Figure 18–13).[54] These structural deformities exist in a non–weight-bearing position. Structural forefoot varus and structural rearfoot varus deformities are usually associated with excessive pronation.[51] A structural forefoot valgus causes excessive supination. The deformities usually exist in one plane, but the subtalar joint will interfere with the normal functions of the foot and make it more difficult for the joint to act as a shock absorber, to adapt to uneven surfaces, and to act as a rigid lever for toe-off. The compensation, which occurs when the foot goes into weight bearing, rather than the deformity itself, usually causes overuse injuries.[31]

Excessive Pronation Excessive or prolonged pronation during running is one of the major causes of stress injuries. Overload of specific structures results when excessive pronation is produced in the stance phase or when pronation is prolonged into the propulsive phase of running.[11] Excessive pronation during the stance phase causes compensatory subtalar joint motion such that the midtarsal joint remains unlocked, resulting in an excessively loose foot.[23] As more motion occurs at the midtarsal joint, the first metatarsal and first cuneiform become more mobile. These bones constitute a functional unit known as the *first ray*. With pronation of the midtarsal joint, the first ray is more mobile because of its articulations with that joint. The first ray is also stabilized by the attachment of the peroneus longus tendon, which attaches to the base of the first metatarsal.[20]

The fibularis longus tendon passes posteriorly around the base of the lateral malleolus and then through a notch in the cuboid to cross the foot to the first metatarsal. The cuboid functions as a pulley to increase the mechanical advantage of the peroneal tendon. Stability of the cuboid is essential in this process. In the pronated position, the cuboid loses much of its mechanical advantage as a pulley; therefore, the peroneus longus tendon no longer stabilizes the first ray effectively. This condition creates hypermobility of the first ray and increased pressure on the other metatarsals. There is also an increase in tibial rotation, which forces the knee joint to absorb more transverse rotation motion.[31]

Prolonged pronation of the subtalar joint does not allow the foot to resupinate in time to provide a rigid lever for toe-off, resulting in a less powerful and efficient force. Thus, various foot and leg problems occur with excessive or prolonged pronation during the stance phase; these problems include stress fractures of the second metatarsal, plantar fasciitis, posterior tibial tendinitis, Achilles tendinitis, tibial stress syndrome, and medial knee pain.[30]

Excessive Supination At heel strike in prolonged or excessive supination, compensatory movement at the subtalar joint does not allow the midtarsal joint to unlock, which causes the foot to remain excessively rigid.[13] Because less movement occurs at the calcaneocuboid joint, the cuboid becomes hypomobile. The fibularis longus tendon has a greater amount of tension because the cuboid has less mobility and thus will not allow mobility of the first ray. In this case, the majority of the weight is borne by the first and fifth metatarsals. Thus, the foot cannot absorb the ground reaction forces as efficiently.[29]

Excessive supination limits tibial internal rotation. Injuries typically associated with excessive supination include inversion ankle sprains, tibial stress syndrome, peroneal tendinitis, iliotibial band friction syndrome, and trochanteric bursitis.[30]

PREVENTION OF FOOT INJURIES

Certainly, the foot is highly vulnerable to a variety of injuries. The repetitive stresses and strains incurred by the foot during athletic activities are unquestionably sufficient to cause both acute traumatic and overuse injuries. Foot injuries can best be prevented by selecting appropriate footwear, using a shoe orthotic, and paying attention to appropriate foot hygiene and care.[53,67]

Appropriate Footwear

The athletic and fitness shoe manufacturing industry has become extremely sophisticated and offers a number of options when it comes to purchasing shoes for different athletic activities. Shoe selection, parts of a shoe, and fitting were discussed in Chapter 7. Selecting an appropriate shoe is one of the most critical considerations in preventing a foot problem. Before a shoe is selected, the athletic trainer should evaluate the patient's foot to determine the existence of a structural deformity, such as a forefoot valgus or varus or a rearfoot varus. The type of shoe selected should depend on the existing structural deformity.

As noted earlier, pronation is a problem of hypermobility. Individuals who excessively pronate need stability and firmness to reduce this excess movement. Research indicates that shoe compression, compared with a barefoot condition, may actually increase pronation.[34] The ideal shoe for a pronated foot is one that is less flexible and has good rearfoot control. Conversely, supinated feet are usually very rigid. Increased cushioning and flexibility benefit this type of foot.

Several construction factors may influence the firmness and stability of a shoe. The basic form upon which a shoe is built is called the last. The upper is fitted onto a last in several ways. Each method has its own flexibility and control characteristics (Figure 18–14). A slip-lasted shoe is sewn together like a moccasin and is very flexible. A board-lasted shoe contains a piece of fiberboard to which the upper is attached, which provides a very firm, inflexible base for the shoe. A combination-lasted shoe is boarded in the back half of the shoe and slip-lasted in the front, which provides rearfoot stability with forefoot mobility.

The shape of the last may also determine shoe selection (Figure 18–15). Most individuals with excessive pronation perform better in a straight-lasted shoe—that is, a shoe in which the forefoot does not

A B C

FIGURE 18–14 Shoe lasts. (A) Slip-lasted. (B) Board-lasted. (C) Combination lasted.

FIGURE 18–15 Shape of the last. (A) Straight. (B) Curved.

curve inward in relation to the rearfoot.[18] Midsole design also affects the stability of a shoe. The midsole separates the upper from the outsole. More dense, less yielding material is often used under the medial aspect of the foot to control pronation.

In an effort to control rearfoot movement, many shoe manufacturers have reinforced the heel counter both internally and externally, often in the form of extra plastic along the outside of the heel counter. Other factors that may affect the performance of a shoe are the outsole contour and composition, lacing systems, and forefoot wedges.[31]

Table 18–2 provides guidelines for choosing the correct shoe components based on the type of foot problem.

Shoe Orthotics

Many injuries to the foot can be prevented by using an orthotic device to correct biomechanical problems that may exist in the foot and that can cause an injury.[14] The orthotic is a plastic, rubber, or leather support that is placed in the shoe as a replacement for the existing insert. Ready-made orthotics can be purchased in sporting goods and shoe stores. Some patients need to have orthotics that are custom-fitted or made by the athletic trainer or podiatrist.[66]

The use of orthotics for correcting specific problems are discussed in the section on rehabilitation at the end of this chapter.

Foot Hygiene

Individuals who perform simple tasks—such as keeping their toenails trimmed correctly; shaving down excessive calluses; keeping their feet clean; wearing clean, correctly fitted socks; and keeping their feet as dry as possible to prevent the development of athlete's foot (see Chapter 28)—can individually and collectively reduce a number of problems that can cause them to miss days of practice or competition.

FOOT ASSESSMENT

When assessing foot injuries, athletic trainers must clearly understand that the foot is part of a kinetic chain that includes both the ankle and the lower leg.[35] Acute injuries must be differentiated from injuries with a relatively slow onset.

History

An athletic trainer making a decision about how to manage a foot injury must perform a quick assessment to determine the type of injury and its history. He or she should ask the following questions:

- Is this the first time this condition has occurred? If it has happened before, when, how often, and under what circumstances did it occur?
- How did the injury occur?
- Did it occur suddenly or come on slowly?
- Was the mechanism a sudden strain, twist, or blow to the foot?
- Where is the pain (ankle, heel, arches, toes)?
- What type of pain is the athlete experiencing?
- Is there muscle weakness?
- Is there any snapping, popping, or crepitus during movement?
- Is there any alteration in sensation?
- Can the patient point to the exact site of the pain?
- When is the pain or other symptoms more or less severe?

TABLE 18–2 Choosing the Correct Shoe Components Based on the Type of Foot Problem

Type of Problem	Shoe Components					
Excessive pronation	Stiff shoe	Dense midsole, medial wedge	Good rearfoot control	Board or combination last	Straight last	Rigid or semirigid orthotic
Excessive supination	Flexible shoe	Soft midsole, lateral wedge	Rearfoot control not necessary	Slip last	Curved last	Soft or semirigid orthotic

- On what type of surface has the patient been training?
- What type of footwear is being worn during training? Is it appropriate for the type of training? Is discomfort increased when footwear is worn?

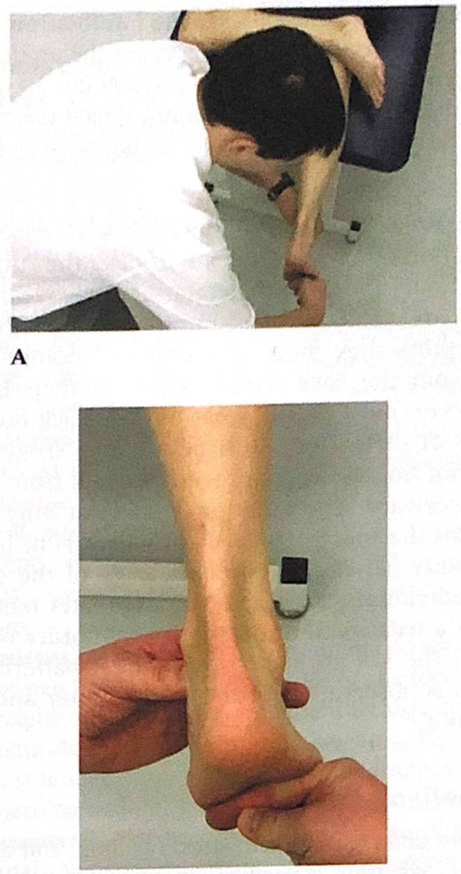
Observation

The athletic trainer should observe the patient to determine the following:

- Is the patient favoring the foot, walking with a limp, or unable to bear weight?
- Is the injured part deformed, swollen, or discolored?
- Does the foot change color when weight bearing and not weight bearing (changing rapidly from a darker to lighter pink when not weight bearing)?
- Is there pes planus (a flatfoot) or pes cavus (a high arch)?
- Is the foot well aligned? Does it maintain its shape on weight bearing?
- Do any abnormalities exist in the toes (e.g., hammertoes, mallet toes, claw toes, Morton's toe, hallux valgus, corns, bunions, plantar warts)?

Looking for Structural Deformities The first step in looking for structural deformities is to establish a position of subtalar neutral. The patient should be prone with the distal third of the leg hanging off the end of the table (Figure 18–16). A line should be drawn bisecting the leg from the start of the musculotendinous junction of the gastrocnemius to the distal portion of the calcaneus. With the patient still prone, the athletic trainer should palpate the talus while the forefoot is inverted and everted. One finger should palpate the talus at the anterior aspect of the fibula and another finger at the anterior portion of the medial malleolus. The position at which the talus is equally prominent on both sides is considered a neutral subtalar position in which the subtalar joint is neither pronated nor supinated.[31]

Once the subtalar joint is placed in a neutral position, the athletic trainer should apply mild dorsiflexion while observing the metatarsal heads in relation to the plantar surface of the calcaneus. Forefoot varus is a rigid osseous deformity in which the medial metatarsal heads are inverted in relation to the plane of the calcaneus. Forefoot varus is the most common cause of excessive pronation (see Figure 18–13A).[13] Forefoot varus can also be caused by soft-tissue tightness of the anterior tibialis muscle along with malposition of the calcaneocuboid joint. This has been referred to as forefoot supinatus and attributed to chronic subtalar joint pronation. Forefoot valgus is a rigid osseous deformity in which the lateral metatarsals are everted in relation to the rearfoot (see Figure 18–13B).



A

B

FIGURE 18–16 **(A)** Position for assessing existing structural deformities. **(B)** Viewing the structural deformity in subtalar neutral.

These rigid forefoot deformities are benign in a non–weight-bearing position; however, during weight bearing, the metatarsal heads must somehow make contact with the surface to bear weight. To accomplish this movement for a forefoot varus, the talus plantar flexes and adducts and the calcaneus everts. For the forefoot valgus, the calcaneus inverts and the talus abducts and dorsiflexes. A forefoot varus is the most common forefoot deformity.[13]

In a rearfoot varus deformity, when the foot is in a subtalar neutral position and non–weight bearing, the medial metatarsal heads are elevated, as in a forefoot varus, and the calcaneus is also in an inverted position (see Figure 18–13C).[60] For the foot to bear weight, the subtalar joint must pronate.

An equinus foot, and particularly a rigid equinus foot, is another structural deformity that is thought to be associated with poor shock absorption during running. In an equinus foot, the forefoot is plantar flexed relative to the rearfoot when the ankle is at 90 degrees of flexion. A similar condition, in which only the first metatarsal is plantar flexed relative to the rearfoot, is referred to as a plantar flexed first ray.[31]

Shoe Wear Patterns Individuals with excessive pronation often wear out the front of the running shoe under the second metatarsal. Shoe wear patterns are commonly misinterpreted by athletes who think they must be pronators because they wear out the back outside edges of their heels. However, most people wear out the back outside edges of their shoes. Just before heel strike, the anterior tibialis fires to prevent the foot from slapping forward. The anterior tibialis not only dorsiflexes the foot but also slightly inverts it, hence the wear pattern on the back edge of the shoe. An individual who excessively supinates tends to show a wear pattern on the lateral border of the shoe. The key to inspection of wear patterns on shoes is observation of the heel counter and the forefoot.[30]

Palpation

Besides determining pain sites, swelling, and deformities, palpation is used to determine and evaluate circulation.

Bony Palpation The following bony landmarks should be palpated:

Medial aspect
- Medial calcaneus
- Calcaneal dome
- Medial malleolus
- Sustentaculum tali (plantar aspect of medial calcaneus)
- Talar head
- Navicular tubercle
- First cuneiform
- First metatarsal
- First metatarsophalangeal joint
- First phalanx

Lateral aspect
- Lateral calcaneus
- Lateral malleolus
- Sinus tarsi
- Peroneal tubercle
- Cuboid bone
- Styloid process (proximal head of fifth metatarsal)
- Fifth metatarsal
- Fifth metatarsophalangeal joint
- Fifth phalanx

Dorsal aspect
- Second, third, fourth metatarsals
- Second, third, fourth metatarsophalangeal joints
- Second, third, fourth phalanges
- Third and fourth cuneiform bones

Plantar aspect
- Metatarsal heads
- Medial calcaneal tubercle
- Sesamoid bones

Soft-Tissue Palpation The following soft-tissue structures should be palpated:

Medial and plantar aspect
- Tibialis posterior tendon
- Flexor hallucis longus tendon
- Flexor digitorum longus tendon
- Deltoid ligament
- Calcaneonavicular ligament (spring ligament)
- Medial longitudinal arch
- Plantar fascia
- Transverse arch

Lateral and dorsal aspect
- Anterior talofibular ligament
- Calcaneofibular ligament
- Posterior talofibular ligament
- Peroneus longus tendon
- Peroneus brevis tendon
- Extensor hallucis longus tendon
- Extensor digitorum longus tendon
- Extensor digitorum brevis tendon
- Tibialis anterior tendon

Pulses To ensure that there is proper blood circulation to the foot, the pulse is measured at the posterior tibial and dorsalis pedis arteries (see Figure 18–9). Pulse in the dorsalis pedis artery is normally felt between the tendons of the extensor hallucis longus and extensor digitorum longus, on a line from the midpoint between the medial and lateral malleoli to the proximal end of the first intermetatarsal space.

Pulse in the posterior tibial artery is normally palpable behind the medial malleolus, 1 inch (2.5 cm) in front of the medial border of the Achilles tendon.[32]

Special Tests

Movement Assessment Both the extrinsic and the intrinsic foot muscles should be assessed for pain and range of motion during active, passive, and resistive isometric movement.

Morton's Test With the foot in a neutral position, transverse pressure is applied to the heads of the metatarsals, causing sharp pain in the forefoot. A positive test may indicate the presence of **metatarsalgia** or a **neuroma** (Figure 18–17).

metatarsalgia Pain in the ball of the foot.

neuroma A bulging that emanates from a nerve.

Neurological Assessment Reflexes and cutaneous distribution should be tested. Skin sensation should be noted for any alteration.

Tendon reflexes, such as in the Achilles tendon (S1 nerve root), should elicit a response when gently tapped. Sensation is tested by running the hands

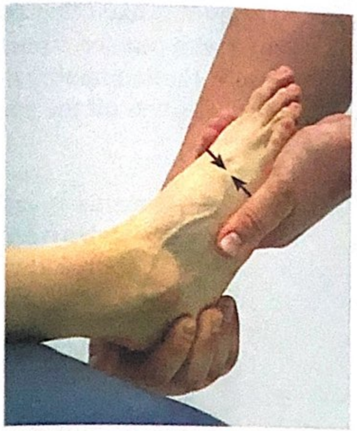


FIGURE 18–17 Morton's test to establish metatarsalgia or a neuroma.

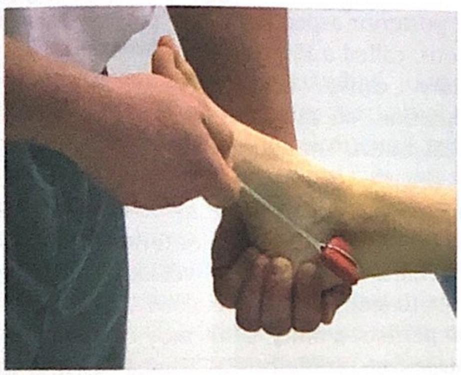


FIGURE 18–18 A positive Tinel's sign may indicate tarsal tunnel syndrome.

over the anterior, lateral, medial, and posterior surfaces of the foot and toes.

Tinel's Sign Test Tapping over the posterior tibial nerve produces tingling distal to that area. Numbness, tingling, and paresthesia may indicate the presence of tarsal tunnel syndrome (Figure 18–18).

RECOGNITION AND MANAGEMENT OF SPECIFIC INJURIES

Most people will at some time develop foot problems that can be attributed to the use of improper footwear, poor foot hygiene, or anatomical structural deviations that result from faulty postural alignments or abnormal stresses. Many activities place exceptional demands on the feet—far beyond what is considered normal. The athletic trainer should be well aware of potential foot problems and should be capable of identifying, ameliorating, and preventing them whenever possible.

Injuries to the Tarsal Region

Fractures of the Talus

Etiology Fractures of the dome of the talus usually occur either laterally from a severe inversion and dorsiflexion force, or medially from an inversion and plantar flexion force, with external rotation of the tibia on the talus.[3]

18–2 Clinical Application Exercise

A 12-year-old, physically immature patient complains of pain in his right heel where the Achilles tendon attaches. This condition is an apophysitis known as Sever's disease.

? Why and how does Sever's disease occur?

The severity of the fracture may range from a nondisplaced compression fracture to a displaced osteochondral fracture. The presence of osteochondral fragments is referred to as *osteochondritis dissecans*.

Symptoms and signs The patient often has a history of repeated trauma to the ankle. He or she feels pain on weight bearing and complains of catching and snapping along with intermittent swelling. The talar dome is tender on palpation over the anteromedial or anterolateral joint line.[3]

Management For accurate diagnosis, an X-ray is essential. Nonsurgical management is appropriate for nondisplaced subchondral compression fractures. Treatment should include protective immobilization with non–weight bearing, progressing to full weight bearing, depending on symptoms. Rehabilitation should concentrate on strengthening and regaining full range of motion in the ankle joint. If conservative treatment fails and symptoms continue or if there is a displaced osteochondral fracture, surgical removal of the loose bodies arthroscopically may be necessary. Following surgery, the patient can expect to resume activity in 6 to 8 months.[3]

Fracture of the Calcaneus

Etiology A fracture of the calcaneus most often occurs from landing after a jump or fall from a height.[41] Avulsion fractures can also occur anteriorly at the attachment of the calcaneonavicular ligament to the sustentaculum tali or posteriorly at the attachment of the talocalcaneal ligament. Anterior avulsion fractures can be misdiagnosed as tendinitis of the posterior tibialis.[27]

Symptoms and signs There is usually immediate swelling and pain and an inability to bear weight. Deformity is not normally present unless there is a displaced comminuted fracture.[43]

Management RICE must be used immediately to minimize pain and swelling before referring the athlete to X-ray for diagnosis. With nondisplaced fractures, immobilization and early range of motion exercises are recommended as soon as acute swelling and pain subside and motion is tolerated.[27]

Calcaneal Stress Fracture

Etiology Calcaneal stress fractures, along with stress fractures of the tibia and of the second metatarsal, are among the most common stress fractures in the lower extremity. A calcaneal stress fracture occurs with repetitive impact during heel strike and is most prevalent among distance runners. It is characterized by a sudden onset of constant pain in the plantar-calcaneal area.[41]

Symptoms and signs Weight bearing, particularly on heel strike in running, increases pain. Complaints of pain tend to continue after exercise stops. The fracture may fail to appear during X-ray examination; a bone scan may be a better diagnostic tool.[43]

Management Management is usually conservative for the first 2 or 3 weeks and includes rest and active range of motion exercises of the foot and ankle. Non–weight-bearing cardiovascular exercise, such as pool running, may continue during this period. After 2 weeks and when pain subsides, activity within pain limits can be resumed gradually, with the athlete wearing a cushioned shoe.

Apophysitis of the Calcaneus (Sever's Disease)

Etiology Calcaneal **apophysitis**, or Sever's disease, occurs in young, physically active patients. Sever's disease is comparable to Osgood-Schlatter disease at the tibial tubercle of the knee (see Chapter 20).[56] Sever's disease is a traction injury at the **apophysis** of the calcaneus (bone protrusion) where the Achilles tendon attaches.[57]

apophysitis (a poff ah cytis) Inflammation of an apophysis.

apophysis (a poff ah sis) Bony outgrowth, such as tubercle or tuberosity.

Symptoms and signs Pain occurs at the posterior heel below the attachment of the Achilles tendon insertion of the child or adolescent athlete. Pain occurs during vigorous activity and does not continue at rest.

Management Apophysitis, like other overuse syndromes, is best treated with rest, ice, stretching (of the Achilles tendon), and antiinflammatory medications. A heel lift can take some stress off the apophysis.

Retrocalcaneal Bursitis

Etiology Retrocalcaneal bursitis is caused by inflammation of the bursa that lies between the Achilles tendon and the calcaneus. Retrocalcaneal bursitis often occurs from the pressure and rubbing of the heel counter of a shoe. This condition is chronic, developing gradually over a long period of time, and may take many days—sometimes weeks or months—to resolve.[17]

An **exostosis** is a benign bony outgrowth or callus that protrudes from the surface of a bone and is usually capped by cartilage. An exostosis that develops on the posterior aspect of the calcaneus, called a Haglund's deformity, causes ongoing inflammation of the retrocalcaneal bursa, sometimes referred to as a "pump bump" (Figure 18–19A).[17]

exostosis (ek sos toe ses) Benign bony outgrowth that protrudes from the surface of a bone and is usually capped by cartilage.

Symptoms and signs Pain may be elicited by palpating the bursa just above and anterior to the insertion of the Achilles tendon. There will likely be some swelling on both sides of the heel cord. If the source of irritation persists, a bony callus may also begin to form.

Management Initially, RICE plus NSAIDs and analgesics are used as needed. Often, the use of ultrasound can reduce the inflammation. Stretching of the Achilles tendon should be routine. A heel lift should be used to take stress off the Achilles tendon. A doughnut heel pad can be used to take pressure off the bursa and an existing exostosis (Figure 18–19B). If necessary, larger shoes with wider heel contours should be worn.[17]

Heel Contusion

Etiology Activities that demand a sudden stop-and-go response or a sudden change from a horizontal

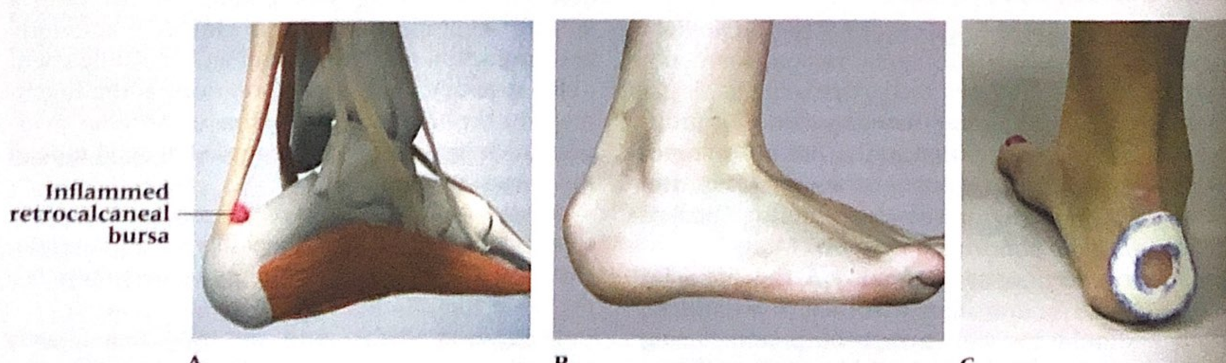


FIGURE 18–19 **(A) Retrocalcaneal bursitis at the attachment of the Achilles tendon to the calcaneous. (B) A pump bump that develops. (C) Can be protected using a doughnut-type pad.**

A

B

FIGURE 18–20 Heel protection. (A) Heel cup. (B) Protective heel doughnut.

to a vertical movement (e.g., basketball, jumping, or the landing in long jumping) are particularly likely to cause heel contusions.[56] The calcaneus is protected by a thick, cornified skin layer and a heavy fat pad covering, but even this thick padding cannot always protect against the impact of jumping or running.[63]

The major function of the tissue heel pad is to sustain hydraulic pressure through fat columns. Tissue compression is monitored by pressure nerve endings from the skin and plantar aponeurosis. Often, the irritation is on the lateral aspect of the heel because of the heel strike in walking or running.[39]

Symptoms and signs When injury occurs, the patient complains of severe pain in the heel and is unable to withstand the stress of weight bearing. Often, there is warmth and redness over the tender area.[43]

Management A contusion of the heel may develop into chronic inflammation of the periosteum. The patient should not bear weight on the heel for at least 24 hours. RICE is applied, and NSAIDs are administered. If pain when walking has subsided by the third day, the patient may resume moderate activity with the protection of a heel cup or protective doughnut (Figure 18–20). The patient should wear shock-absorbent footwear.

Cuboid Subluxation

Etiology Pronation and trauma have been reported to be prominent causes of cuboid subluxation.[58] This condition is sometimes incorrectly confused with plantar fasciitis. However, the patient usually complains of a midfoot sprain with pain on the dorsum of the foot and/or over the anterior/lateral ankle frequently after an inversion mechanism. The primary reason for pain is the stress placed on the long peroneal muscle when the foot is in pronation. In this position, the long peroneal muscle allows the cuboid bone to move downward medially.

Symptoms and signs This displacement of the cuboid causes pain along the fourth and fifth metatarsals as well as over the cuboid. This problem often refers pain to the heel area as well. Many times this pain is increased when the patient stands after a prolonged non–weight-bearing period.

Management Dramatic treatment results may be obtained by manipulating to restore the cuboid to its natural position (Figure 18–21). Once the cuboid is manipulated, an orthotic often helps support it in its proper position. If manipulation is successful, quite often the patient can return to play immediately with little or no pain. The patient should wear an appropriately constructed orthotic when practicing or competing to reduce the chances of recurrence.

FIGURE 18–21 A cuboid manipulation is done with the patient prone. The lateral plantar aspect of the forefoot is grasped by the thumbs, with the fingers supporting the dorsum of the foot. The thumbs should be over the cuboid. The manipulation should be a thrust downward to move the cuboid into its more dorsal position. Often, a pop is felt as the cuboid moves back into place.

Tarsal Tunnel Syndrome

Etiology The tarsal tunnel is a loosely defined area behind the medial malleolus that forms a tunnel with an osseous floor and the roof composed of the flexor retinaculum. Through this tunnel pass the tibialis posterior, flexor hallucis longus, and flexor digitorum muscles with their surrounding synovial sheaths and the tibial nerve artery and vein.[52] Any condition that compromises the structures within this tunnel can cause tarsal tunnel syndrome, including tenosynovitis, previous fractures, excessive pronation, or any acute trauma.[67]

Symptoms and signs Complaints of pain and paresthesia are typical, particularly along the medial and plantar aspects of the foot. Complaints of increased pain at night are also common. Tinel's sign will be positive in cases of tarsal tunnel syndrome (see Figure 18–18). If the condition persists, motor weakness and atrophy may gradually appear, following the course of the tibial nerve.

Management Initial conservative management includes the use of antiinflammatory medication and other antiinflammatory modalities. The use of an appropriate orthotic to correct excessive pronation may effectively reduce the symptoms. Surgery may be necessary if the symptoms become recurrent.[55]

Tarsometatarsal Fracture/Dislocation (Lisfranc Injury)

Etiology Named after a French surgeon who described amputations at the tarsometatarsal joint, this is an uncommon injury that can cause long-term disability. The ankle is plantar flexed with the rearfoot locked, and there is a sudden, forceful hyper–plantar flexion of the forefoot that results in dorsal displacement of the proximal end of the metatarsals. The dorsum of the foot rolls forward, with the body weight providing the force to displace the base of the metatarsals dorsally (Figure 18–22).[65]

Symptoms and signs Symptoms may be relatively subtle. The patient complains of pain and an inability to bear weight. Swelling and tenderness are localized over the dorsum of the foot. There may be a fracture of the metatarsals. Sprain of the fourth and fifth proximal metatarsals causes ongoing pain. It is not uncommon to overlook the serious disruption of the supporting ligaments because attention is often focused on a metatarsal fracture.

FIGURE 18–22 A Lisfranc injury is the dorsal displacement of the proximal end of the metatarsals.

Management If the athletic trainer suspects this injury, the patient should be referred to the physician for evaluation. The key to treatment is first recognizing the injury, then restoring alignment, and finally maintaining stability.[69] Closed reduction often fails, and most likely it will be necessary to do an open reduction with internal fixation to stabilize the dislocation. Potential complications include metatarsalgia, limited motion of the metatarsophalangeal joints, and long-term disability.[65]

Injuries to the Metatarsal Region

Pes Planus Foot (Flatfoot)

Etiology The term *pes planus* refers to a type of foot in which the medial longitudinal arch appears to be flat and is sometimes said to be fallen (Figure 18–23A). In general, pes planus is associated with excessive foot pronation and may be caused by a number of factors, including a structural forefoot varus deformity, shoes that are too tight, trauma that weakens supportive structures (such as muscles and ligaments), overweight, and excessive exercise that repeatedly subjects the arch to severe pounding on an unyielding surface.

18-3 Clinical Application Exercise

A patient comes to an outpatient clinic in a hospital, complaining of her flatfeet and that she has pain in her knees and a big callus under her second metatarsal.

? What is likely causing this problem, and how can it usually be corrected?

Symptoms and signs The patient may complain of pain and a feeling of weakness or fatigue in the medial longitudinal

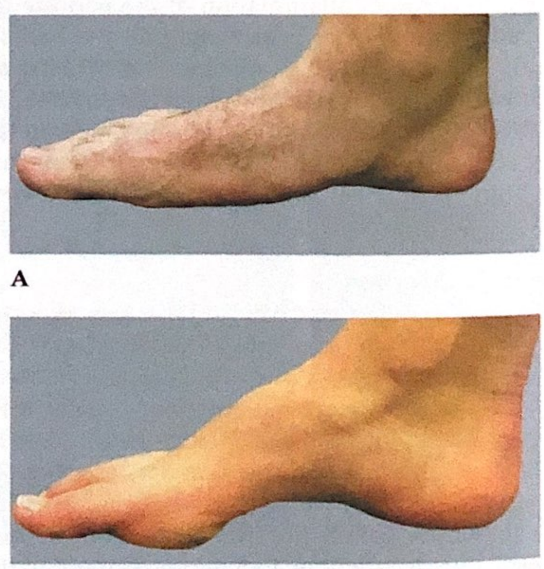


FIGURE 18–23 (A) Pes planus foot. (B) Pes cavus foot.

arch. There may be calcaneal eversion, a bulging of the navicular bone, a flattening of the medial longitudinal arch, and dorsiflexing with lateral splaying of the first metatarsal.

Management Regardless of how flattened the medial longitudinal arch appears to be, if it is not causing the individual any pain or related symptoms, then absolutely nothing should be done to try to correct the apparent problem. Attempts to do so may, in fact, create an unnecessary problem. However, if the patient is experiencing pain, an appropriately constructed orthotic designed to correct excessive pronation by using a medial wedge will most likely alleviate symptoms. In certain cases, incorporating an arch support into the orthotic or taping the arch for support may be helpful.

Pes Cavus Foot (High Arch Foot)

Etiology The term *pes cavus* refers to a type of foot that has an arch that is higher than normal (Figure 18–23B). Sometimes called *clawfoot or hollow foot*, pes cavus is not as common as pes planus. A pes cavus is generally associated with excessive supination. The accentuated high medial longitudinal arch may be congenital or may indicate a neurological disorder.[11]

Symptoms and signs In cases of pes cavus, shock absorption is poor, and thus problems such as general foot pain, metatarsalgia, and clawed or hammertoes are seen. Commonly associated with this condition are a structural forefoot valgus deformity and an abnormal shortening of the Achilles tendon. The Achilles tendon is directly linked with the plantar fascia (see Figure 18–3). Also, because of the abnormal distribution of body weight, heavy calluses develop on the ball and heel of the foot.[63]

Management As is the case with pes planus, pes cavus may be asymptomatic, in which case no attempt should be made to correct the problem. If there are associated problems, then an orthotic should be constructed using a lateral wedge to correct a structural forefoot valgus deformity. Stretching of the Achilles tendon and the plantar fascia may also be helpful.

Second Metatarsal Stress Fracture (Morton's Toe)

Etiology Normally, the first metatarsal is longer than the second. Morton's toe is a condition in which there is an abnormally short first metatarsal, and thus the second toe appears to be longer than the great toe (Figure 18–24). Much of the weight bearing is ordinarily on the first metatarsal. Because the first metatarsal is short, however, more weight must be borne by the second metatarsal instead. This uneven weight distribution becomes even more of a problem in a running gait, during which weight bearing tends to shift more to the second metatarsal.

A Morton's toe is not an injury and can be a benign condition that causes no problems. However, if the second metatarsal is subjected to more stress, particularly during running, a stress fracture could develop.[64]

Symptoms and signs Symptoms are those of stress fractures in general. The patient complains of pain both during and after activity, and there may be an area of point tenderness. A bone scan would be positive for a stress fracture. A callus is likely to form under the second metatarsal head.

Management If a Morton's toe is not causing any symptoms, nothing should be done to try to correct the problem. If a Morton's toe is associated with a structural forefoot varus deformity, an orthotic with a medial wedge would likely be helpful.

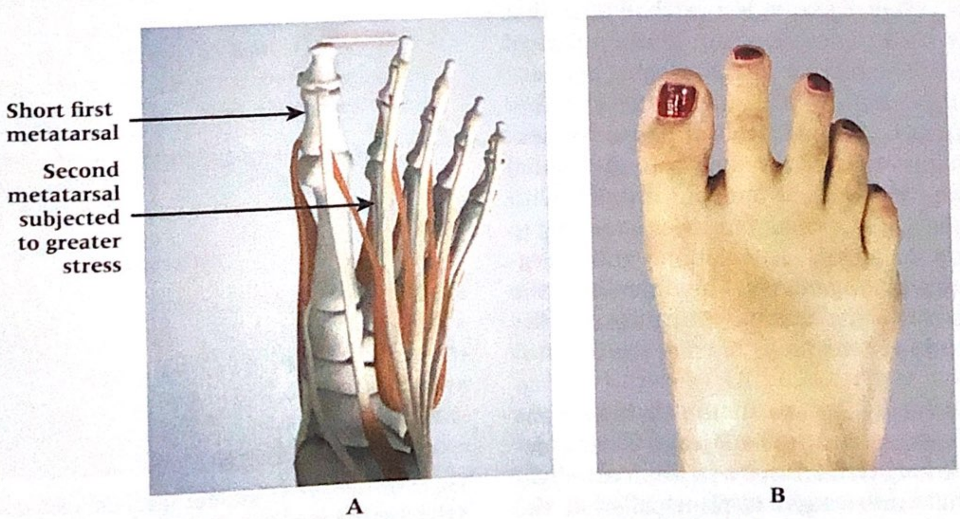


FIGURE 18–24 In a Morton's toe, the first metatarsal is abnormally short.

Longitudinal Arch Strain

Etiology Longitudinal arch strain is usually caused by subjecting the musculature of the foot to increased stress produced by repetitive contact with hard surfaces. In this condition, there is a flattening or depression of the longitudinal arch while the foot is in the midsupport phase, resulting in a strain to the arch.[33] Such a strain may appear suddenly, or it may develop slowly over a considerable length of time.

18–4 Clinical Application Exercise

A distance runner is experiencing pain in the left arch. There is palpable tenderness in the left foot's aponeurosis, primarily in the epicondyle region of the calcaneus.

? What condition does this scenario describe, and how should it be managed?

Symptoms and signs As a rule, pain is experienced only during running or jumping. The pain usually appears just below the posterior tibialis tendon and is accompanied by swelling and tenderness along the medial aspects of the foot. This injury may also be associated with a sprain of the calcaneonavicular ligament as well as a strain of the flexor hallucis longus tendon.

Management The management of a longitudinal arch strain involves immediate care, consisting of RICE, followed by appropriate therapy and reduction of weight bearing. Weight bearing must be performed pain free. Arch taping technique no. 1 or 2 might be used to allow earlier pain-free weight bearing (see Figure 8–20 through 8–23).

Plantar Fasciitis Heel pain is a very common problem in the athletic and nonathletic population. This phenomenon has been attributed to several etiologies, including heel spurs, plantar fascia irritation, and bursitis.[17] *Plantar fasciitis* is a catchall term that is commonly used to describe pain in the proximal arch and heel. The plantar fascia (plantar aponeurosis) runs the length of the sole of the foot (see Figure 18–3). It is a broad band of dense connective tissue that is attached proximally to the medial surface of the calcaneus. It fans out distally, with fibers and their various small branches attaching to the metatarsophalangeal articulations and merging into the capsular ligaments. The function of the plantar fascia is to assist in maintaining the stability of the foot and in securing or bracing the longitudinal arch.[36]

Etiology Tension develops in the plantar fascia both during extension of the toes and during depression of the longitudinal arch as a result of weight bearing.[1] When the weight is principally on the heel, as in ordinary standing, the tension exerted on the fascia is negligible. However, when the weight is shifted to the ball of the foot (on the heads of the metatarsals), fascial tension is increased. In running, because the toe-off phase involves both a forceful extension of the toes and a powerful thrust by the ball of the foot (on the heads of the metatarsals), fascial tension is increased to approximately twice the body weight.[12] Tightening of the plantar fascia during dorsiflexion, thus shortening the longitudinal arch, has been described as the "windlass" mechanism.[7]

Plantar fasciitis can occur in individuals with pes cavus, in which case the foot has too little motion, or in those with a pes planus, in which case there is too much motion.[7]

Street shoes, by nature of their design, take on the characteristics of splints and tend to restrict foot action to such an extent that the arch may become somewhat rigid. This rigidity occurs because of shortening of the ligaments and other mild abnormalities. The athlete, changing from such footwear into a flexible gymnastic slipper or soft track shoe, often experiences trauma when the foot is subjected to stress. Trauma may also result from poor running technique.

A number of anatomical and biomechanical conditions have been studied as possible causes of plantar fasciitis. Those conditions include leg length discrepancy, excessive pronation of the subtalar joint, inflexibility of the longitudinal arch, and tightness of the gastrocnemius-soleus unit.[52] Wearing shoes without sufficient arch support, running with a lengthened stride, and running on soft surfaces are also potential causes of plantar fasciitis.[48]

Symptoms and signs The patient complains of pain in the anterior medial heel, usually at the attachment of the plantar fascia to the calcaneus (Figure 18–25). The pain eventually moves into the central portion

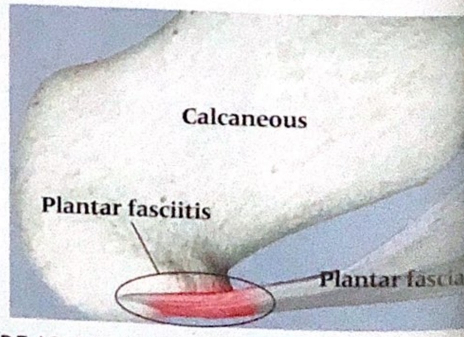


FIGURE 18–25 In plantar fasciitis, pain usually develops at the attachment to the medial portion of the calcaneous.

MANAGEMENT PLAN

Plantar Fasciitis

Injury Situation A marathon runner injured the proximal arch and heel when he stepped into a hole during a meet. The patient continued to run and work out for a week before reporting his injury to the athletic trainer.

Symptoms and Signs The patient complained of early pain in the medial arch and medial distal heel that tended to move centrally as the week progressed. He complained of severe pain when rising in the morning and after sitting for a long period. The area appeared slightly swollen with a severe, sharp pain on palpation at the plantar fascia insertion and medial aspect of the calcaneus. Pain increased with passive dorsiflexion of the great toe. An X-ray showed the beginning of a heel spur. The patient was found to have a cavus foot.

Management Plan The patient was diagnosed as having plantar fasciitis (heel spur syndrome), and a conservative plan was chosen.

Phase 1 Acute Injury **GOALS:** Minimize inflammation and pain.
ESTIMATED LENGTH OF TIME (ELT): 1 week.

- **Therapy** RICE plus NSAID as needed to reduce pain and inflammation. Injection therapy consisting of a steroid and anesthetic for trigger points.
- **Exercise rehabilitation** Toe touch crutch walking. Begin heel cord stretching and rolling pin exercise to increase fascia flexibility.

Phase 2 Repair **GOALS:** Gain full weight bearing and walking pattern.
ELT: 1 to 3 weeks.

- **Therapy** Ultrasound to increase blood flow. Cross-friction massage over injury site. Apply shock absorption shoe insert with cutout 1 to 2 inches (3 to 5 cm) in the tender area. Apply arch taping.
- **Exercise rehabilitation** Continue heel cord stretching and rolling pin exercise to stretch the plantar fascia. Begin a program of gradual pain-free weight bearing. Begin a program of foot flexor strengthening.

Phase 3 Remodeling **GOALS:** Focus on full pain-free weight bearing while engaged in running.
ELT: 2 weeks.

- **Therapy** Ultrasound as warranted. Continue cross-friction massage. Use a heel cup and arch taping when athlete is supporting weight.
- **Exercise rehabilitation** Continue heel cord and plantar fascia stretching. Use shoes with a reinforced heel counter for heel control. Initiate foot flexor strengthening against tubular resistance. Perform general exercise to the lower leg. Begin a running program that is pain free.

Criteria for Return to Competitive Cross-Country Running

1. Proximal arch and heel are pain free.
2. Heel cord and plantar fascia are stretched.
3. Lower leg has maximum strength.
4. Patient is able to run competitively without pain.
5. Patient is psychologically ready for competition.

of the plantar fascia. This pain is increased when the patient rises in the morning or bears weight after sitting for a long period. However, the pain lessens after a few steps. Pain also will be intensified when the toes and forefoot are forcibly dorsiflexed. If irritation persists, a painful heel spur will probably develop at the attachment of the plantar fascia to the medial aspect of the calcaneus; the heel spur will be visible on an X-ray (Figure 18–26).

Management Management of plantar fasciitis generally requires an extended period of treatment.[61] It is not uncommon for symptoms to persist for as long as 8 to 12 weeks. Orthotic therapy is very useful in the treatment of this problem. A soft orthotic works better than a hard orthotic. An extra-deep heel cup should be built into the orthotic. The orthotic should be worn at all times, especially when the athlete rises from bed in the morning.[31] Use of a heel cup

FIGURE 18–26 X-ray of a large plantar calcaneal exostotic spur.

18–5 Clinical Application Exercise

A basketball player playing in a recreation league game sustains a grade 2 lateral sprain of the left ankle.

? What metatarsal fracture may be associated with this type of sprain?

compresses the fat pad under the calcaneus, providing a cushion under the area of irritation. When soft orthotics are not feasible, taping may reduce the symptoms. A simple arch taping or alternative taping often allows pain-free ambulation.[31] The use of a night splint to maintain a position of static stretch has also been recommended (Figure 18–27). In some cases, the athlete may need to use a short leg walking cast for 4 to 6 weeks.

The patient should engage in vigorous Achilles tendon stretching and in exercises that stretch the plantar fascia in the arch, such as rolling the plantar surface of the foot back and forth over a tennis ball, a baseball, or some other rigid, round surface.[62] Exercises that increase dorsiflexion of the great toe also may be of benefit for this problem. Stretching should be done at least three times a day. Antiinflammatory medications are recommended. Steroidal injection may be warranted at some point if symptoms fail to resolve.

FIGURE 18–27 A night splint can be used to stretch the plantar fascia.

Jones Fracture

Etiology Fractures may occur to any of the metatarsals and can be caused by inversion and plantar flexion of the foot; by direct force, such as being stepped on; or by repetitive stress. By far the most common acute fracture is to the diaphysis at the base of the fifth metatarsal, which is referred to specifically as a Jones fracture (Figure 18–28).[46]

Symptoms and signs A Jones fracture is characterized by immediate swelling and pain over the fifth metatarsal. Healing of a Jones fracture is slow and frustrating for the patient. This injury has a high nonunion rate, and the course of healing is unpredictable.[28] Nonunion fractures can occur as a result of several factors, including insufficient fracture immobilization (fixation), inadequate blood supply, chronic disease states (diabetes, renal failure, metabolic bone disease), fractures associated with tumors (pathological fractures), or infection. In a nonunion fracture, osteocytes and osteoblasts are replaced by chondroblasts. Thus, the fracture repairs itself by replacing what would normally be bone tissue with cartilage between the fractured bone ends.

Management Treatment for a Jones fracture is controversial, but it appears that the use of crutches with no immobilization, gradually progressing to full weight bearing as pain subsides, may allow the patient to return to activity in about 6 weeks. However, nonunion may cause a refracture to occur. It has been recommended that patients be treated more aggressively using early internal fixation.[45] It has also been suggested that an electric or ultrasonic bone-growth stimulator will promote healing in a Jones fracture.[10]

Metatarsal Stress Fractures

Etiology The most common metatarsal stress fracture in the foot involves the shaft of the second metatarsal and is often referred to as a *march fracture*. It occurs in the runner who has suddenly changed patterns of training, such as increasing mileage, running hills, or running on a harder surface. An individual who has an atypical condition,

18–6 Clinical Application Exercise

A triathlete changes her running patterns by increasing distance and performing more hill work. She complains to the athletic trainer of a gradually worsening pain in her forefoot. Inspection reveals point tenderness in the region of the fourth metatarsal bone. X-ray reveals a stress fracture.

? How should this condition be managed?

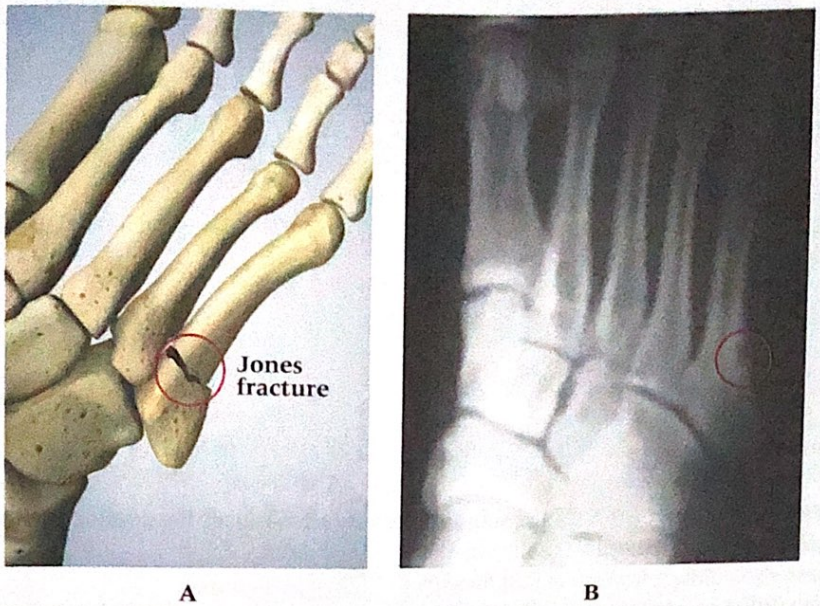


FIGURE 18–28 **(A)** A Jones fracture occurs at the neck of the fifth metatarsal. **(B)** Jones fracture X-ray.

such as a structural forefoot varus, hallux valgus, flatfoot, or short first metatarsal, is more predisposed to a second metatarsal stress fracture.[19,57]

A patient can also experience a stress fracture of the fifth metatarsal at the insertion of the peroneus brevis tendon, but this injury should not be confused with a Jones fracture.[4]

Symptoms and signs Over a 2 to 3-week period, dull pain begins to occur during exercise, then progresses to pain at rest. Pain is initially diffuse, then localizes to the site of the fracture. Patients usually report having increased the intensity or duration of their exercise program.

18–7 Clinical Application Exercise

A dancer complains to the athletic trainer of swelling, tenderness, and aching in the head of the first metatarsophalangeal joint of her left foot. On inspection, the athletic trainer observes that the great toe is deviated laterally.

? What is this condition commonly called, and why does it occur?

Management A bone scan is the best way to detect the presence of a stress fracture. Management of a metatarsal stress fracture usually consists of 2 to 4 days of partial weight bearing followed by 2 weeks of rest. Return to running should be very gradual. An orthotic that corrects excessive pronation can help take stress off the second metatarsal.[9]

Bunions (Hallux Valgus Deformities) and Bunionettes (Tailor's Bunions)?

Etiology A bunion, one of the most frequent painful deformities, occurs at the head of the first metatarsal (Figure 18–29). The term *bunion* is often used to refer to an exostosis. Commonly, a bunion is associated with a structural forefoot varus in which the first ray tends to splay outward, putting pressure on the first metatarsal head.[40] Bunions are often caused by shoes that are pointed, too narrow, or too short. It is generally believed that women's shoes play a predominant role in the development of a hallux valgus deformity.[16]

The bursa over the first metatarsophalangeal joint becomes inflamed and eventually thickens. Tendinitis may develop in the flexor tendons of the great toe.[47] The joint becomes enlarged and the great toe becomes malaligned, moving laterally toward the second toe, sometimes to such an extent that it eventually overlaps the second toe. This type of bunion is also associated with a depressed or flattened transverse arch and a pronated foot.

The bunionette, or tailor's bunion, is much less common than hallux valgus deformity, affecting the fifth metatarsophalangeal joint. In this case, the little toe angulates toward the fourth toe, causing an enlarged metatarsal head.[8]

In all bunions, both the flexor and extensor tendons are malaligned, creating more angular stress on the joint. NOTE: Sesamoid fractures and sesamoiditis can be secondary to hallux valgus.

Symptoms and signs In the beginning of bunion formation, there is tenderness, swelling, and enlargement of the joint. Poorly fitting shoes increase the irritation and pain. As the inflammation continues, angulation of the toe progresses, eventually leading to painful ambulation.