The Foot and Ankle: An Overview of Arthrokinematics and Selected Joint Techniques

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ABSTRACT: Limited range of motion of the ankle is common following a period of immobilization or injury to the lower extremity. If not corrected, this limited range of motion will disturb normal joint arthrokinematics and could affect the athlete's performance. Consequently, the athletic trainer must thoroughly evaluate the various joints of the ankle and foot in order to determine appropriate treatment. A comprehensive evaluation should include assessment of passive accessory motions at the foot and ankle. If accessory movements are restricted at any joint, mobilization techniques can be used to restore normal ankle/foot joint arthrokinematics. This article describes the biomechanics of the tibiofibular, talocrural, subtalar, and midtarsal joints and is a presentation of basic mobilization techniques for the ankle and related joints.

Ankle injuries are commonly seen in athletic training facilities. An ankle sprain is one of the most common injuries occurring during athletic events.[16] Injuries range from a simple lateral ankle sprain (grade I) to total disruption of the joint (grade III), requiring a period of immobilization. Immobilization can result in adhesion formation and joint capsule shortening and can involve several joints, including the proximal and distal tibiofibular joints, and/or the subtalar and midtarsal joints.[1,5]

According to Akeson et al,[1] fibrofatty connective tissue begins to proliferate within a joint as early as 2 weeks postimmobilization of an adult rat knee. From 30 to 60 days, adhesions develop between the fibrofatty connective tissue and the underlying cartilage surface. As a result of these tissue changes, joint arthrokinematics might be altered. Ankle stiffness can also result from immobilization of other joints, such as the knee or hip.

Rehabilitation of the injured ankle should focus on progressive range of motion and strengthening. Complete range of motion at any given joint requires appropriate soft tissue length and full accessory motions. Therefore, to improve range of motion, soft tissue stretching and restoration of normal joint arthrokinematics should be incorporated. If normal arthrokinematics of the foot and ankle are not restored, abnormal stress is placed on the ankle and surrounding joints, possibly resulting in reinjury. The purpose of this article is to review the arthrokinematics of the ankle and foot complex (proximal tibiofibular joint to midtarsal joint) and the principles of joint mobilization specific to these joints.

NORMAL ARTHROKINEMATICS

To appreciate the selection and application of joint mobilization techniques for the foot and ankle, it is important to first understand normal arthrokinematics. The next few paragraphs describe the arthrokinematics of the tibiofibular, talocrural, subtalar, and midtarsal joints (Fig 1).

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Tibiofibular Joint

The tibiofibular joint consists of the junction between the tibia and fibula. Proximally, this joint is classified as a plane synovial joint in which gliding occurs between the articulating surfaces. The proximal joint is primarily affected by movement of the knee, but can also be affected by traumatic inversion forces directed at the ankle.[9,12,13]

The distal tibiofibular joint is the articulation between a concave tibial facet and a convex fibular facet.[13] Movement at the foot will have a direct effect on the distal tibiofibular joint. During foot dorsiflexion, the fibula must glide superiorly and rotate laterally.[13] This movement occurs to accommodate the wider anterior portion of the talus as it moves into the mortise.[8] Actual separation of the distal tibiofibular joint with dorsiflexion varies from 1 mm to 4 mm of spread.[3,8] During plantar flexion, the accessory movement is reversed with the fibula gliding inferiorly and internally rotating toward the tibia.

Talocrural Joint

The talocrural joint is a uniaxial modified hinge synovial joint designed for stability. It is comprised of the proximal articular surface of the talus (trochlea) and the distal articular surfaces of the tibia and fibula. Motion at the talocrural joint is primarily dorsiflexion and plantar flexion. Because the trochlea of the talus is wider anteriorly than posteriorly and the radius of curvature is longer laterally, a helical movement occurs during plantar flexion-dorsiflexion rather than a pure swing. During dorsiflexion the talus glides in a posteromedial direction on the tibia, while in plantar flexion the talus glides in an anterolateral direction. Consequently, weight-bearing dorsiflexion of the ankle is accompanied by internal rotation of the limb, and weight-bearing plantar flexion is accompanied by

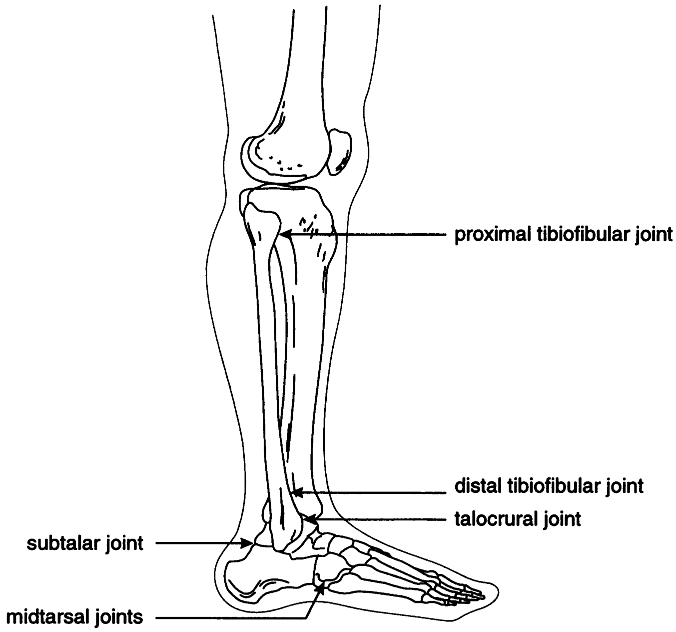

Fig 1. Joints of the lower leg.

external rotation of the limb. Accessory component movements for plantar flexion and dorsiflexion are listed in Table 1.

Subtalar Joint

The subtalar joint consists of a bicondylar articulation between the talus and calcaneus.[2] The arthrokinematics of the subtalar joint can be very complicated due to its triplanar movement. Subtalar joint motion in weight bearing and nonweight bearing are described differently.[1,4] The nonweight-bearing subtalar joint motion is described strictly by calcaneal movement. Pronation consists of calcaneal eversion, calcaneal dorsiflexion, and calcaneal abduction (medial tilt), whereas supination involves calcaneal inversion, calcaneal plantar flexion, and calcaneal adduction (lateral tilt).

Pronation occurs early in the gait cycle; the foot begins to pronate at heel strike and continues until midstance. Weight-bearing pronation consists of calcaneal eversion, talar adduction (medial glide), talar plantar flexion (posterior glide), and tibiofibular internal rotation. Supination occurs during midstance through preswing. Weight-bearing supination involves calcaneal inversion, talar abduction (lateral glide), and talar dorsiflexion (anterior glide) with tibiofibular external rotation.

The importance of subtalar joint pronation becomes apparent during gait as the foot becomes a mobile adapter during the loading response to accommodate to the ground.[4] During the later stages of gait, the foot supinates to become a rigid lever in preparation for push-off.[4]

Midtarsal Joint

The midtarsal joint is composed of the talonavicular and calcaneocuboid joints.[12] When the subtalar joint is supinated, the midtarsal joint becomes locked. It unlocks when the subtalar joint is pronated. Supination requires inferior and medial glide of the navicular on the talar head, while a superior and lateral glide of the navicular accompanies eversion.[6] Table 2 presents the accessory joint components of supination and pronation.

In addition to basic range-of-motion measurement, strength assessment, and joint stress testing, the athletic trainer's evaluation of the ankle-foot complex should include assessment of joint play movements. Each joint should be assessed for normal accessory movements. Any disturbance along the lower extremity chain causing alteration of normal arthrokinematics will result in compensation at any or all other lower extremity joints.[15]

JOINT MOBILIZATION FOR THE ANKLE

Passive accessory movements are performed by an athletic trainer to assess joint arthrokinematics, and, when indicated, joint mobilization is used to increase joint mobility within the anatomical limit of a joint's range of motion.[2,9,10,14] Two distinct grading systems are commonly used for joint mobilization techniques.[7,9,13] One technique, described by Maitland,[11] uses a five-grade system incorporating various degrees of oscillations within various degrees of tissue resistance. A second system developed by Kaltenborn[7] uses a three-grade system of sustained translatory techniques (Fig 2). Treatment direction is generally indicated by the convex-concave rule.[7,9] The convex-concave rule states that, when a convex surface moves on a concave surface, the mobilization force is applied opposite to the angular movement of the bone. If the moving surface is concave, the mobilization force occurs in the same direction as bone movement.

For the purpose of stretching a tight joint capsule following ankle immobilization, sustained stretch techniques can be used as a beginning technique.[9] This technique uses the gliding component of joint motion to restore joint play and improve joint mobility. A sustained glide force of 6 to 10 seconds is applied parallel to the joint surfaces with a force large enough to place a stretch on the joint capsule. After the sustained 6 to 10 seconds, the force is partially released, then reapplied at 3- to 4-second intervals.[8,9] The number of sustained stretches per session will depend on the effectiveness of the technique in regaining joint play.

Reassessment before and after each treatment will indicate the need for further joint mobilization. One general contrain-

Table 1. Component Movements for Dorsiflexion and Plantar Flexion

	Dorsiflexion	Plantar Flexion
Proximal tibiofibular joint	Fibula glides superiorly	Fibula glides inferiorly
Distal tibiofibular joint	Superior glide of tibia and fibula	Inferior glide of tibia and fibula
Talocrural joint	Talus posteromedial glide on tibia	Talus anterolateral glide on tibia

Table 2. Component Movements for Supination and Pronation

	Supination	Pronation
Subtalar joint (nonweight bearing)	Calcaneal inversion, plantar flexion, and adduction	Calcaneal eversion, dorsiflexion, and abduction
Subtalar joint (weight bearing)	Calcaneal inversion, talar abduction, and dorsiflexion	Calcaneal eversion, talar adduction, and plantar flexion
Midtarsal joint	Inferior and medial glide of the navicular on the talus	Superior and lateral glide of the navicular on the talus

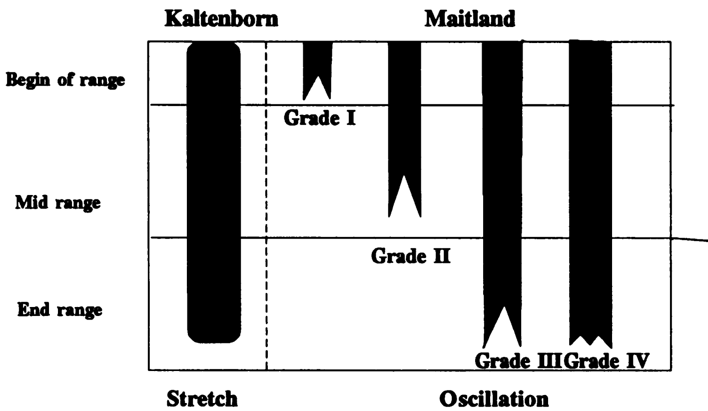

Fig 2. Joint mobilization techniques.

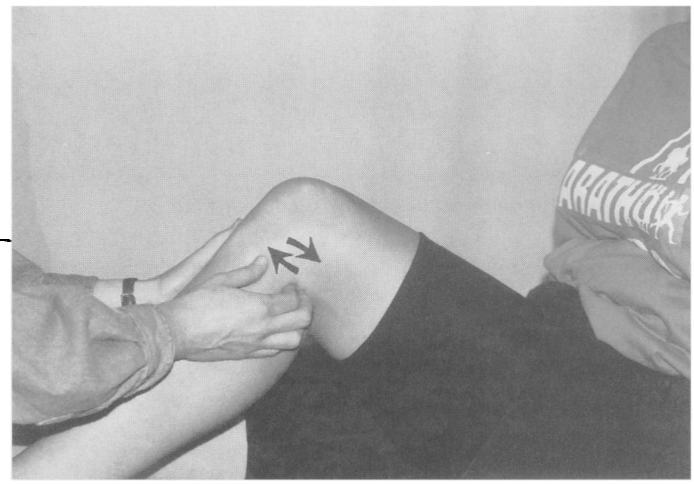
Fig 3. Anterior/posterior glide of the proximal tibiofibular joint.

dication to joint mobilization is hypermobility. When dealing with an unstable joint, one would not apply these techniques in the hypermobile planes. Other contraindications include: acute stage of inflammatory reaction, infection, advanced osteoarthritis, and vascular disease.[14]

An example of an indication for ankle/foot mobilization would be following a healed bimalleolar fracture for which the athlete was immobilized for 6 weeks. Once the cast was removed, gentle mobilization of the proximal and distal fibula and subtalar joint can begin if stiffness exists in these joints. Gentle oscillatory distraction can be used to aid in swelling reduction, pain reduction, and lymphatic drainage. More specific capsular stretching should be initiated to improve limited range of motion once pain and swelling are no longer a primary issue.

The following section is designed as a review of accessory movement for motions about the ankle and foot. For a more complete description of joint mobilization techniques, refer to the reference list. It is the responsibility of the reader to pursue supervised instruction before directly applying these techniques to the athlete.

JOINT MOBILIZATION TECHNIQUES

Tibiofibular Joint

Proximal Tibiofibular Joint (Anterior/Posterior Glide; Fig 3)

- *Indication*—To increase joint play at the tibiofibular joint. The fibular head must move anteriorly on knee flexion and posteriorly on knee extension.
- *Patient*—Supine with the knee flexed to 90° with foot flat.
- *Operator*—Stabilize the knee with the medial hand. Grasp the head and neck of the proximal fibula with the lateral hand, the thumb contacting anteriorly, and the index and long finger pads contacting posteriorly. (Be cautious of the peroneal nerve.)
- *Mobilizing Force*—The lateral hand may glide the proximal fibula posteriorly or anteriorly.

Distal Tibiofibular Joint (Posterior Glide; Fig 4)

- *Indication*—To assist in increasing the joint mortise spread during dorsiflexion.
- *Patient*—Supine with knee in extension.
- *Operator*—Place the fingers of the medial hand under the tibia and the thumb over the tibia to stabilize it. Place the lateral hand using the thenar eminence over the lateral malleolus, with fingers underneath.
- *Mobilizing Force*—Glide the lateral malleolus posteriorly directing force through the left thenar eminence.

Talocrural Joint

Distraction (Fig 5)

- *Indication*—To increase joint play at the ankle mortise. Oscillations may also be used for pain control.
- *Patient*—Supine with lower extremity extended and ankle in a resting position.
- *Operator*—Stand or sit at the end of the table and wrap the fingers of both hands over the dorsum of the patient's foot. Place your thumbs on the plantar surface of the foot.

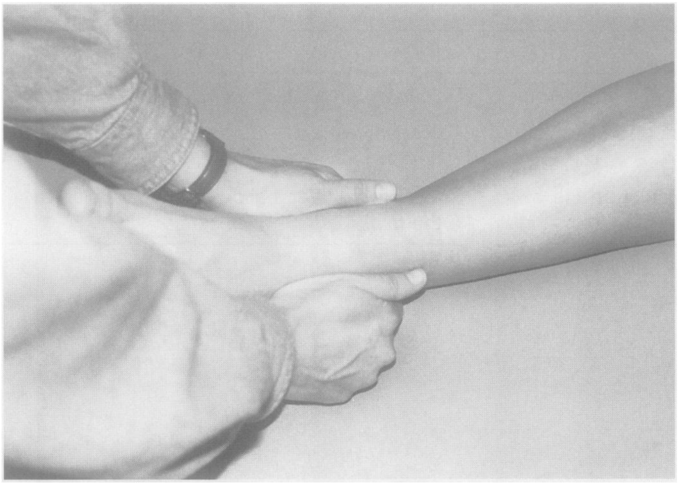

Fig 4. Posterior glide of the distal tibiofibular joint.

Fig 5. Distraction of the talocrural joint.

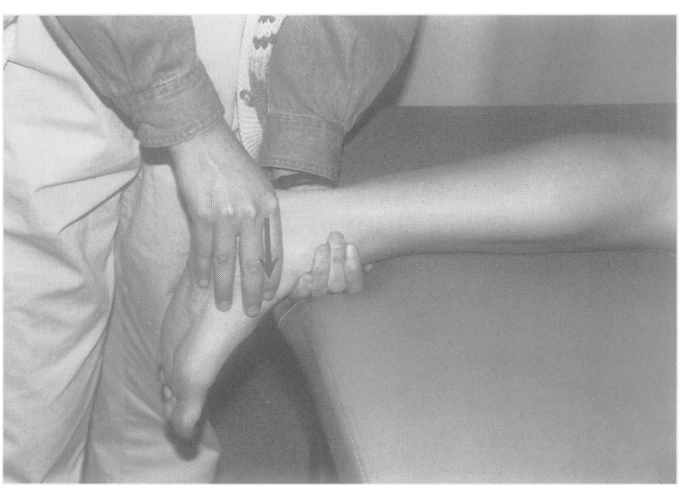

Fig 6. Ventral glide of the talocrural joint.

- *Mobilizing Force*—Distract the joint with both hands by leaning back, being careful to keep the athlete's foot in the mobilizing plane.

Ventral Glide (Fig 6)

- *Indication*—To increase plantar flexion.

Fig 7. Dorsal glide of the talocrural joint.

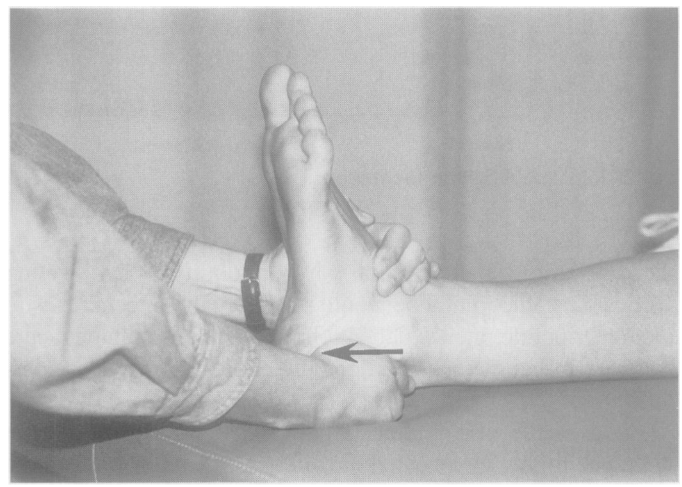

Fig 8. Distraction of the subtalar joint.

- *Patient*—Prone with knee relaxed and foot over the edge of the plinth.
- *Operator*—Operator's cranial hand grasps the anterior/distal surface of the tibia and fibula. The caudal hand contacts the posterior talus/calcaneus with the web space.
- *Mobilizing Force*—Glide the calcaneus and talus downward in an anterior direction.

Dorsal Glide (Fig 7)

- *Indication*—To increase dorsiflexion.
- *Patient*—Supine and relaxed with heel over the edge of the plinth.
- *Operator*—Stabilize the distal tibia against the plinth with the cranial hand, wrapping the fingers around posteriorly. The web of the caudal hand grasps the neck of the talus with the fingers wrapped around the foot.
- *Mobilizing Force*—Glide the talus posteriorly on the tibia.

Subtalar Joint

Distraction (Fig 8)

- *Indication*—General mobility; pain control.
- *Patient*—Supine with leg supported on the table.

- *Operator*—The distal hand grasps around the calcaneus from the posterior aspect of the foot. The other hand fixates the talus.
- *Mobilizing Force*—Pull the calcaneus distally with respect to the long axis of the leg. Medial and lateral glides of the calcaneus on the talus are used to improve eversion and inversion.

Medial Glide (Fig 9)

- *Indication*—To increase medial glide of the calcaneus on the talus.
- *Patient*—Sidelying with leg supported on the table and lateral side up.
- *Operator*—Align shoulder and arm parallel to the bottom of the foot. Stabilize the talus with your proximal hand. Place the base of the distal hand on the side of the calcaneus laterally and wrap the fingers around the plantar surface.
- *Mobilizing Force*—Apply a glide medially.

Lateral Glide (Fig 10)

- *Indication*—To increase lateral glide of the calcaneus on the talus.
- *Patient*—Sidelying with leg supported on the table and the medial side up.
- *Operator*—Align shoulder and arm parallel to the bottom of the foot. Stabilize the talus with your proximal hand. Place the base of the distal hand on the side of the calcaneus medially and wrap the fingers around the plantar surface.
- *Mobilizing Force*—Apply a glide laterally.

Midtarsal Joint

These glides can be used for the talonavicular joint, calcaneocuboid joint, naviculocuneiform joint, or the cuneiform-metatarsal joints.

Plantar Glide (Fig 11)

- *Indication*—To increase the medial arch of the foot.
- *Patient*—Supine with the knee relaxed.
- *Operator*—Fixate the more proximal bone with your finger by grasping dorsally at the level of the talar neck, the thumb wraps around laterally and the rest of the fingers wrap around medially. The other hand grasps the navicular, the thumb contacts dorsally and the hand and fingers wrap around the foot medially and plantarly.
- *Mobilizing Force*—Move the distal bones plantarly.

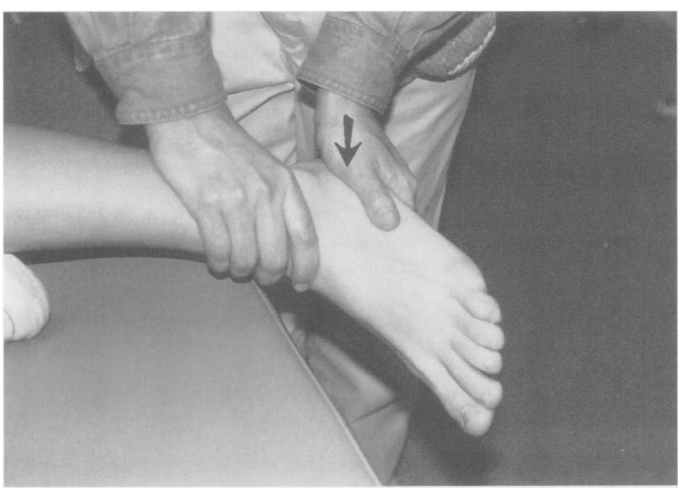

Fig 9. Medial glide of the subtalar joint.

Fig 11. Plantar glide of the midtarsal joint.

Fig 10. Lateral glide of the subtalar joint.

Fig 12. Dorsal glide of the midtarsal joint.

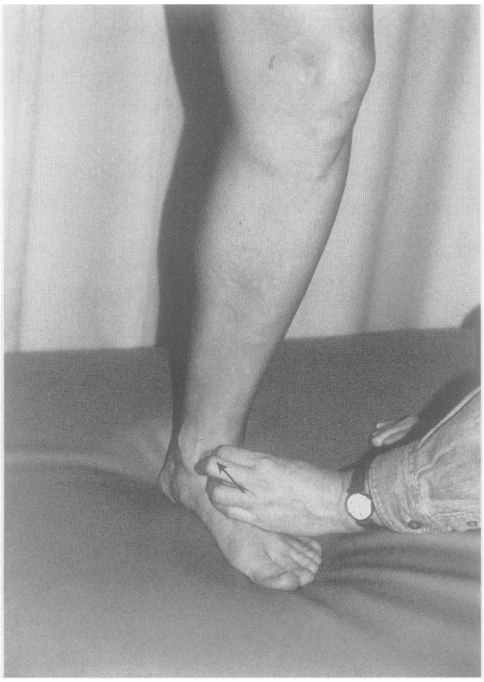

Fig 13. Talar glide in a weight-bearing position.

Dorsal Glide (Fig 12)

- *Indication*—To decrease the medial arch of the foot.
- *Patient*—Prone with hip and knee flexed.
- *Operator*—Fixate the calcaneus with one hand. With your other hand, wrap your fingers around the lateral side of the foot.
- *Mobilizing Force*—Move the distal bones in a dorsal direction.

Weight-Bearing Talar Glide (Fig 13)

- *Indication*—To increase dorsiflexion.
- *Patient*—Standing with the knee slightly bent.
- *Operator*—Apply pressure to the anterior talus.
- *Mobilizing Force*—Pressure should be applied in a posterior glide direction as the patient flexes his knee and dorsiflexes his foot.

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