



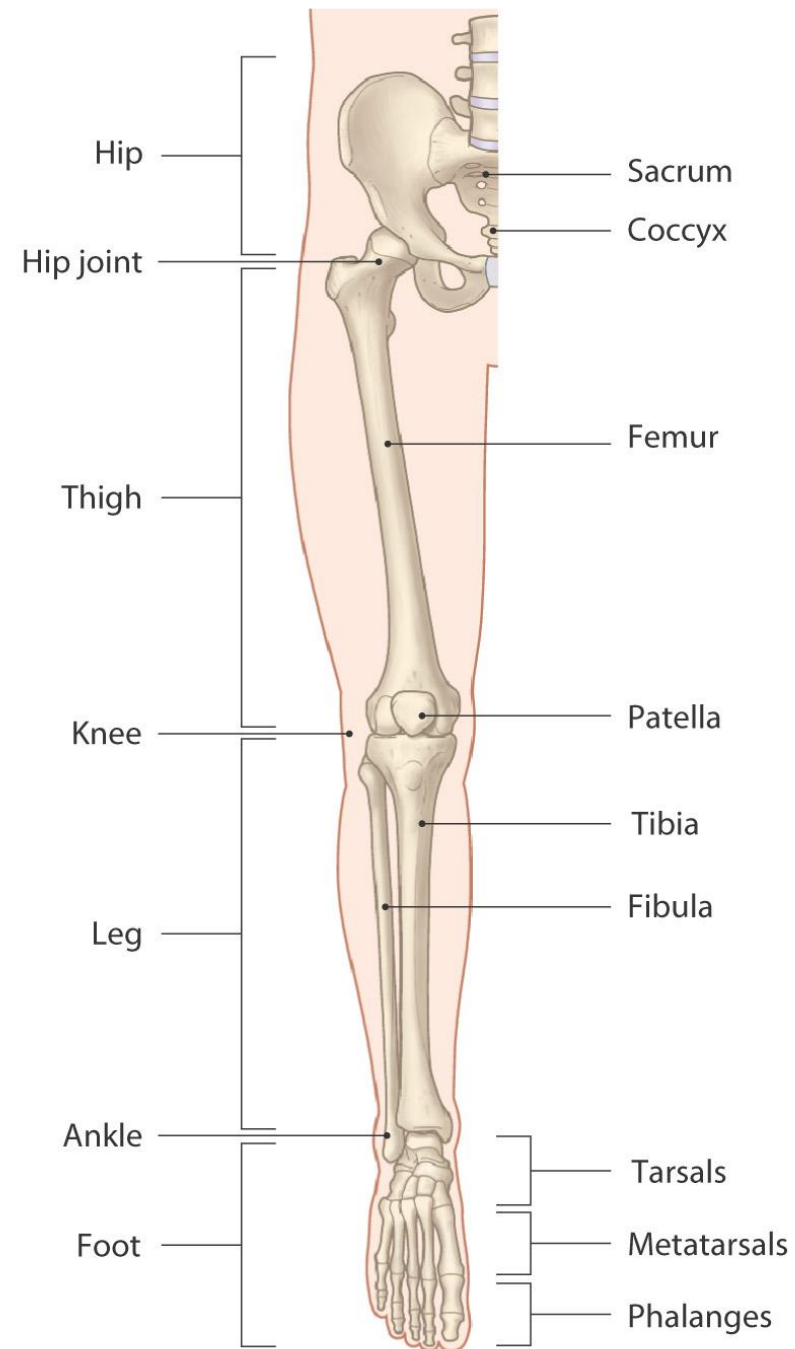
Physiotherapy Department

Biomechanics

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Biomechanics of the Joints of Lower Limb



Biomechanics of the Ankle



Lecture 11

Biomechanics of the Ankle

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Synopsis

- Overview
- Articulation
- Osteokinematics
- Arthrokinematics
- Muscles acting on the joint

Objectives

- By the end of this lecture, students should understand and be able to describe the basic biomechanics of the ankle as follows:
 - Articulation
 - Osteokinematics
 - Arthrokinematics
 - Muscles acting on the joint

Biomechanics of the ankle joint

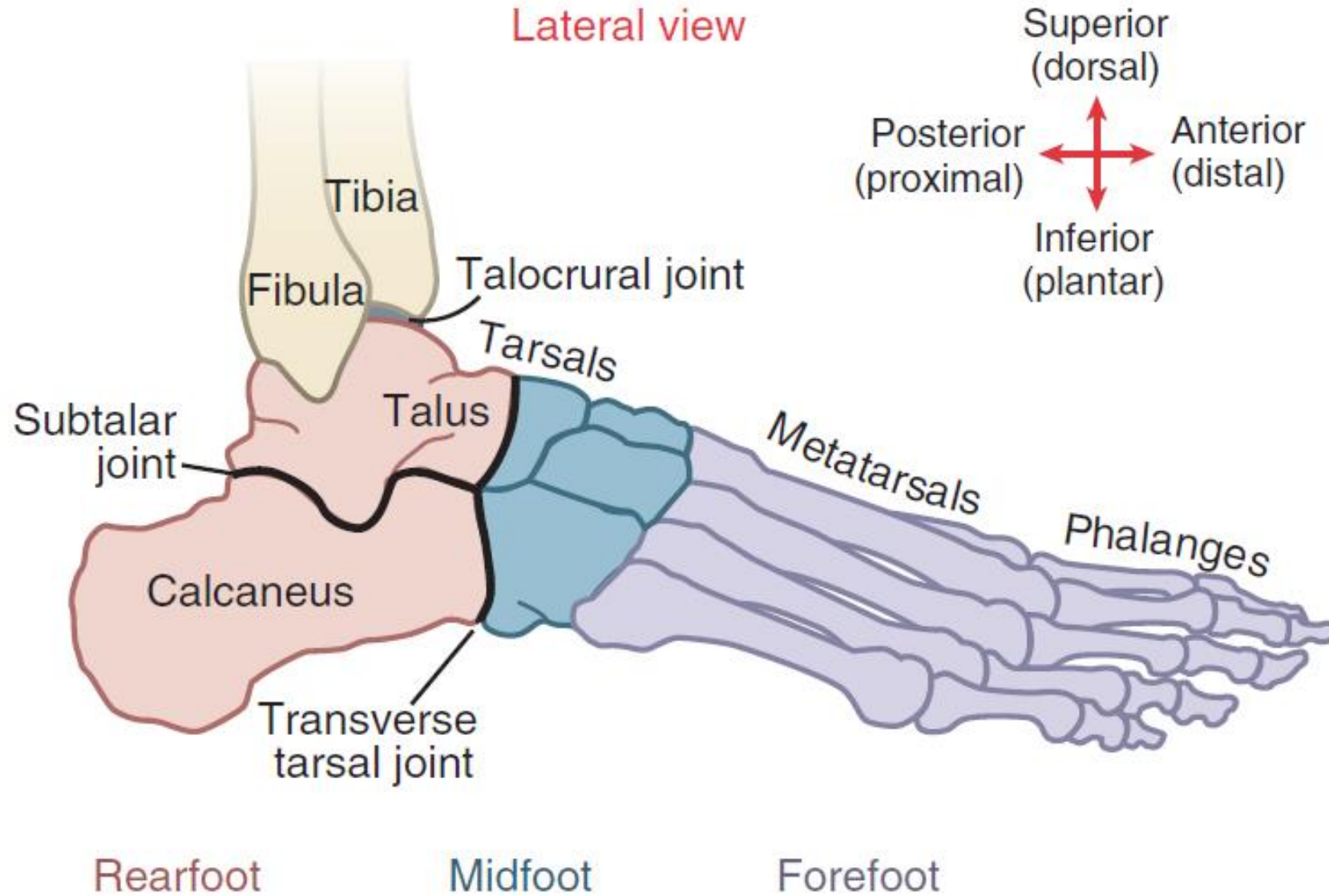
- Joints of the ankle and foot arise from the articulations of the distal tibia and fibula as well as the bones of the foot
- Foot is divided into three sub-regions
 - Fore foot
 - Mid foot
 - Hind foot
- Osteological features of the distal tibia, fibula, and bones of the foot provide the surfaces for muscle attachments and joint articulations for the ankle and foot region

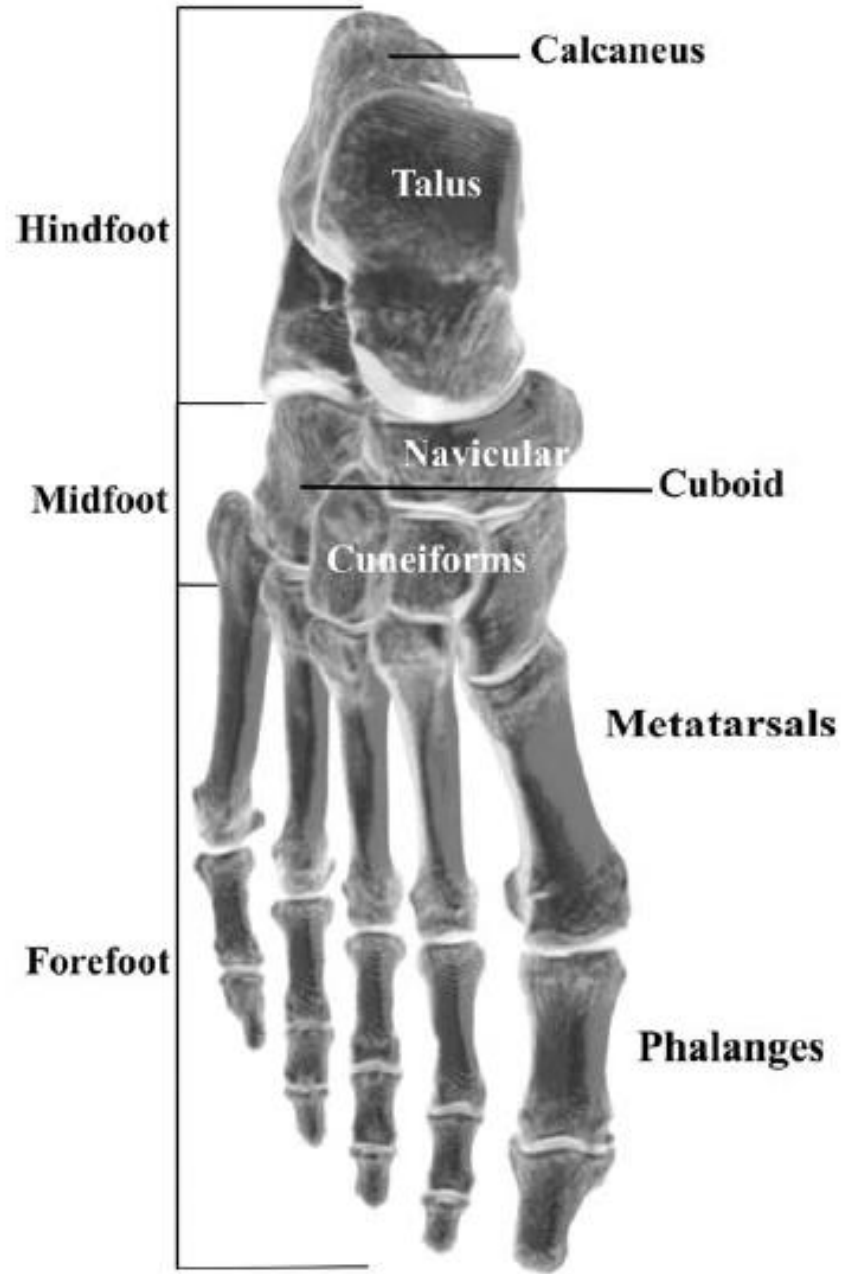
Structural Organization of the Bones and Joints of the Ankle and Foot

	Ankle	Foot
Bones	<p>Tibia</p> <p>Fibula</p> <p>Talus</p>	<p>Rearfoot: Calcaneus and talus*</p> <p>Midfoot: Navicular, cuboid, and cuneiforms</p> <p>Forefoot: Metatarsals and phalanges</p>
Joint	<p>Talocrural joint</p> <p>Proximal tibiofibular joint</p> <p>Distal tibiofibular Joint</p>	<p>Rearfoot: Subtalar joint</p> <p>Midfoot: Transverse tarsal joint: talonavicular and calcaneocuboid; distal intertarsal joint: cuneonavicular, cuboideonavicular, and intercuneiform and cuneocuboid complex</p> <p>Forefoot: Tarsometatarsal, intermetatarsal, metatarsophalangeal, interphalangeal joints</p>

*Talus is included as a bone of the ankle and of the foot.

Lateral view





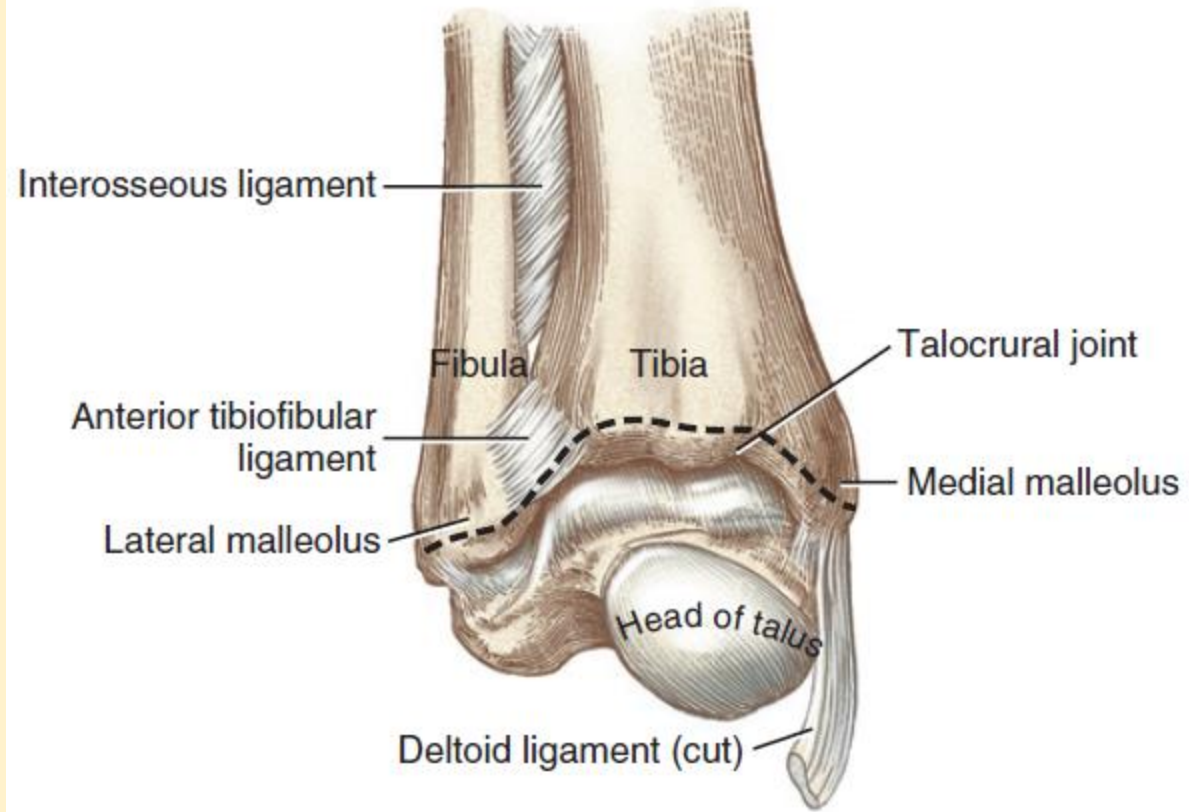
Biomechanics of the ankle joint

Osteologic Features of the Fibula and Distal Tibia

- Fibula
 - Head
 - Lateral malleolus
 - Articular facet (for the talus)

- Distal Tibia
 - Medial malleolus
 - Articular facet (for the talus)
 - Fibular notch

Anterior view



Biomechanics of the ankle joint

Osteologic Features of the Tarsal Bones

- Talus
 - Trochlear surface
 - Head
 - Neck
 - Anterior, middle, and posterior facets
 - Talar sulcus
 - Lateral and medial tubercles

Biomechanics of the ankle joint

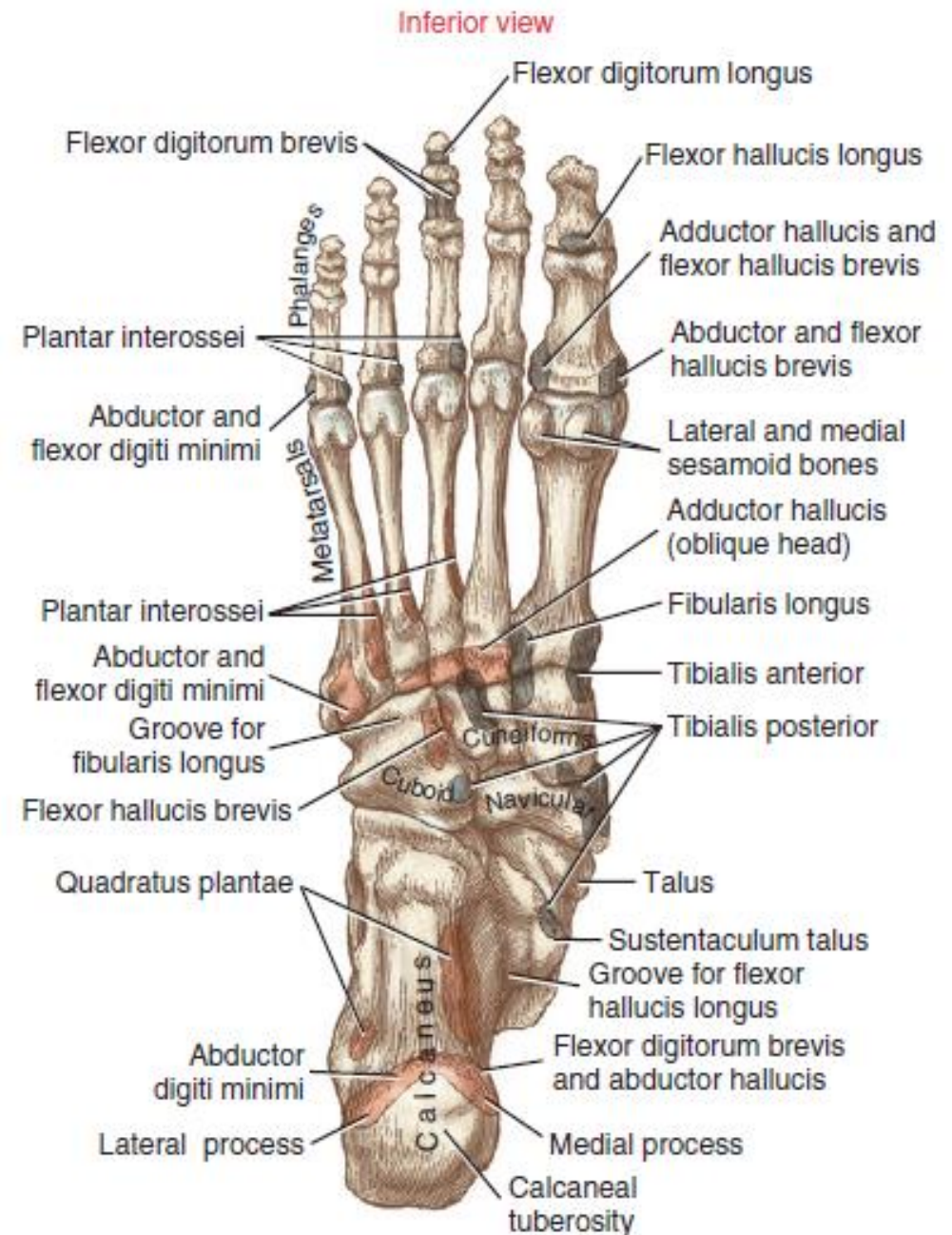
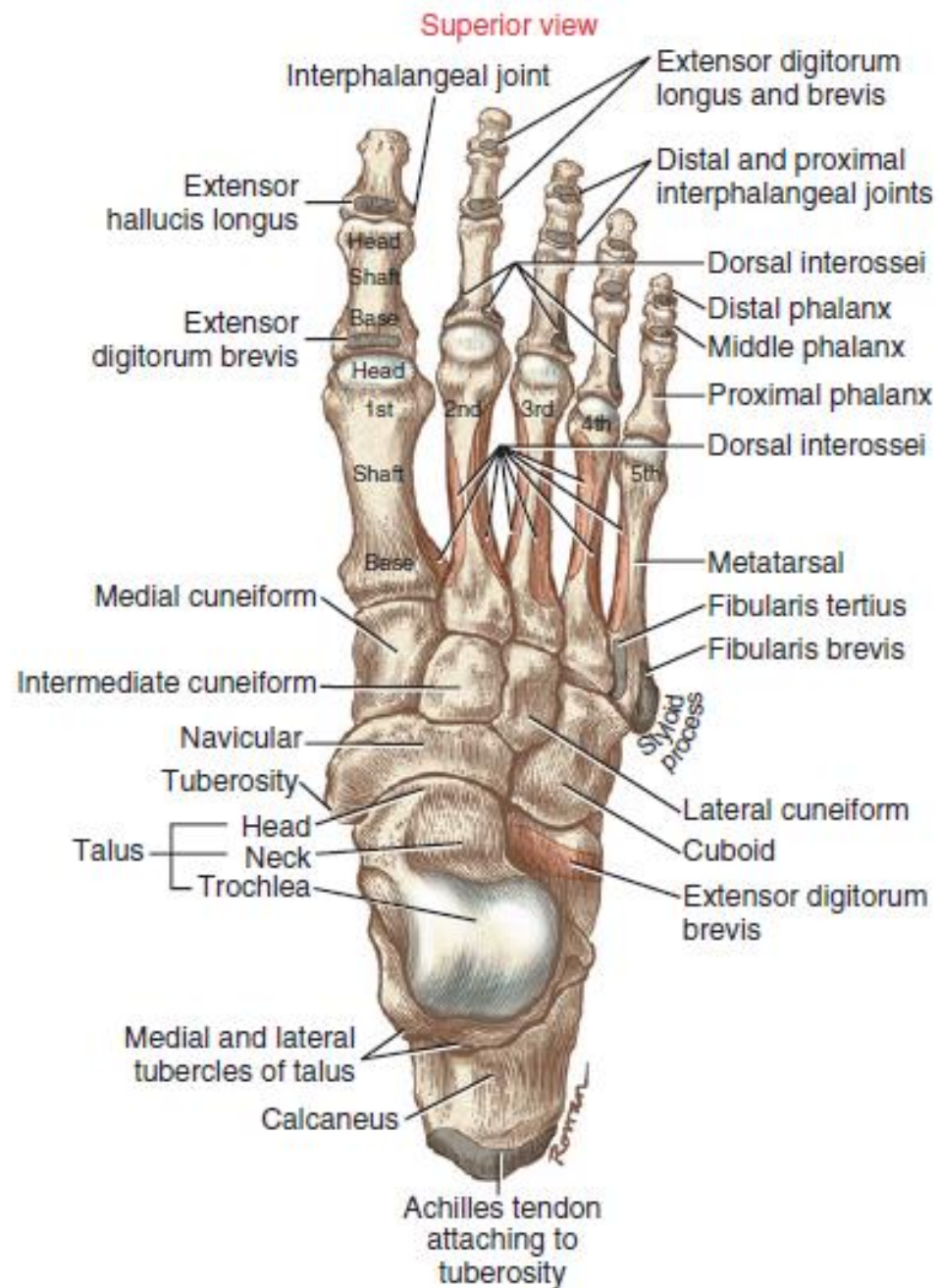
Osteologic Features of the Tarsal Bones

- Calcaneus
 - Tuberosity
 - Lateral and medial processes
 - Anterior, middle, and posterior facets
 - Calcaneal sulcus
 - Sustentaculum talus

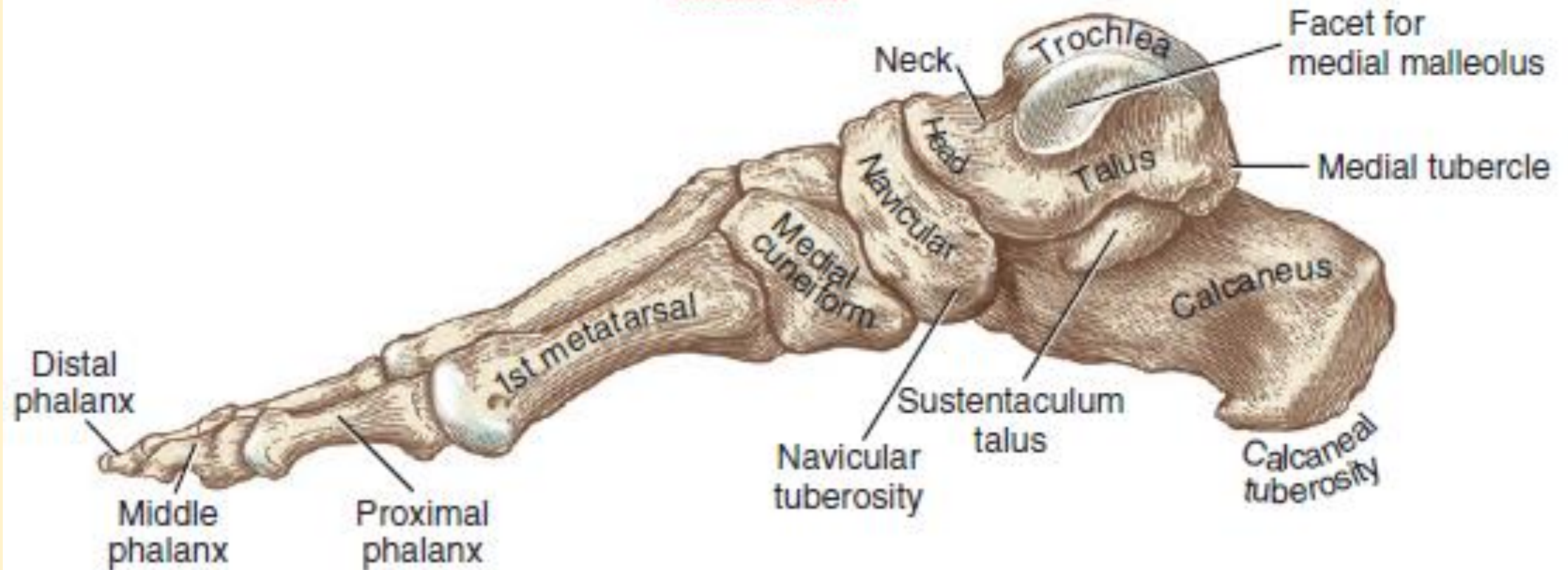
Biomechanics of the ankle joint

Osteologic Features of the Tarsal Bones

- Navicular
 - Proximal concave (articular) surface
 - Tuberosity
- Medial, Intermediate, and Lateral Cuneiforms
 - Transverse arch
- Cuboid
 - Groove (for the tendon of the fibularis longus)



Medial view



Biomechanics of the ankle joint

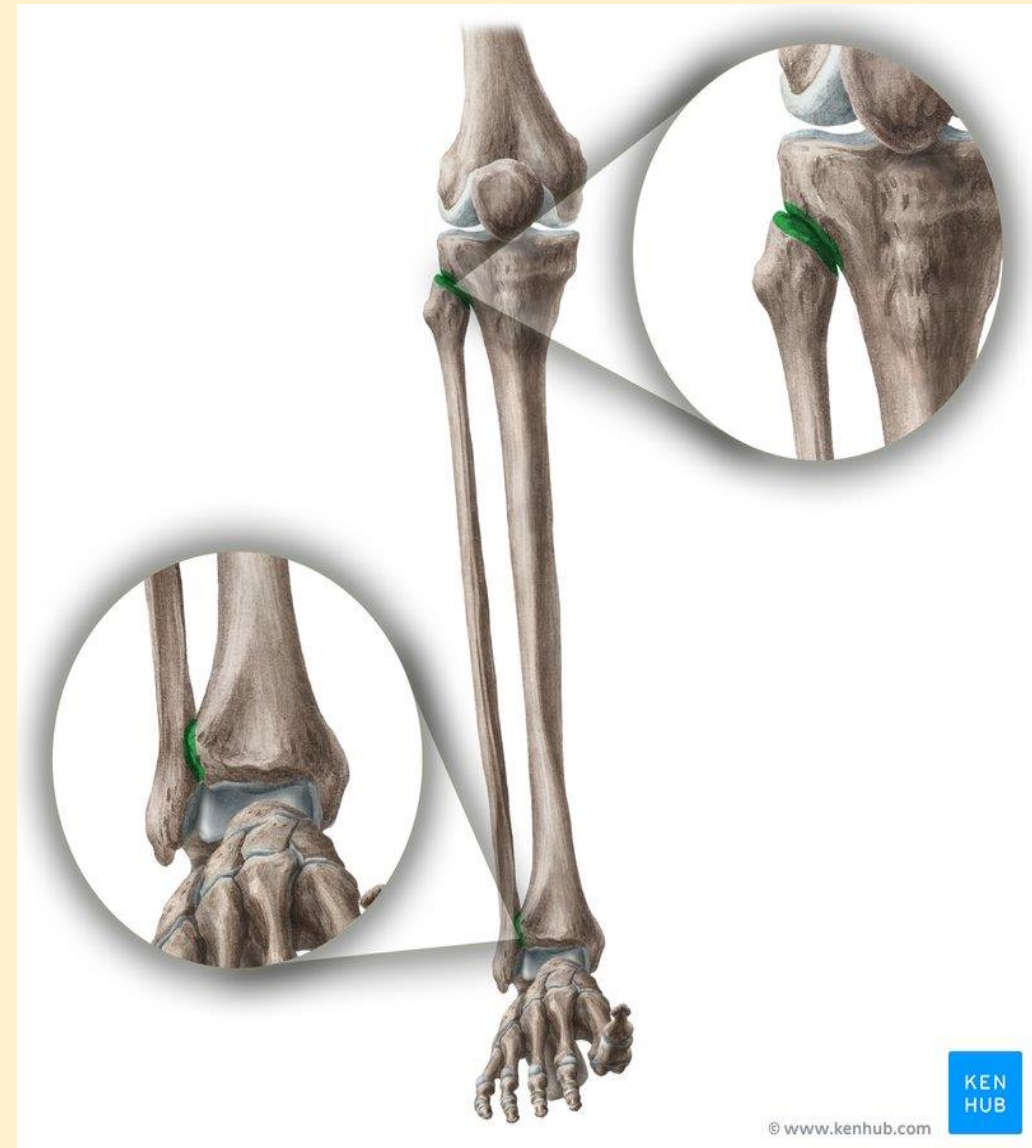
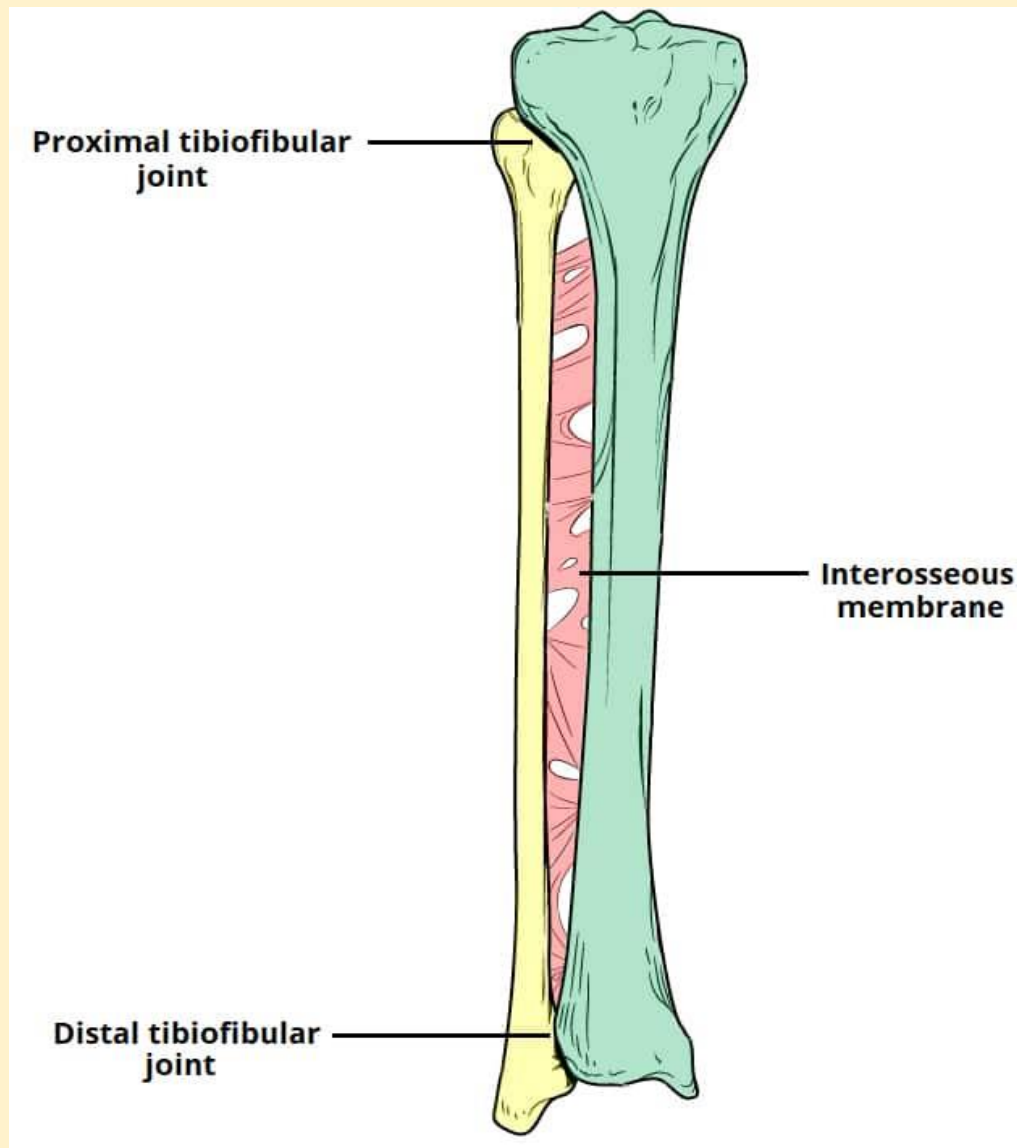
- The ankle joint comprises three joint articulations:
 - Superior tibiofibular
 - Inferior tibiofibular
 - Talocrural (ankle mortise)

Articulation:

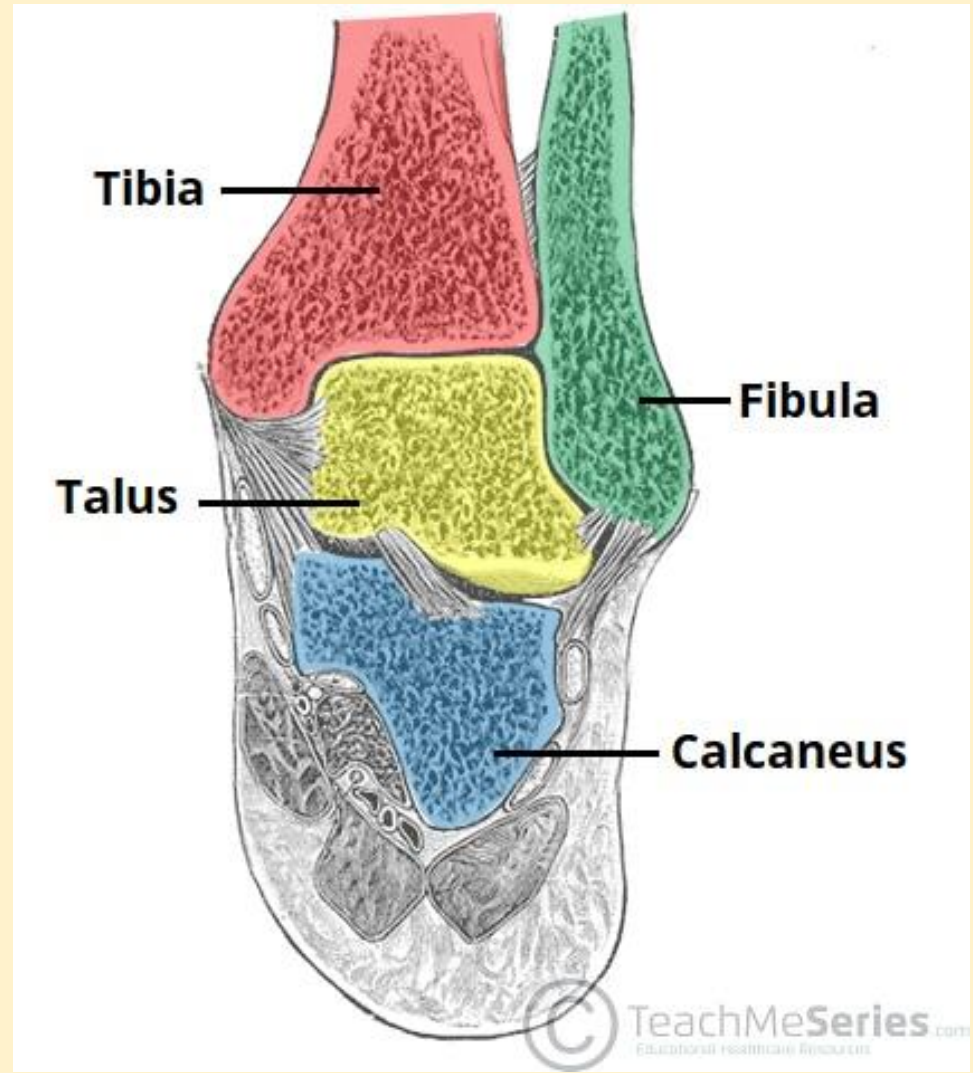
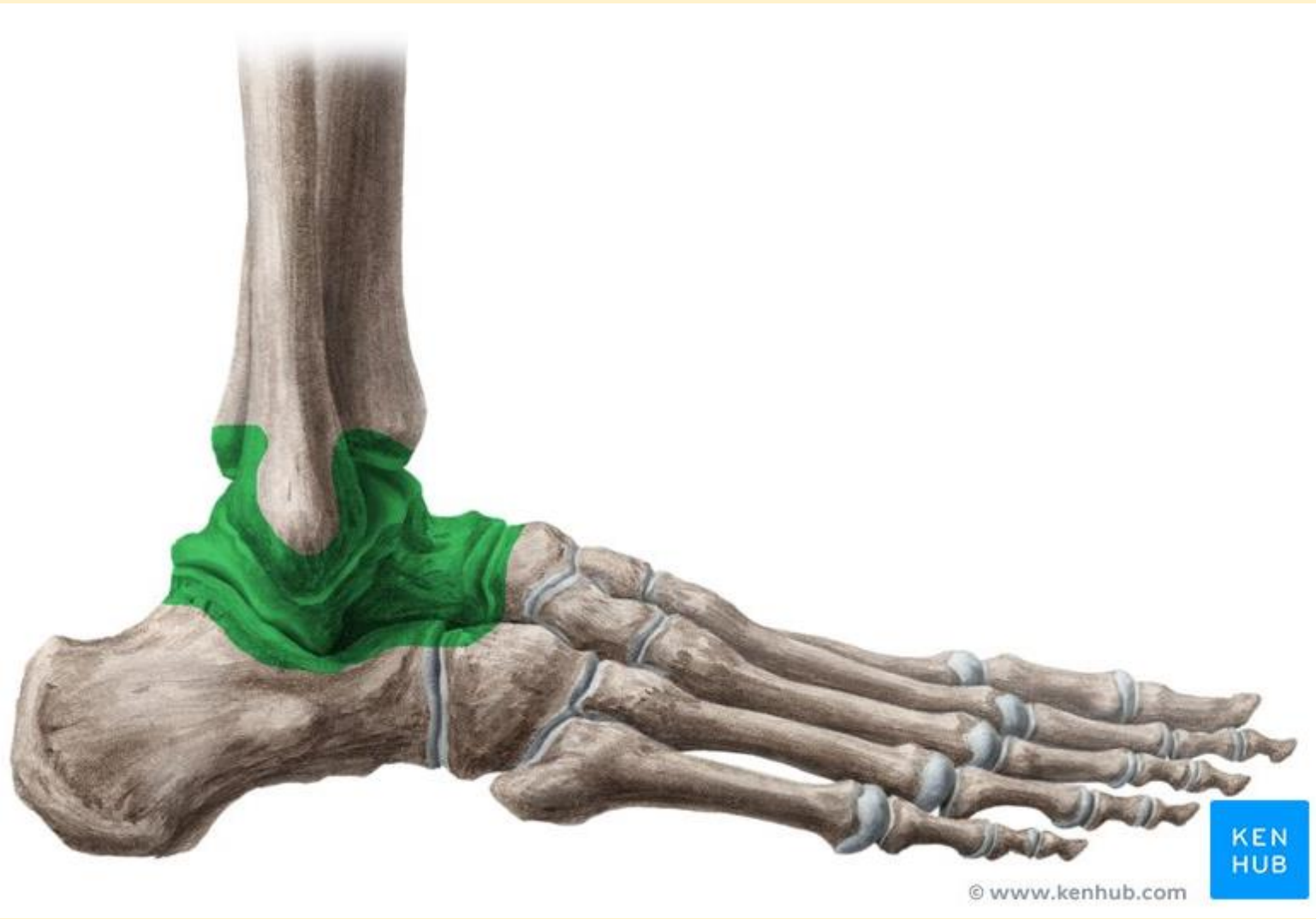
- Proximal tibiofibular: A union between slightly convex tibial facet and a slightly concave fibular facet
- Distal tibiofibular: A fibrous union between a concave facet on the lateral aspect of the distal tibia and a convex facet on the distal fibula

Biomechanics of the ankle joint

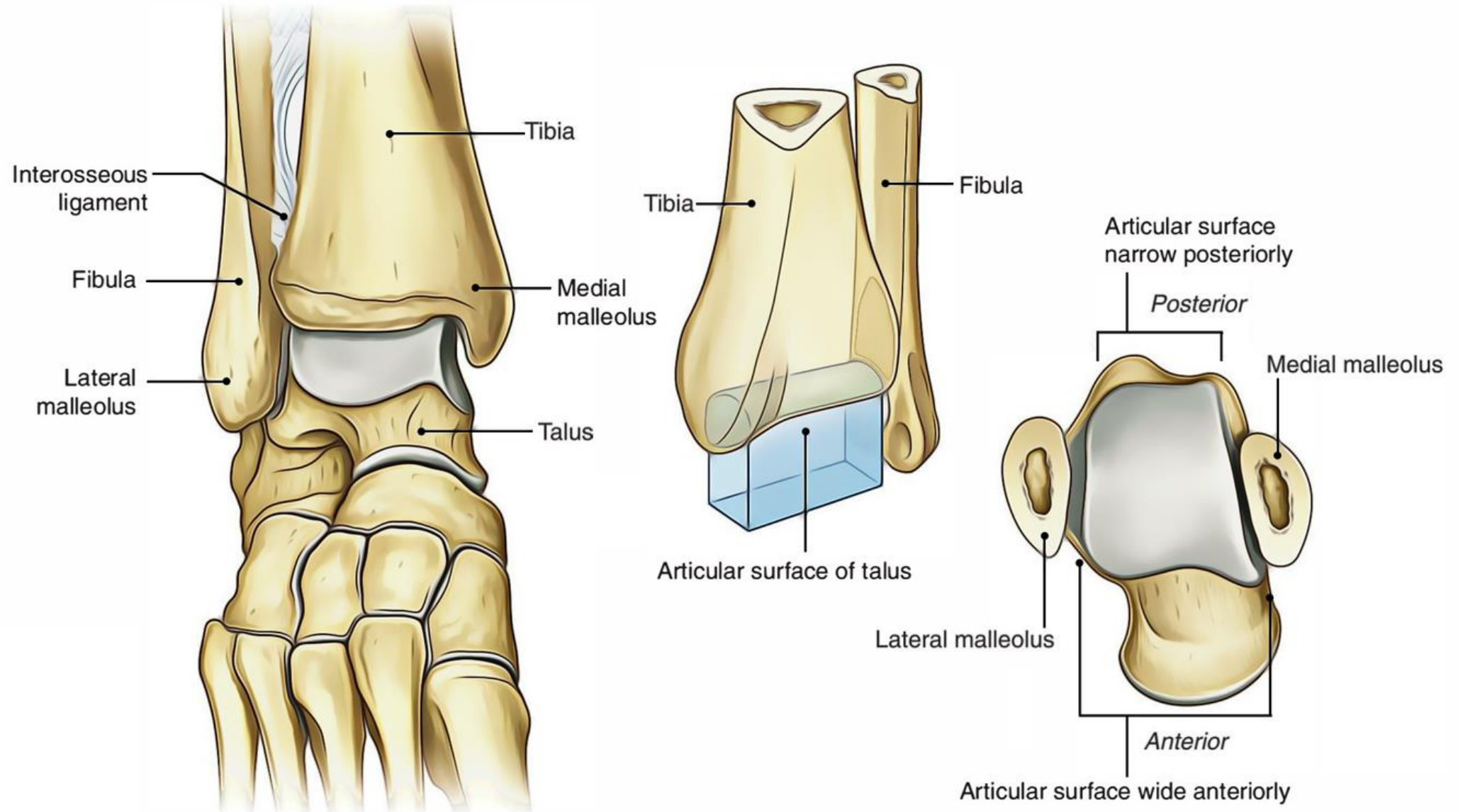
- Talocrural: A union between the concave surfaces of the distal tibia and the tibial and fibular malleoli superiorly, and the convex dome of the talus inferiorly
- Calcaneo-valgus refers to an increase in the medial angle between the calcaneus and posterior leg
- Calcaneo-varus refers to a decrease in the medial angle between the calcaneus and posterior leg



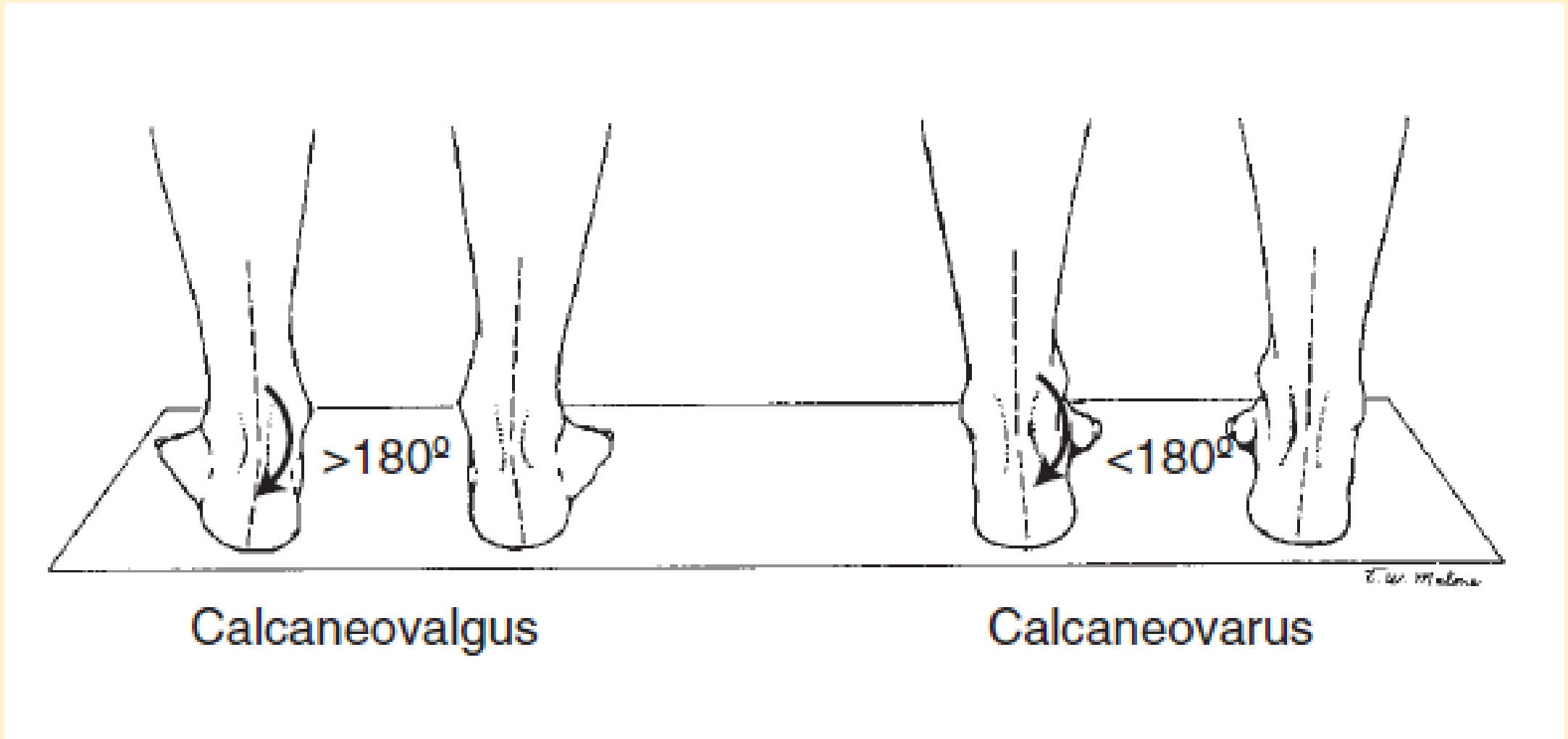
Superior and inferior tibiofibular articulations



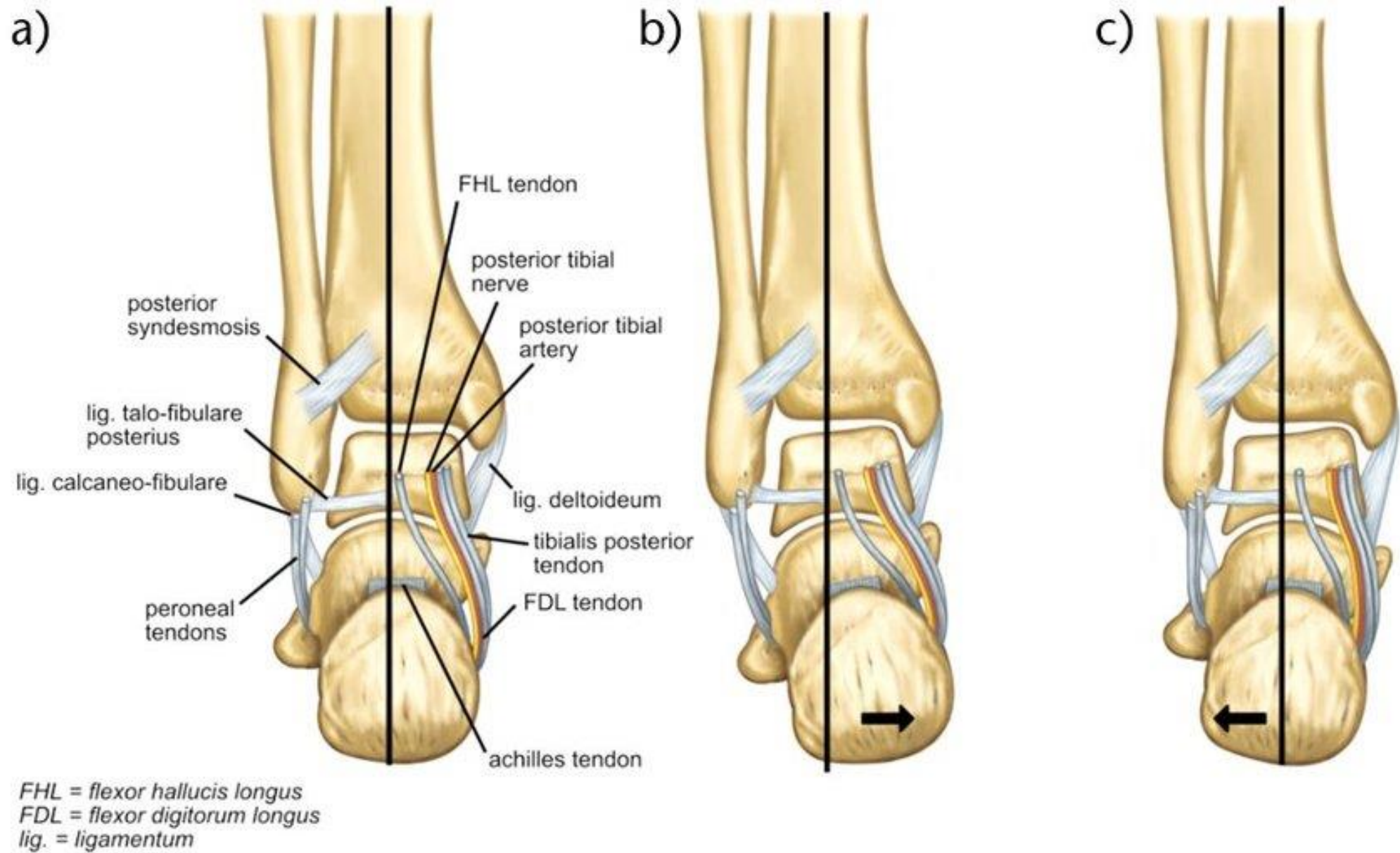
Ankle mortise



Ankle mortise



Abnormal articulation at the ankle



An illustration of tibio-calcaneal mechanical axis:
 a) healthy ankle; b) varus tilt c) valgus tilt

Biomechanics of the ankle joint

Osteokinematics

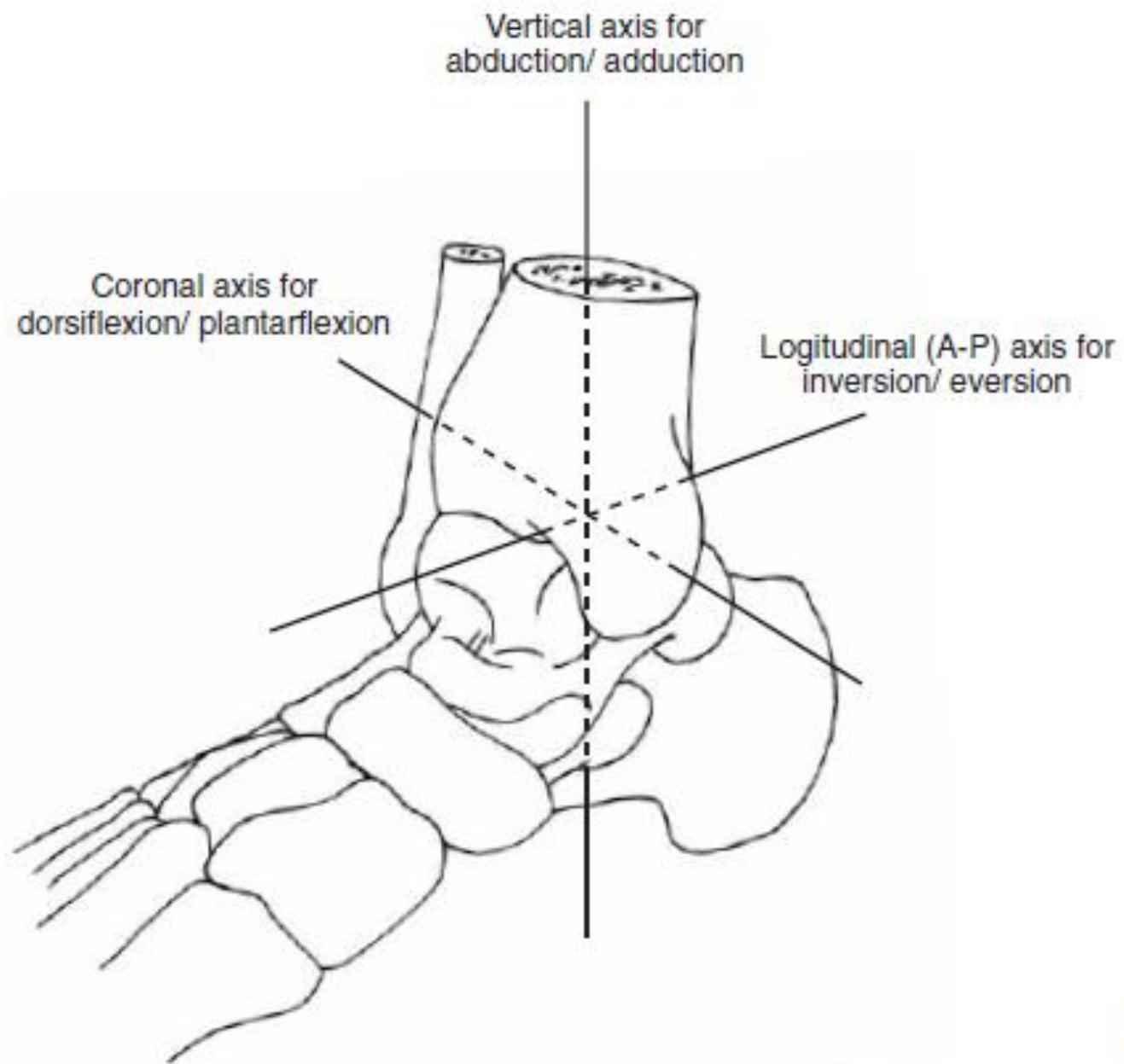
- Tibiofibular joints:
 - Proximal and distal tibiofibular joints are anatomically distinct from the talocrural joint but function to serve the ankle
 - Proximal tibiofibular joint is a plane synovial joint that allows a small amount of superior and inferior sliding of the fibula on the tibia and a slight amount of rotation.
 - Distal tibiofibular joint is a syndesmosis, or fibrous union, but it also allows a small amount of motion
- Talocrural joint:
 - Talocrural joint is a synovial hinge joint with 1 degree of freedom. The motions available are dorsiflexion and plantarflexion

Biomechanics of the ankle joint

- Being a hinge joint, the ankle/talocrural joint only allows plantar flexion (flexion) and dorsiflexion (extension)
- Plantar flexion and dorsiflexion occur on the transverse (medial-lateral) axis that passes through the talus in the sagittal plane
- Degree of movement in the ankle joint amounts to approximately 30-50° of plantar flexion, and about 20° of dorsiflexion

Biomechanics of the ankle joint

- Because the lateral malleolus is more distal and posterior than the medial malleolus, the axis for movement is oblique and thus motions do not occur purely in the sagittal plane
- Dorsiflexion of the ankle brings the foot up with slight abduction and pronation/eversion
- Plantarflexion brings the foot down with slight adduction and supination/inversion
- Ankle is considered to be in the 0-degree neutral position when the foot is at a right angle to the tibia



Biomechanics of the ankle joint

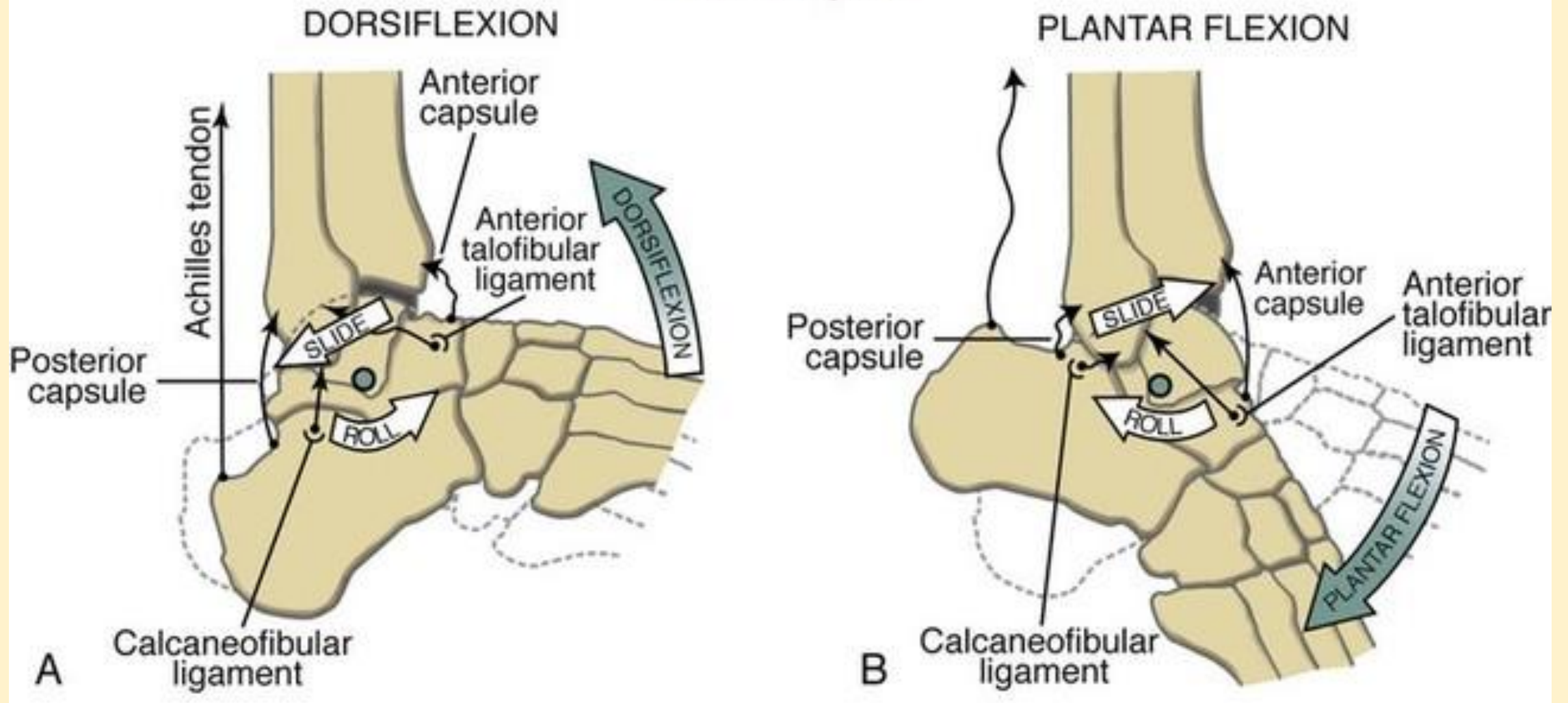
Arthrokinematics

- Tibiofibular joints:
 - During dorsiflexion of the ankle, the fibula moves proximally and slightly posteriorly (lateral rotation) away from the tibia.
 - During plantarflexion, the fibula glides distally and slightly anteriorly (medial rotation) toward the tibia
 - During inversion, the fibular glides distally and slightly posteriorly
 - During eversion, the fibular glides proximally and slightly anteriorly

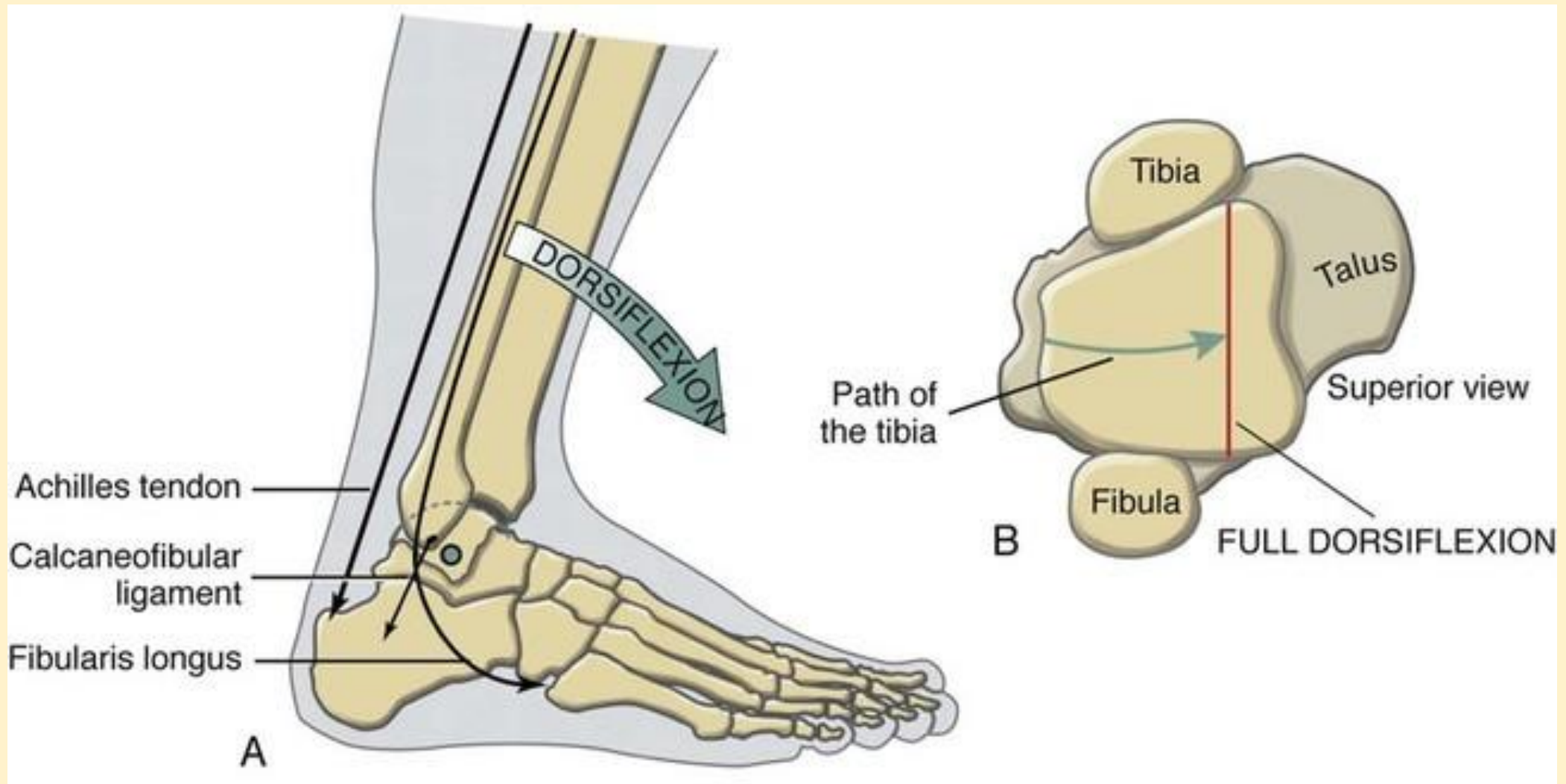
Biomechanics of the ankle joint

- Talocrural joint:
 - During dorsiflexion in the non-weight-bearing position, the talus rolls anteriorly and slides posteriorly
 - During plantarflexion, the talus rolls posteriorly and slides anteriorly
 - During dorsiflexion, in the weight-bearing position with the talus fixed, the tibia moves anteriorly
 - During plantarflexion in a weight-bearing position the tibia moves posteriorly

Talocrural joint



Arthrokinematics of the ankle/talocrural joint in open kinematic



Arthrokinematics of the ankle/talocrural joint in closed kinematic

Biomechanics of the ankle joint

Muscles acting on the joints

- The following group of muscles produce movement at the ankle
 - Plantar flexors (posterior compartment of the leg)
 - Dorsi flexors (anterior compartment of the leg)
 - Invertors
 - Evertors

Muscles acting on the ankle joint

Plantar flexion	Gastrocnemius, soleus, flexor digitorum longus, flexor hallucis longus, fibularis longus, tibialis posterior
Dorsiflexion	Tibialis anterior, extensor digitorum longus, extensor hallucis longus, fibularis tertius
Inversion	Tibialis anterior, tibialis posterior
Everson	Fibularis longus, fibularis tertius, fibularis brevis

Contributions and Questions



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References

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