The Ankle and Foot Joint

- 26 bones
- 19 large muscles
- Many small (intrinsic) muscles
- More than 100 ligaments
- Support & propulsion
  - Foot trouble - common ailment
  - Poor foot mechanics leads to foot discomfort
  - No substitute for adequate muscular development, strength, & proper foot mechanics

The Ankle and Foot Joint - Walking & running

- Stance phase
  - Heel-strike occurs when landing on heel, foot should be in supination
  - Midstance immediately follows with foot moving into pronation
  - Toe-off follows midstance, foot returns to supination prior to & during push off

The Ankle and Foot Joint - Walking & running

- Swing phase
  - occurs when foot leaves ground & leg moves forward to another point of contact

The Ankle and Foot Joint

- Problems arise
  - foot is too rigid & does not pronate adequately
  - foot remains in pronation past midstance
- Walking
  - one foot is always in contact with ground
- Running
  - point when neither foot is in contact with ground

Bones

- 26 bones in each foot that form arch
- Body weight is transferred from tibia to talus & calcaneus (tarsal bones)
- 5 other rear & midfoot tarsal bones
  - Navicular - between talus & 3 cuneiform bones
  - Cuboid - between calcaneus and 4th & 5th metatarsals
  - 5 metatarsals - anterior to tarsals
  - 5 phalanges
    - 3 phalanxes in each except 1st toe (2 phalanxes)
    - 2 sesamoids beneath 1st metatarsophangeal joint

Bones

- Distal malleoli of tibia & fibula
  - Enlarged & protrude horizontally & inferiorly
  - Serve as pulley for posterior tendons to increase mechanical advantage of muscles in performing inversion & eversion actions

Bones

- Pulley for posterior tendons
  - Peroneus brevis & peroneus longus
    - immediately behind lateral malleolus
  - “Tom, Dick & Harry” muscles immediately posterior to medial malleolus
    - Tibialis posterior
    - Flexor digitorum longus
    - Flexor hallucis longus

• Base of 5th metatarsal
  – enlarged & prominent to serve as insertion for peroneus brevis & tertius

• Tibialis anterior inserts on inner surface of medial cuneiform & base of 1st metatarsal
• Peroneus longus inserts on undersurface of medial cuneiform & 1st metatarsal
• Tibialis posterior - multiple insertions on lower inner surfaces of navicular, cuneiform, & 2nd - 5th metatarsal base

• Extensor digitorum longus inserts on tops of 2nd - 5th distal phalanxes bases
• Flexor digitorum longus inserts on undersurfaces of 2nd - 5th distal phalanxes bases
• Extensor hallucis longus inserts on top of 1st distal phalanx base
• Flexor hallucis longus inserts on undersurface of 1st distal phalanx base
• Posterior surface of calcaneus – very prominent & serves as insertion for Achilles tendon of gastrocnemius-soleus complex

• Tibiofibular joint
  – Syndesmotic amphiarthrodial joint
  – Joined at both proximal & distal tibiofibular joints
  – Ligaments and a strong, dense interosseus membrane between tibia & fibula shafts provide support
  – Minimal movement possible
  – Distal joint becomes sprained occasionally in heavy contact sport
Joints

• Tibiofibular joint
  – Syndesmosis joint sprain
    • "High ankle sprain" primarily involves anterior inferior tibiofibular ligament
    • More severe injuries can involve posterior tibiofibular ligament, interosseous ligament, & interosseous membrane


Joints

• Ankle joint (talocrural joint)
  – Hinge or ginglymus-type joint
  – Talus, distal tibia, & distal fibula
  – 50 degrees of plantar flexion
  – 15 to 20 degrees of dorsiflexion
  – Greater range of dorsiflexion with knee flexed (reduces gastrocnemius tension)
  – Fibula rotates 3 to 5 degrees externally with ankle dorsiflexion & 3 to 5 degrees internally during plantarflexion
  – Syndesmosis joint widens by 1 to 2 millimeters during full dorsiflexion

Joints

• Subtalar & transverse tarsal joints
  – Inversion & eversion occurs here
  – Classified as gliding or arthrodial
  – Combined movement of
    • 20 to 30 degrees of inversion
    • 5 to 15 degrees of eversion
  – Intertarsal & tarsometatarsal joints
    – Arthrodial
    – Minimal movement

Joints

• Metatarsophalangeal joints
  – Phalanges join metatarsals
  – Classified as condyloid-type joints
  – Great toe metatarsophalangeal (MP) joint flexes 45 degrees & extends 70 degrees
  – MP joints of the four lesser toes
    • 40 degrees of flexion
    • 40 degrees of extension
    • also abduct & adduct minimally
Joints

- Great toe interphalangeal (IP) joint flexes from 0 degrees of full extension to 90 degrees of flexion
- Proximal interphalangeal (PIP) joints in lesser toes flexes from 0 degrees of extension to 35 degrees of flexion
- Distal interphalangeal (DIP) joints flexes 60 degrees & extend 30 degrees
- Much variation from joint to joint & from person to person

Ankle sprains very common injury
- Sprains involve stretching or tearing of one or more ligaments
- Most common ankle sprain results from excessive inversion that causes damage to lateral ligamentous structures, primarily anterior talofibular ligament & calcaneofibular ligament

Ligaments in foot & ankle maintain arches
- Two longitudinal arches
  - Medial longitudinal arch - extends from calcaneus bone to talus, navicular, 3 cuneiforms, and proximal ends of 3 medial metatarsals
  - Lateral longitudinal arch - extends from calcaneus to cuboid and proximal ends of 4th & 5th metatarsals
- Long arches may be high, medium, or low
Joints

- Transverse arch
  - extends across foot from 1st metatarsal to the 5th metatarsal

Movements

- Dorsiflexion (flexion)
  - movement of top of ankle & foot toward anterior tibia
- Plantar flexion (extension)
  - movement of ankle & foot away from tibia

Movements

- Eversion
  - turning ankle & foot outward; abduction, away from midline; weight is on medial edge of foot
- Inversion
  - turning ankle & foot inward; adduction, toward midline; weight is on lateral edge of foot

Movements

- Toe flexion
  - movement of toes toward plantar surface of foot
- Toe extension
  - movement of toes away from plantar surface of foot
Movements

• Pronation
  – combination of ankle dorsiflexion, subtalar eversion, & forefoot abduction (toe-out)
• Supination
  – combination of ankle plantar flexion, subtalar inversion, & forefoot adduction (toe-in)

Muscles

• Group according to location & function
  – Anterior ankle & foot - dorsal flexors
  – Posteriorly - plantar flexors
    • triceps surae
      – gastrocnemius & soleus
  – Laterally - evertors
  – Medially - invertors

Muscles

• Lower leg - divided into 4 compartments
  – Dense fascia - tightly surrounds & binds each
    • Facilitates venous return & prevents excessive swelling of muscles during exercise
  – Anterior compartment
    • Dorsiflexor group - tibialis anterior, peroneus tertius, extensor digitorum longus, & extensor hallucis longus
  – Lateral compartment
    • Peroneus longus & peroneus brevis (two most powerful evertors)

Muscles

– Superficial posterior compartment
  • Gastrocnemius, soleus, & plantaris - plantar flexors
– Deep posterior compartment
  • Flexor digitorum longus, flexor hallucis longus, popliteus, & tibialis posterior
  • All are plantar flexors & invertors except popliteus
Muscles

- Acute & chronic injuries are common
  - "Shin splints" - common term describing painful leg condition often associated with running activities
    - Not a specific diagnosis
    - Attributed to a number of different specific musculotendinous injuries
    - Most often involves tibialis posterior, medial soleus, or anterior tibialis, but may also involve extensor digitorum longus
    - May be partially prevented by stretching plantar flexors & strengthening dorsiflexors

- Painful cramps - acute muscle spasm in gastrocnemius & soleus
  - Occur somewhat commonly
  - May be relieved through active & passive dorsiflexion

- Complete rupture of Achilles tendon
  - Very disabling injury

- Several ankle & foot muscles produce more than one movement

Ankle & foot joint muscles by function

- Plantar flexors
  - Gastrocnemius
  - Flexor digitorum longus
  - Flexor hallucis longus
  - Peroneus (fibularis) longus
  - Peroneus (fibularis) brevis
  - Plantaris
  - Soleus
  - Tibialis posterior

- Evertors
  - Peroneus (fibularis) longus
  - Peroneus (fibularis) brevis
  - Peroneus (fibularis) tertius
  - Extensor digitorum longus
Muscles
Ankle & foot joint muscles by function
• Dorsiflexors
  – Tibialis anterior
  – Peroneus (fibularis) tertius
  – Extensor digitorum longus (extensor of lesser toes)
  – Extensor hallucis longus (extensor of great toe)

Muscles
Ankle & foot joint muscles by function
• Invertors
  – Tibialis anterior
  – Tibialis posterior
  – Flexor digitorum longus (flexor of lesser toes)
  – Flexor hallucis longus (flexor of great toe)

Muscles
Ankle & foot joint muscles by compartment
• Anterior compartment
  – Tibialis anterior
  – Extensor hallucis longus
  – Extensor digitorum longus
  – Peroneus (fibularis) tertius

Muscles
Ankle & foot joint muscles by compartment
• Lateral compartment
  – Peroneus (fibularis) longus
  – Peroneus (fibularis) brevis
Muscles
Ankle & foot joint muscles by compartment
• Deep posterior compartment
  – Flexor digitorum longus
  – Flexor hallucis longus
  – Tibialis posterior
• Superficial posterior compartment
  – Gastrocnemius (medial head)
  – Gastrocnemius (lateral head)
  – Soleus

Nerves
• Sciatic nerve
  – tibial division
  • gastrocnemius (medial head), soleus, tibialis posterior, flexor digitorum longus, & flexor hallucis longus
  • medial & lateral plantar nerves
    – intrinsic foot muscles
    – medial plantar nerve
      » adductor hallucis, flexor hallucis brevis, first lumbricale, & flexor digitorum brevis

• Sciatic nerve
  – common peroneal (fibular) division
  • Superficial peroneal nerve
    – peroneus longus & peroneus brevis
  • Deep peroneal nerve
    – tibialis anterior, extensor digitorum longus, extensor hallucis longus, peroneus tertius, & extensor digitorum brevis

• Sciatic nerve
  – superficial peroneal nerve
  – flexor digitorum longus
  – extensor hallucis longus
Gastrocnemius Muscle

- Plantar flexion of ankle
- Flexion of knee

Soleus Muscle

- Plantar flexion of ankle

Peroneus Longus (fibularis) Muscle

- Eversion of foot
- Plantar flexion of ankle

Peroneus Brevis (fibularis) Muscle

- Eversion of foot
- Plantar flexion of ankle
Peroneus Tertius (fibularis) Muscle

- Eversion of foot
- Dorsiflexion of ankle

Extensor Digitorum Longus Muscle

- Extension of four lesser toes at metatarsophalangeal, proximal & distal interphalangeal joints
- Dorsiflexion of ankle
- Eversion of foot

Extensor Hallucis Longus Muscle

- Dorsiflexion of ankle
- Extension of great toe at metatarsophalangeal & interphalangeal joints
- Weak inversion of foot

Tibialis Anterior Muscle

- Dorsiflexion of ankle
- Inversion of foot
Tibialis Posterior Muscle

- Plantar flexion of ankle
- Inversion of foot

Flexor Digitorum Longus Muscle

- Flexion of 4 lesser toes at metatarsophalangeal, proximal & distal interphalangeal joints
- Inversion of foot
- Plantar flexion of ankle

Flexor Hallucis Longus Muscle

- Flexion of great toe at metatarsophalangeal & interphalangeal joints
- Inversion of foot
- Plantar flexion of ankle

Intrinsic Muscles of the Foot

- All originate & insert within the foot
- Extensor digitorum brevis is on dorsum of foot
- Remainder are in a plantar compartment in 4 layers on plantar surface of foot
Intrinsic Muscles of the Foot

- **First (superficial) layer:** Abductor hallucis, flexor digitorum brevis, abductor digit minimi (quinti)

- **Second layer:** Quadratus plantae, lumbricales (4)


- **Third layer:** Flexor hallucis brevis, adductor hallucis, flexor digiti minimi (quinti) brevis

- **Fourth (deep) layer:** Dorsal interossei (4), plantar interossei (3)


Intrinsic Muscles of the Foot

- **Grouped by location**
  - **Medial** - attach to great toe proximal phalanx
    - Abductor hallucis & flexor hallucis brevis - medially
    - Adductor hallucis - centrally beneath metatarsals

- **Central location**
  - Beneath the foot
    - Quadratus plantae, 4 lumbricales, 4 dorsal interossei, 3 plantar interossei, flexor digitorum brevis
  - Dorsal compartment
    - Extensor digitorum brevis
  - Lateral – attach on lateral aspect of base of 5th phalange proximal phalanx
    - abductor digit minimi, flexor digiti minimi brevis
    - quinti is sometimes used instead of minimi
Intrinsic Muscles of the Foot

• Grouped by action
  – 4 muscles act on great toe
    • abductor hallucis - abduction of great toe & assists flexor hallucis brevis in flexing great toe at MP joint
    • adductor hallucis - adduction of great toe
    • extensor digitorum brevis - extension of great toe at MP joint
  – 4 lumbricales
    • flexors of the 2nd, 3rd, 4th, & 5th phalanges at MP joints

Intrinsic Muscles of the Foot

• Grouped by action
  – quadratus plantae
    • flexors of 2nd, 3rd, 4th, & 5th phalanges at DIP joints
  – 3 plantar interossei
    • adductors & flexors of proximal phalanges of 3rd, 4th, & 5th phalanges
  – 4 dorsal interossei
    • abductors & flexors of 2nd, 3rd, & 4th phalanges MP joints

Intrinsic Muscles of the Foot

• Grouped by action
  – flexor digitorum brevis
    • flexes middle phalanges of 2nd, 3rd, 4th, & 5th phalanges
  – extensor digitorum brevis
    • extends great toe & 2nd, 3rd, 4th phalanges at MP joints
  – 5th toe muscles
    • abductor digiti minimi abducts proximal phalanx
    • flexor digiti minimi brevis flexes proximal phalanx

Intrinsic Muscles of the Foot

• Grouped by action
  – extensor hallucis longus
    • agnosts
      – Tibialis anterior
      – Extensor digitorum longus
      – Peroneus (fibularis) tertius
      • Extensor hallucis longus

Ankle Dorsiflexion

• Agonists
  – Tibialis anterior
  – Extensor digitorum longus
  – Peroneus (fibularis) tertius
  • Extensor hallucis longus
Ankle Plantar Flexion

- Agonists
  - Gastrocnemius
  - Soleus
    - Flexor digitorum longus
    - Flexor hallucis longus
    - Peroneus (fibularis) longus
    - Peroneus (fibularis) brevis
    - Plantaris
    - Tibialis posterior

Transverse Tarsal & Subtalar Inversion

- Agonists
  - Tibialis anterior
  - Tibialis posterior
    - Flexor digitorum longus
    - Flexor hallucis longus

Transverse Tarsal & Subtalar Eversion

- Agonists
  - Peroneus (fibularis) longus
  - Peroneus (fibularis) brevis
  - Peroneus (fibularis) tertius
  - Extensor digitorum longus

Toe Flexion

- Agonists
  - Flexor hallucis longus
  - Flexor digitorum longus
Toe Extension

- Agonists
  - Extensor hallucis longus
  - Extensor digitorum longus