Anatomy:
Muscles and Tendons

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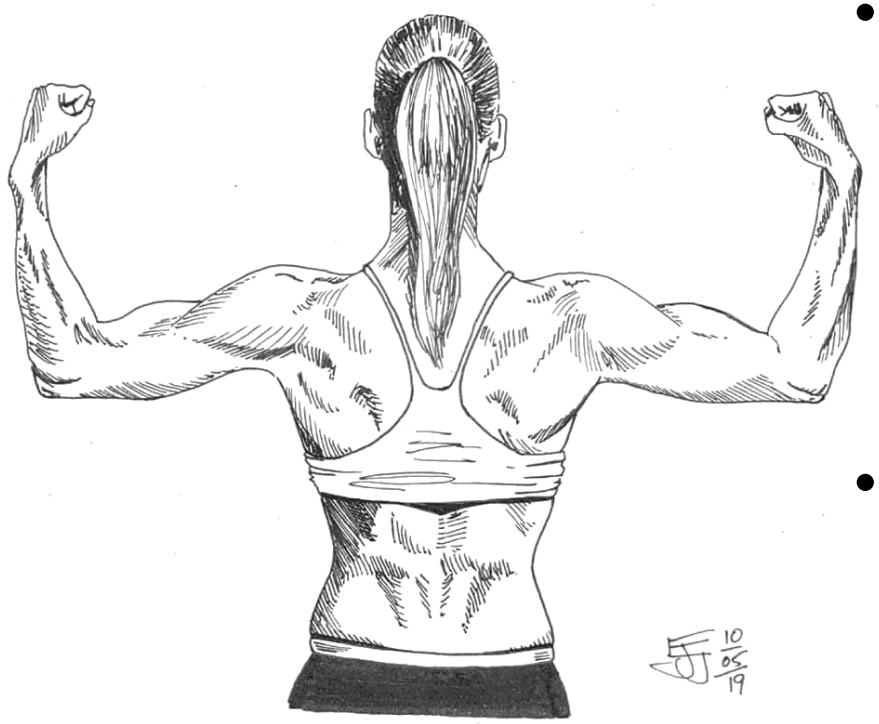
What is a Muscle?



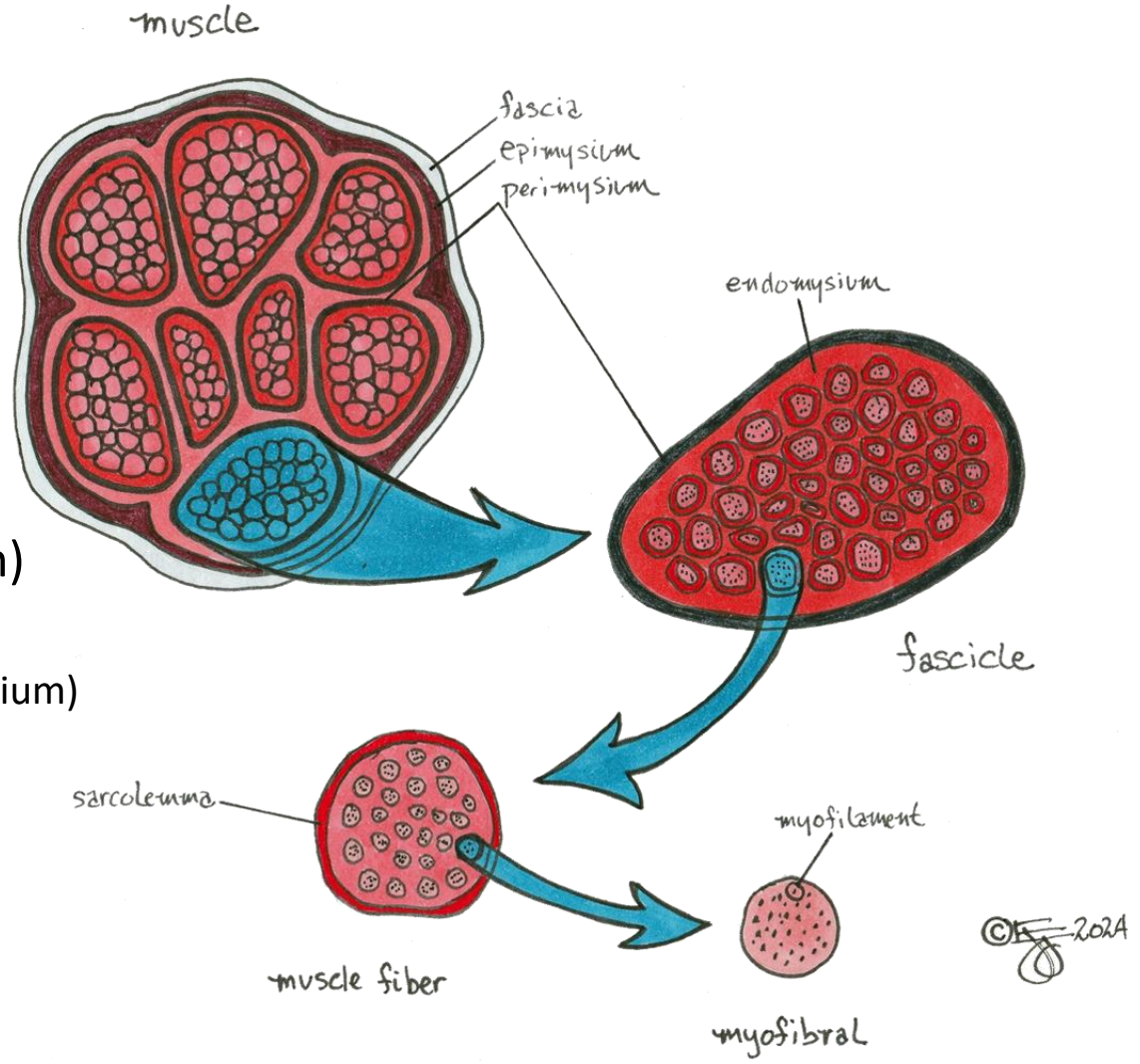
- There are about 600 muscles in the human body.
- Three main types of muscle are skeletal, smooth and cardiac.
  - Skeletal – what we think of as our “muscles”
  - Smooth – involuntary muscles found within our organs
  - Cardiac – specific to the heart
- The brain, nerves and skeletal muscles (collectively known as the *neuromuscular system*) work together to facilitate movement.

Muscles

- Each muscle is made up of thousands of elastic muscle fibers bundled tightly together into fasciculi. Every fasciculus (or fascicle) is wrapped in a perimysium (a thin transparent membrane). Individual muscle fibers within each fasciculi are surrounded by a tissue sheath called an endomysium. Inside the endomysium, the striated muscle fiber is surrounded by a cell membrane called the sarcolemma.
- The outermost connective tissue sheath surrounding the entire muscle is known as epimysium. Portions of the epimysium project inward to divide the muscle into multiple compartments filled with fasciculi. Finally, the entire muscle is wrapped in a fascia.
- An individual muscle fiber is made up of blocks of proteins called myofibrils, which contain the protein myoglobin and molecules to provide the oxygen and energy required for muscle contraction.
- A myofibril contains myofilaments (thick myofilaments called myosin and thin ones called actin) that fold together when given the signal to contract. This contraction shortens the length of the muscle fiber which, in turn, shortens (or “flexes”) the entire muscle if enough fibers are stimulated at the same time.

Muscle Structure

- Muscle (surrounded by epimysium and fascia)
  - Compartment (shaped by inward pointing epimysium)
    - Fasciculus (surrounded by perimysium)
      - Muscle fiber (surrounded by sarcolemma and endomysium)
        - Myofibrils
          - Myofilaments (myosin and actin)



Skeletal Muscles

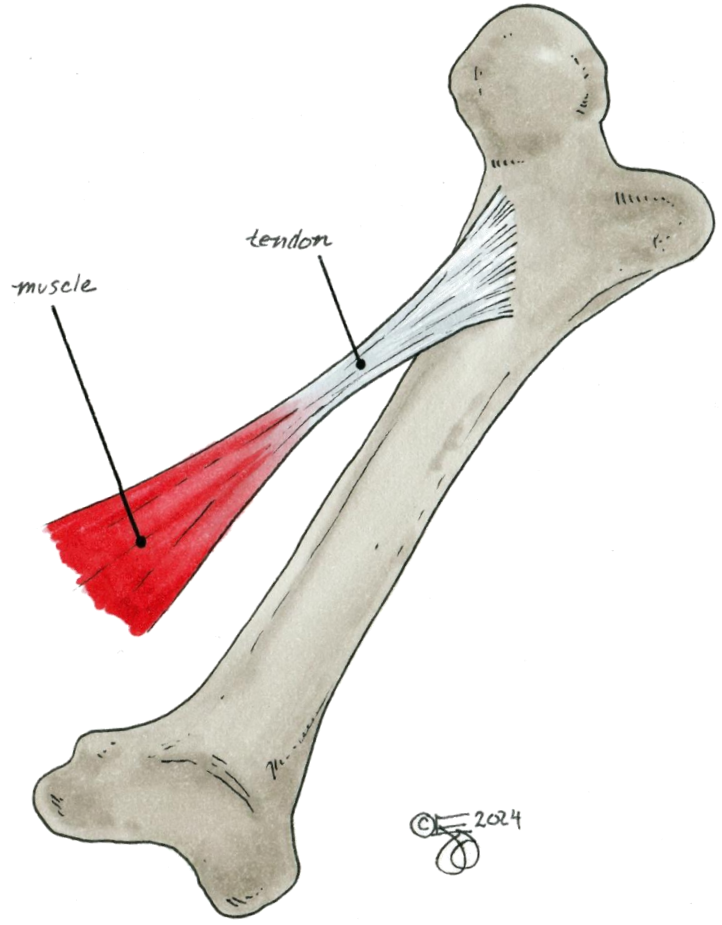
- Skeletal muscles are specialized soft tissue that is attached to bones (via the tendinous portion of the muscle) and allows movement.
- Skeletal muscles and bones make up the so-called *musculoskeletal system*.
- In addition to facilitating motion, skeletal muscle also provides structural support and helps in maintaining the posture of the body.
- In most cases, skeletal muscle is grouped into opposing pairs such as the quadriceps and the hamstring on the front and back of the thigh.
- Skeletal muscles – termed *voluntary* muscles - are under our conscious control.
- Skeletal muscles are also known as *striated* muscles, since the tissue looks striped when viewed under magnification.

Muscle Contractions

- Isometric - Muscular contraction against resistance in which the length of the muscle remains the same
- Isotonic - Muscular contraction against resistance in which the length of the muscle changes
  - Concentric - A *concentric* contraction causes muscles to shorten, thereby generating force
  - Eccentric – An *eccentric* contraction causes muscles to elongate in response to a greater opposing force
- Example: A *concentric* contraction is made during the upward motion of the pull up, which is usually the most difficult part, because you are pulling up your entire bodyweight. The *eccentric* contraction of a pull up is the portion when you are slowly lowering your body back to the ground. Some people might not be able to do the concentric pull up, but if one can jump up to the top of a pull up or use a box to get there, most people will be able to slowly lower themselves down.

What is a Tendon?

- In many places in the body, muscle connects directly to a bone or structure. In places where this isn't possible, the muscle and bone are connected by a tendon. The tendon acts as a bridge and transfers the movement of the muscle to the bone.
- Tendons are made of connective tissue that has a lot of strong collagen fibers in it.
- Tendons are quite resistant to tearing, but not very stretchy.
- Compared to muscles, they have fewer blood vessels in them and, as such, are prone to injury when overstrained and take a lot longer to heal than other types of tissue in the body.
- Some tendons run through narrow tunnels made of bones and ligaments, and some are stretched over bumpy parts of bones. In these places, the tendons are often protected by layers of connective tissue known as *tendon sheaths*. Tendon sheaths are filled a lubricant called synovial fluid (or synovium) which helps the tendons to slide smoothly and freely within the sheaths.



Strain or Sprain?

- **Strains** are injuries to the *muscles or tendons*. Strains occur as a result of a sudden tear, twist, or pull of the muscle. Strains are a type of acute injury caused by overstretching or over-contracting. After a strain, common symptoms include pain, weakness, and muscle spasms. Muscle cramps and loss of motion are common with a strain. Limited motion and inflexibility can further affect a strained joint.

- **Sprains** are injuries to the *ligaments*. Sprains occur as a result of a ligament stretch or tear. Sprains are a type of acute injury caused by trauma such as a fall or an external force that displaces the surrounding joint from its normal alignment. Sprains range in severity from a minor ligamentous stretch to a complete tear. Bruising, swelling, instability, and painful movement are all common symptoms of a sprain.

- Sprains and strains are equally bad. Strains affect the tendons, while sprains affect the ligaments. Tendons and ligaments are both connective tissues that are graded in severity. Therefore, you can have a mild sprain or a severe strain, or vice versa.

- Both sprains and strains are graded, with grade one being the least severe and grade three being the worst.
  - Grade I indicates the structure has been overstretched
  - Grade II refers to a partial tear
  - Grade III describes a complete tear

Tendinopathy Vs. Tendinitis

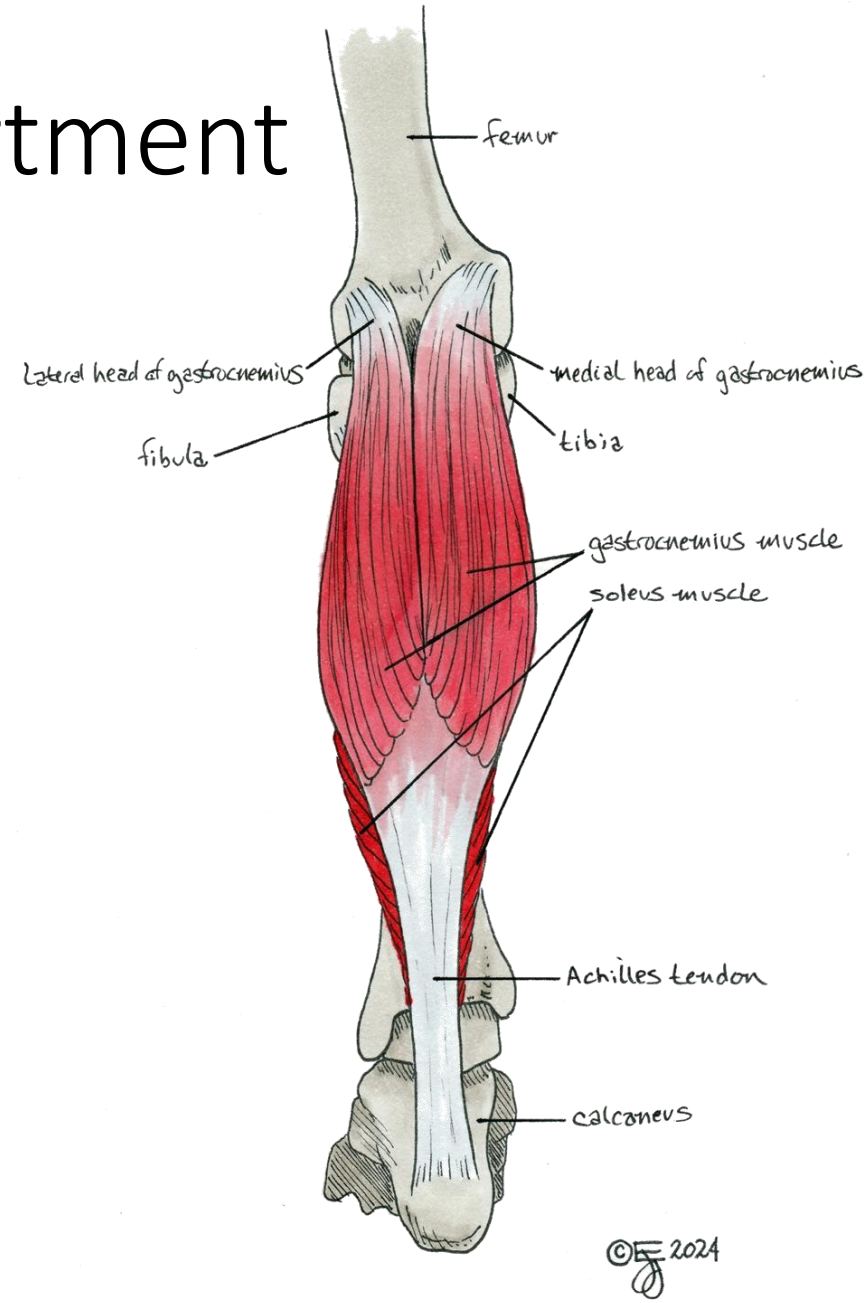
- Tendinitis - is the inflammation of the tendon and results from micro-tears that happen when the musculotendinous unit is acutely overloaded with a tensile force that is too heavy and/or too sudden. The healing time for tendinitis is several days to 6 weeks, depending on whether treatment starts with early presentation or chronic presentation.
- Tendinosis (tendinopathy) - is a degeneration of the tendon's collagen in response to chronic overuse; when overuse is continued without giving the tendon time to heal and rest, such as with repetitive strain injury, tendinosis results. Healing time for tendinosis recognized at an early stage can be as brief as 6–10 weeks; however, treatment once the tendinosis has become chronic can take 3–9 months.
- Traditional thinking is that tendinitis is the precursor to tendinosis. The tendinitis instigates a healing process that changes the collagen and weakens the tendon, advancing to tendinosis. This assumption may exist because the stages of soft-tissue healing are typically listed as: inflammation response, regeneration (collagen production), and remodeling (strengthening of the collagen in the direction of the forces placed upon it).
- However, the suggestion that tendinitis precedes tendinosis is inconsistent with the fact that a healthy tendon is up to two times as strong as the muscle, making the tendon quite unlikely to tear before the muscle…unless the tendon has already been weakened by degenerative changes
- They are, in fact, two different conditions. The most prominent treatment goal for tendinitis is to reduce inflammation, a condition that isn't present in tendinosis.
- Tenosynovitis - is tendinitis with inflammation of the tendon sheath lining. Symptoms usually include pain with motion and tenderness with palpation. Chronic deterioration or inflammation of the tendon or tendon sheath can cause scars that restrict motion.

Locations of Muscles

- Broadly speaking…
  - Plantar flexors – Posterior calf/ankle
  - Dorsiflexors – Anterior calf/dorsum of foot
  - Invertors – Medial calf/ankle
  - Evertors – Lateral calf/ankle

Superficial Posterior Compartment

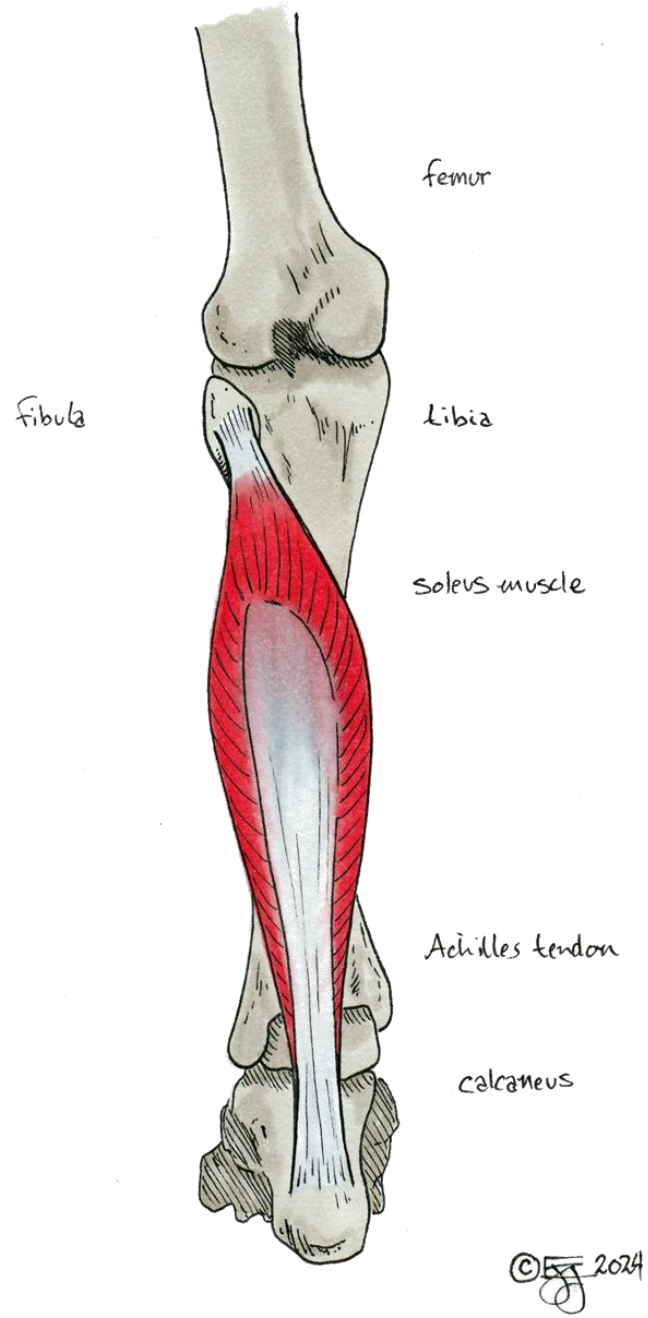
- The Achilles tendon is formed by the *tripceps surae* – a composite muscle made up of the two-headed gastrocnemius muscle and the soleus muscle.
- The Achilles tendon is the thickest, strongest tendon in the body.
- The triceps surae is provides nearly all (approx. 93%) of the force available for ankle plantarflexion. The gastroc-soleus-Achilles complex is also responsible for the control and decelaration of dorsiflexion at the ankle.
- The Achilles can stretch by 4% of it's length; any more than that will tear it. A stretch of 8% will cause a complete rupture.



Soleus

- Proximal attachment: Soleal line, posterior surface of tibia and posterior aspect of fibular head
- Distal attachment: Calvaneus via Achilles tendon
- Action: Plantarflexion of the ankle joint

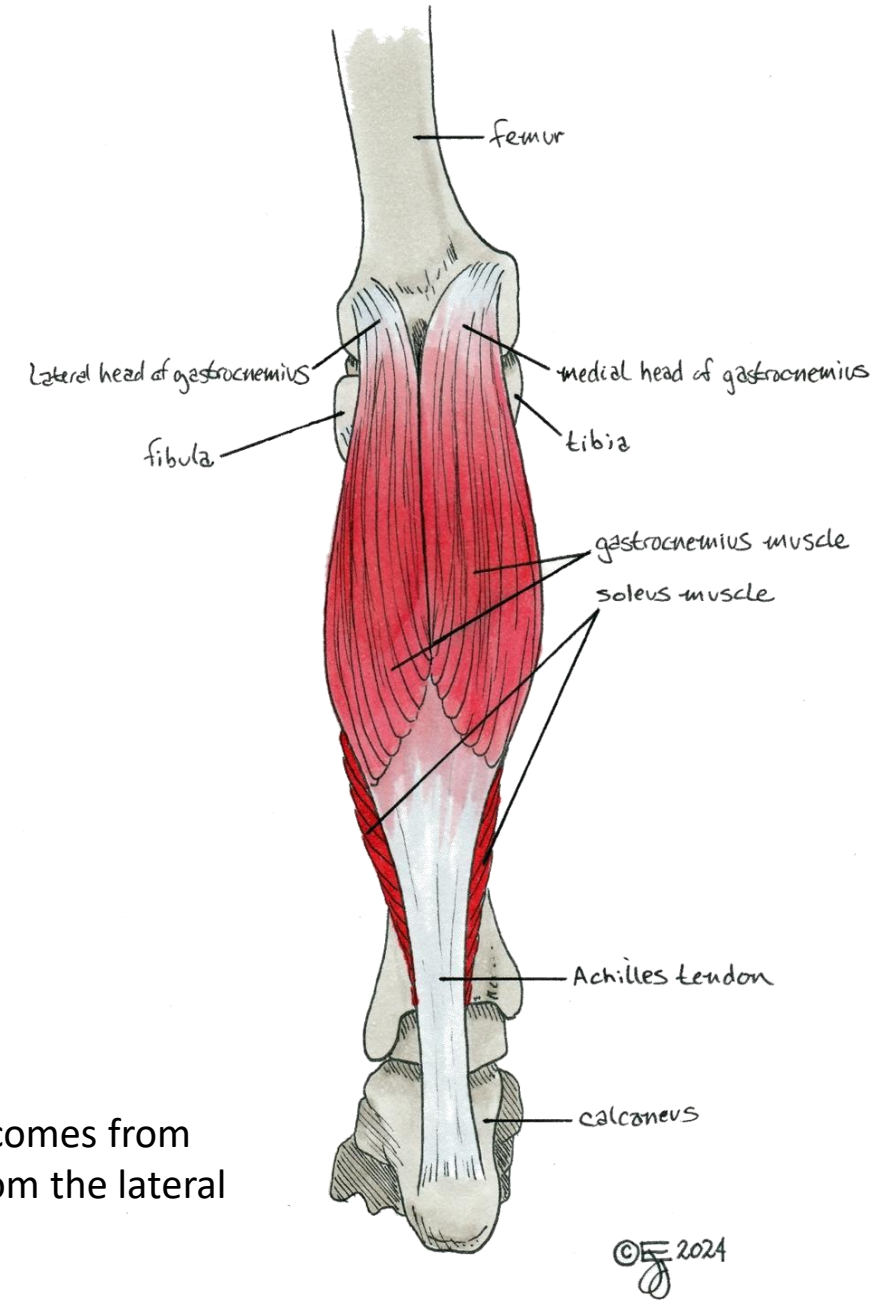
- Lies “under” the gastrocnemius



Gastrocnemius

- Proximal attachment: Posterior surfaces of the femoral condyles
- Distal attachment: Calcaneus via Achilles tendon
- Action: Plantarflexion of the ankle joint

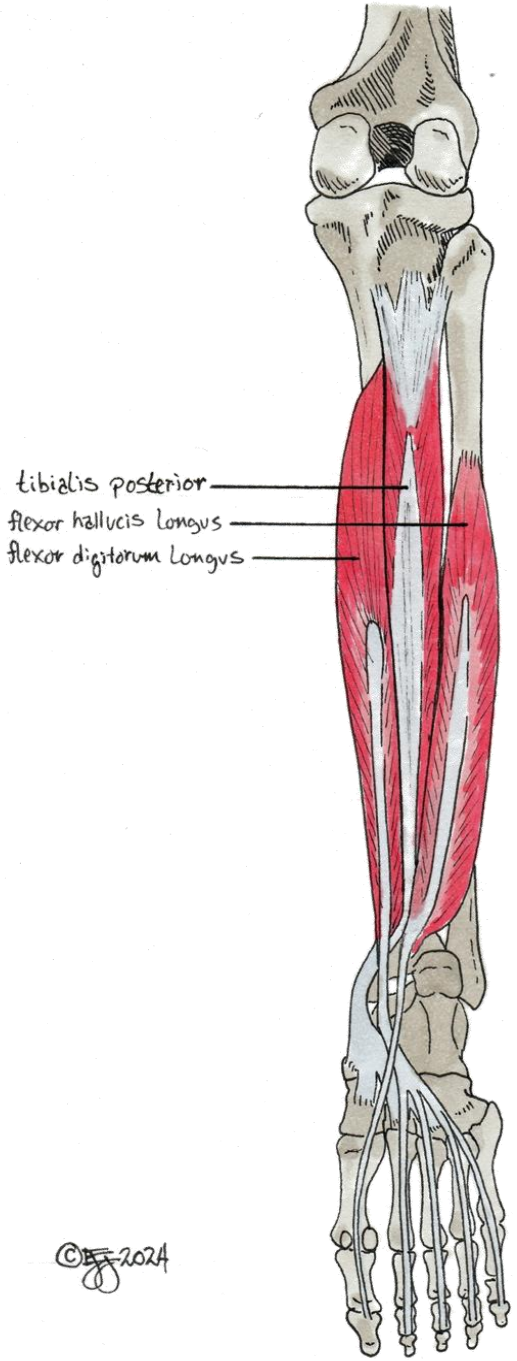
- Lies “over” the soleus



Note – There is also a weak (and often overlooked) ankle plantarflexor muscle that comes from the posterior femur and joins into the Achilles called the *plantaris* muscle. It runs from the lateral supracondylar line of the femur and joins the Achilles on the tendon’s medial side.

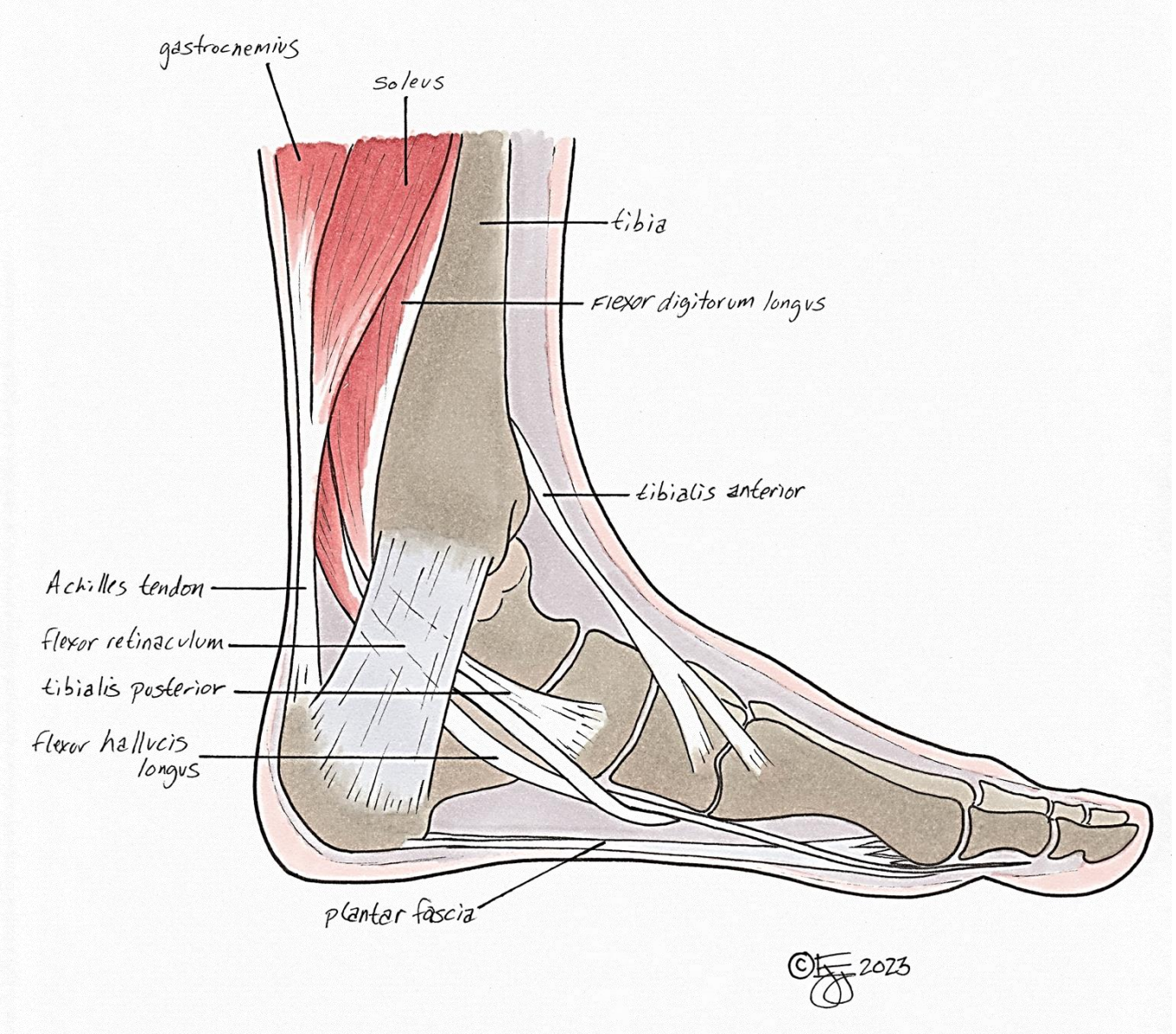
Deep Posterior Compartment

- Flexor Digitorum Longus
  - Proximal attachment: Middle, posterior surface of tibia
  - Distal attachment: Distal phalanges of 2nd through 5th toes
  - Action: Flexion of toes, weak plantarflexion and inversion
- Flexor Hallucis Longus:
  - Proximal attachment: Middle half of posterior fibula
  - Distal attachment: Distal phalanx of 1st toe
  - Action: Flexion of 1st toe, weak plantarflexion and inversion
- Tibialis Posterior
  - Proximal attachment: Proximal, posterior shafts of tibia and fibula, interosseus membrane
  - Distal attachment: Plantar surface of navicular, all three cuneiforms, cuboid, bases of 2nd through 5th metatarsals



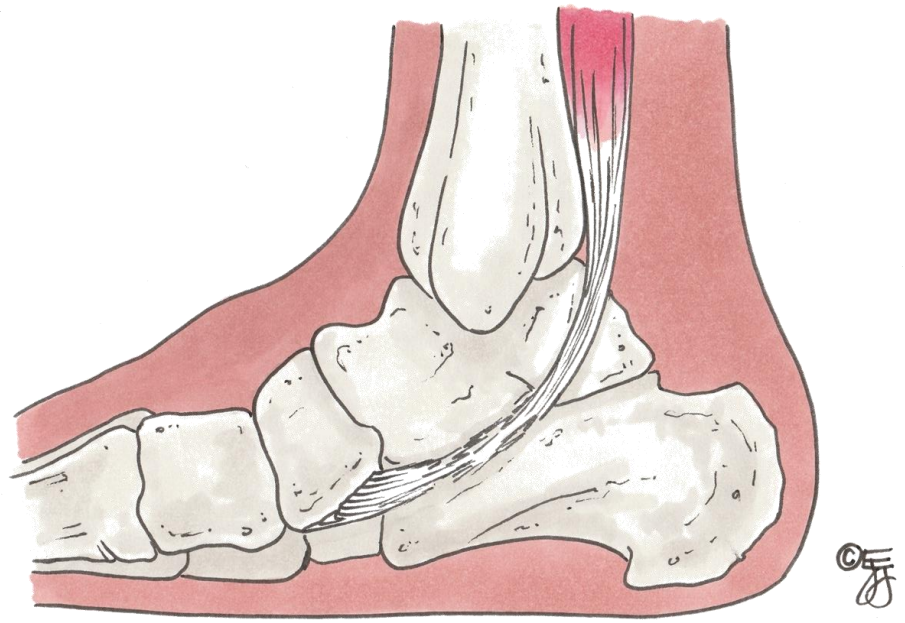
Tibialis Posterior

- Action: Generally speaking, plantarflexion and inversion
- Tibialis posterior is a biphasic muscle/tendon.
  - Swing phase, fires to position foot in supination at heel strike. Relaxes immediately thereafter.
  - Stance phase, fires again as body mass passes over dorsum of foot to, in effect, create a rigid lever arm of the first ray to effect toe off.
- Tibialis posterior tendon is also frequently described as “maintaining the medial longitudinal arch”. While this is technically accurate, it is a gross oversimplification and a mischaracterization to blame adult acquired flatfoot solely on PTT dysfunction.



A word on posterior tibial tendon dysfunction…

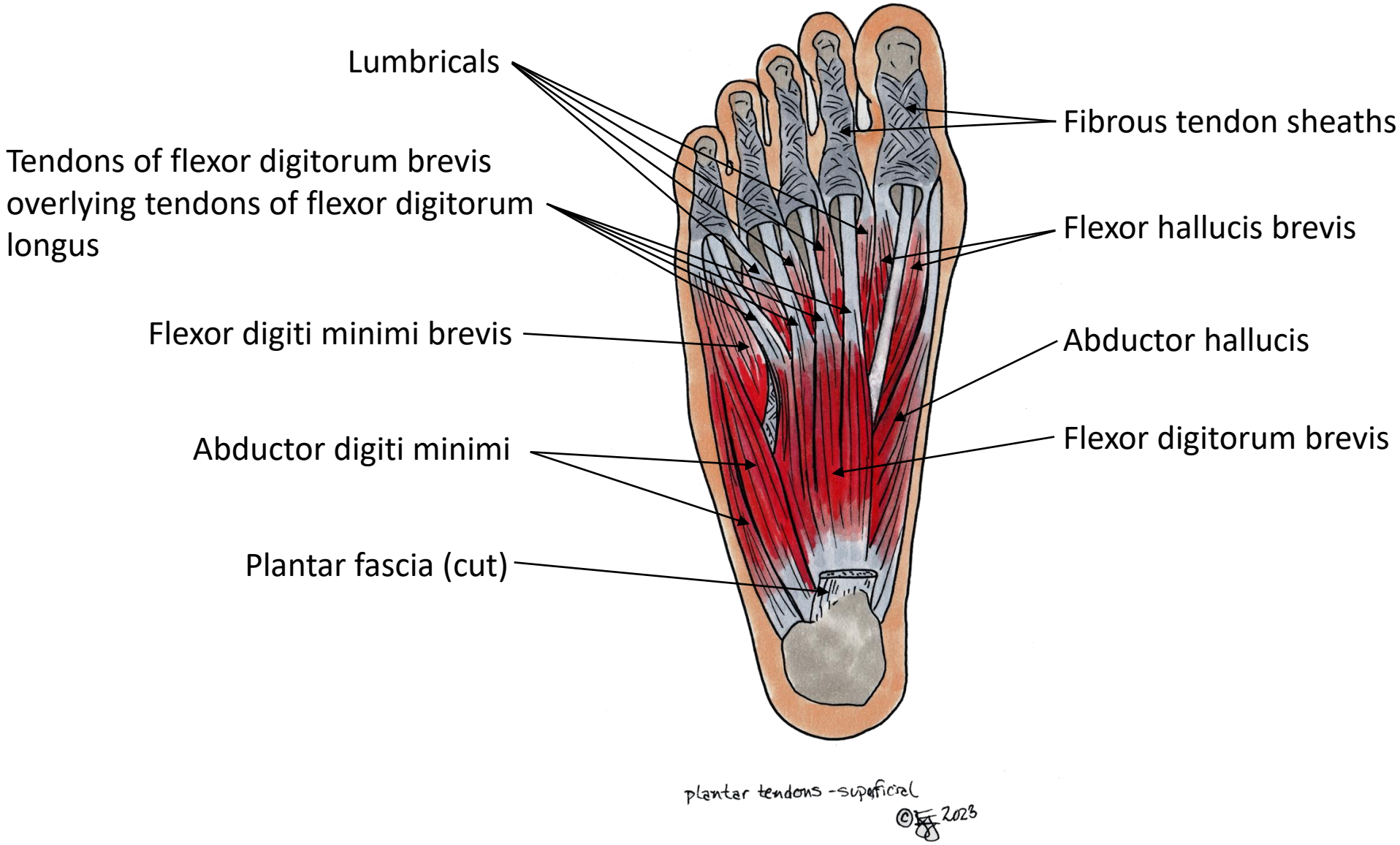
- Does PTTD really cause AAFD?
- Yes and no…
- It does, but not all by itself.
- AAFD is caused by a cascade of events that may begin with PTTD but…
- **The terms are *not* interchangeable!**
- Since 1999, it has been referred to as AAFD as the function or dysfunction of the PPT alone cannot account for the character and severity of the deformity/disability.



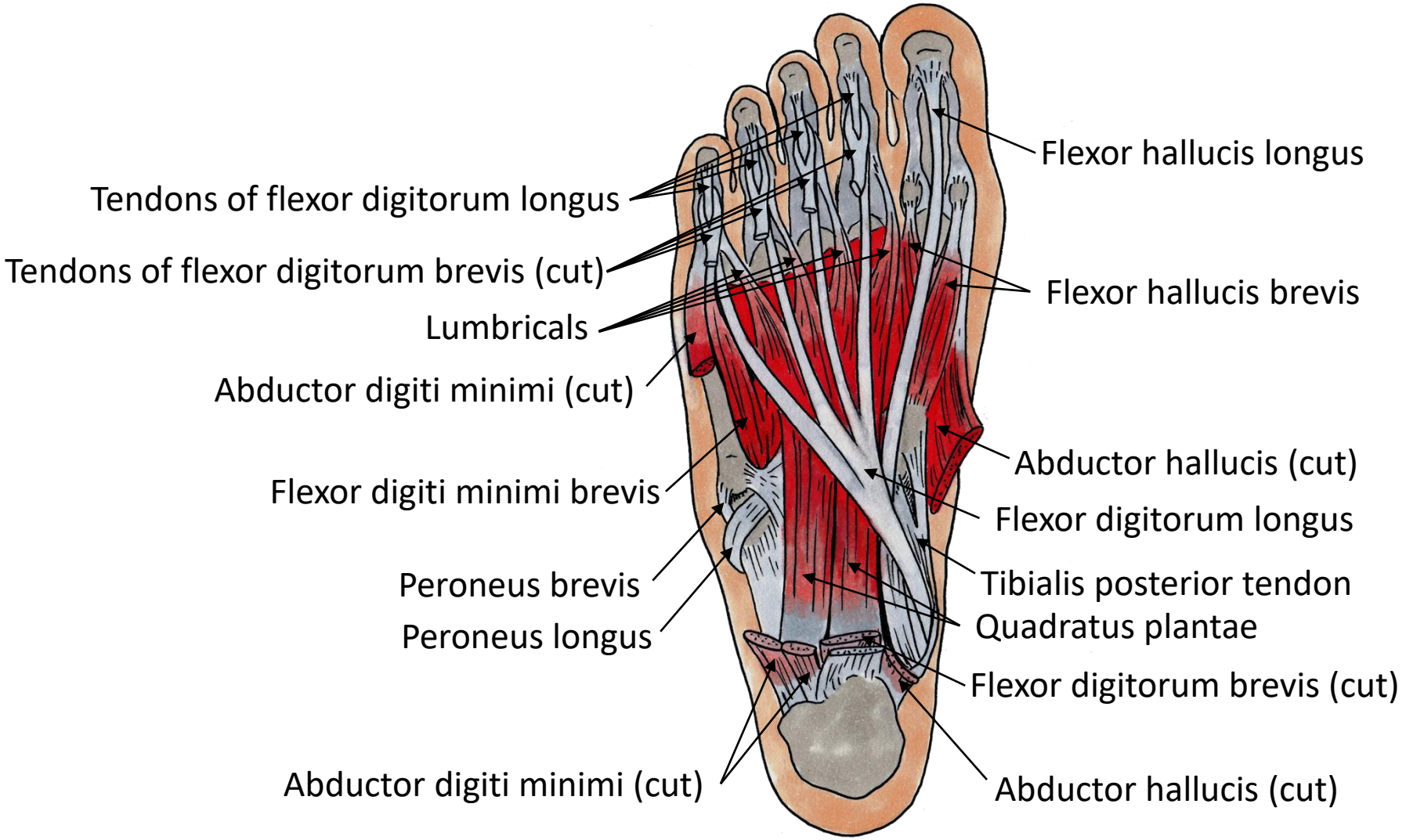
How does AAFD happen?

- Posterior tibial tendon stretches and weakens and…
- Plantar fascia weakens, and
- Spring ligament fails, and
- Talonavicular joint capsule fails, and
- Deltoid ligament weakens and fails, and
- Talocalcaneal interosseus ligament fails, and
- Dorsolateral peritalar subluxation.

Plantar Foot Tendon Anatomy - Superficial

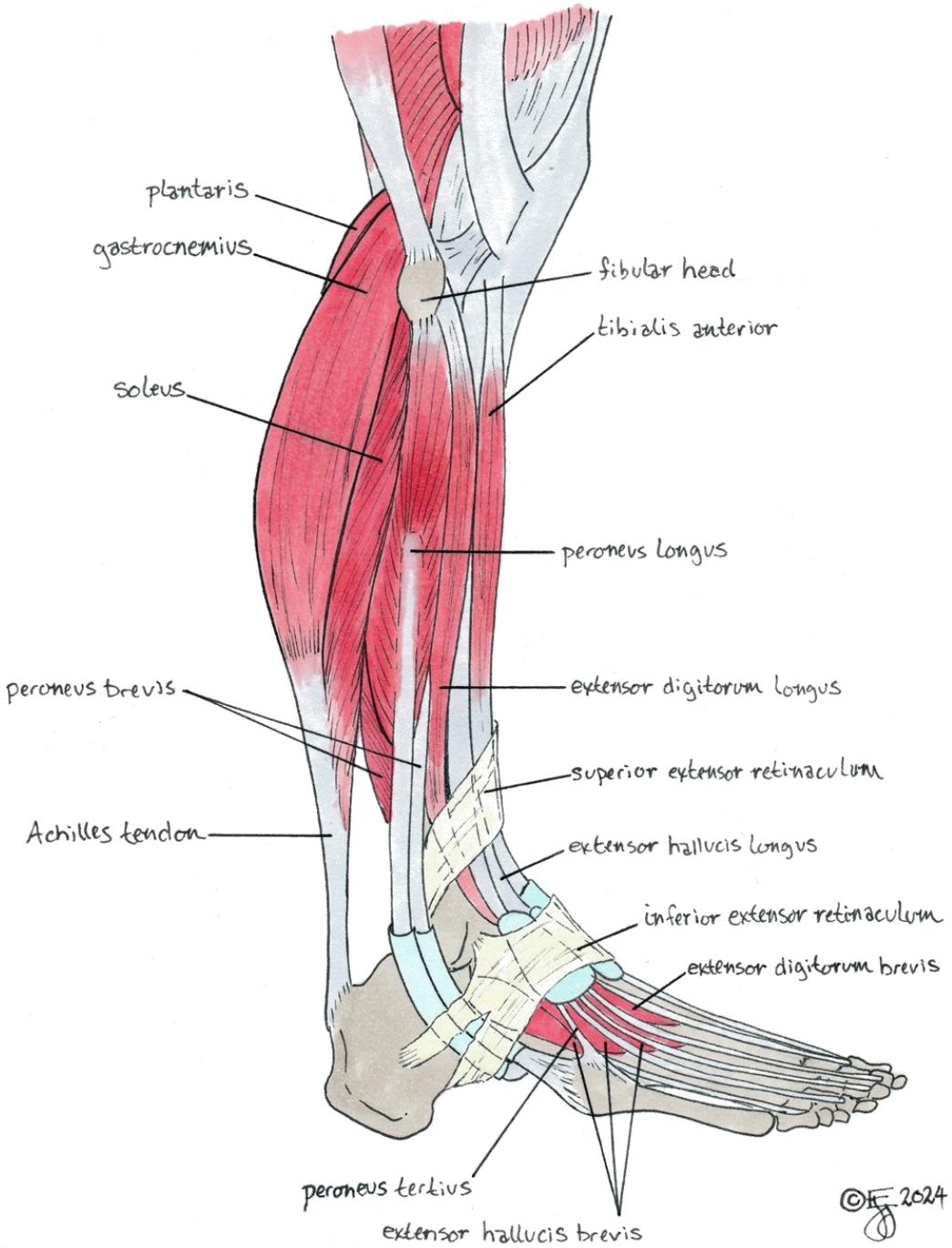


Plantar Foot Tendon Anatomy - Deep



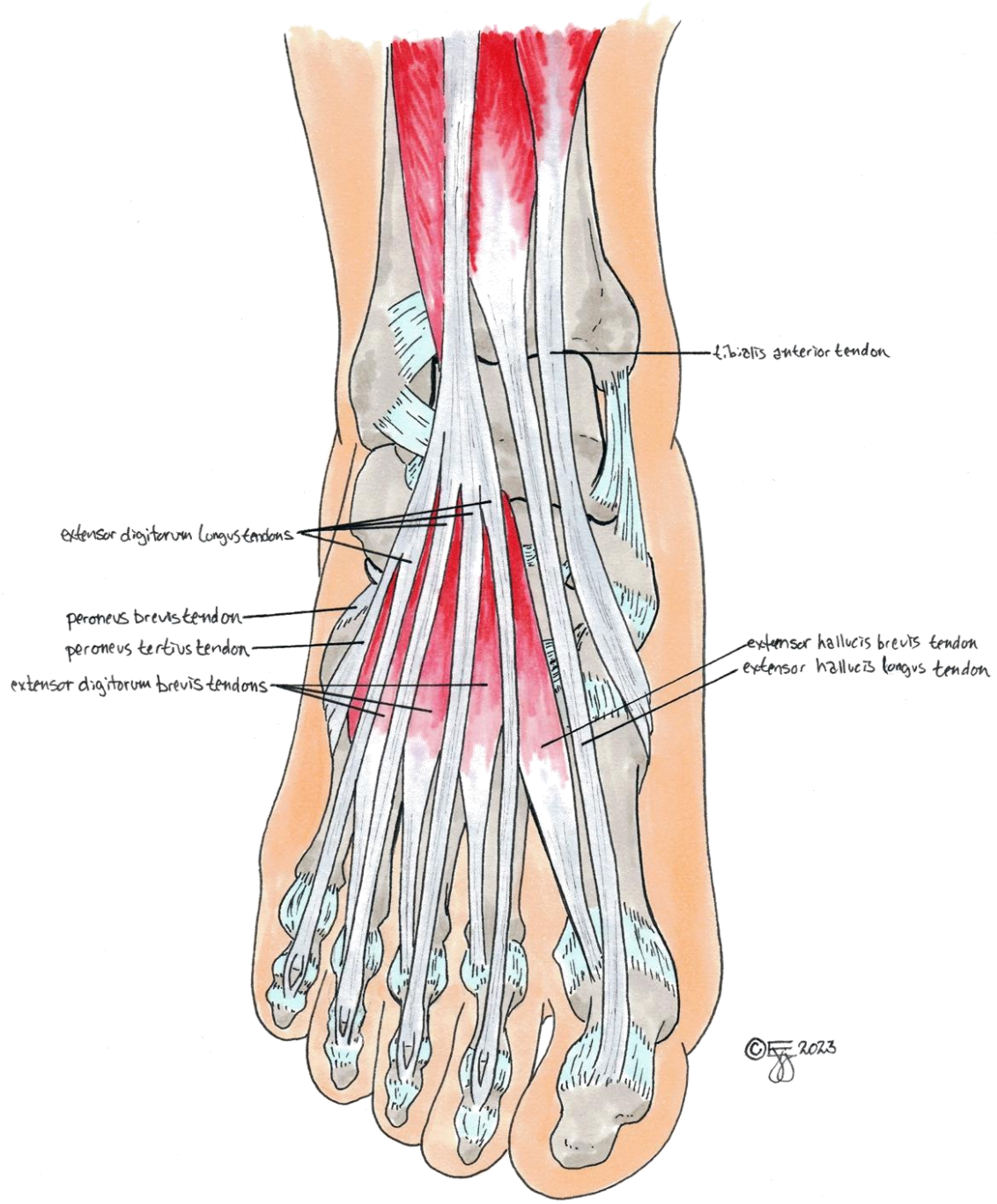
Lateral Compartment

- Peroneus (Fibularis) Longus
  - Proximal attachment: Fibular head and proximal 2/3 of fibula
  - Distal attachment: Base of 1st metatarsal and medial cuneiform
  - Action: Eversion of STJ and plantarflexion
- Peroneus (Fibularis) Brevis
  - Proximal attachment: Distal 2/3 of fibula
  - Distal attachment: Styloid process of 5th metatarsal
  - Action: Eversion of STJ and plantarflexion
- Peroneus (Fibularis) Tertius and Quartus
  - Present in approx. 8% of population
- The peroneal tendons provide lateral ankle stability during ambulation



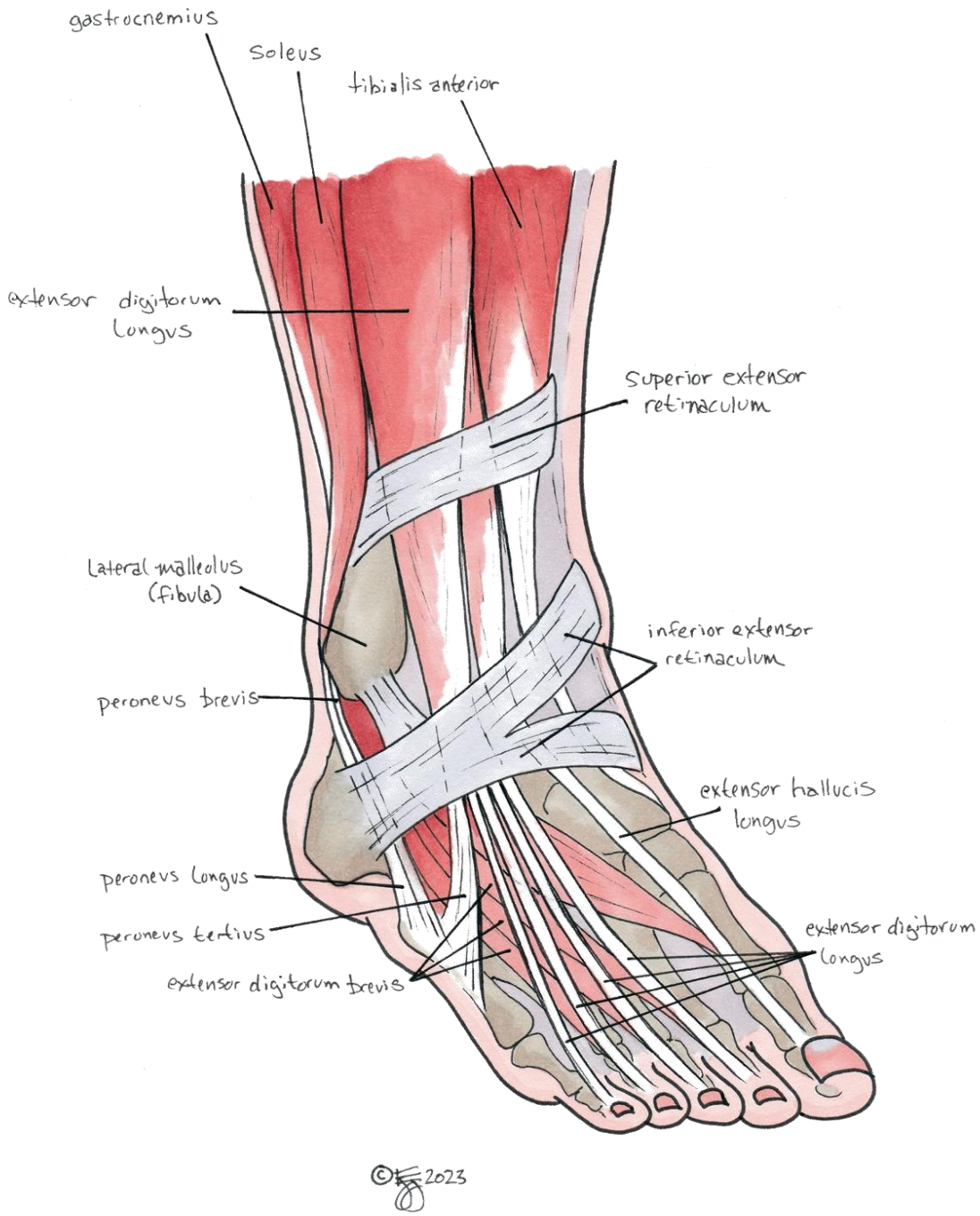
Anterior Compartment

- Tibialis Anterior
  - Proximal attachment: Lateral condyle of tibia, anterior shaft of fibula, interosseus membrane
  - Distal attachment: Medial cuneiform, base of 1st metatarsal
  - Action: Dorsiflexion of ankle, inversion of STJ



Anterior Compartment

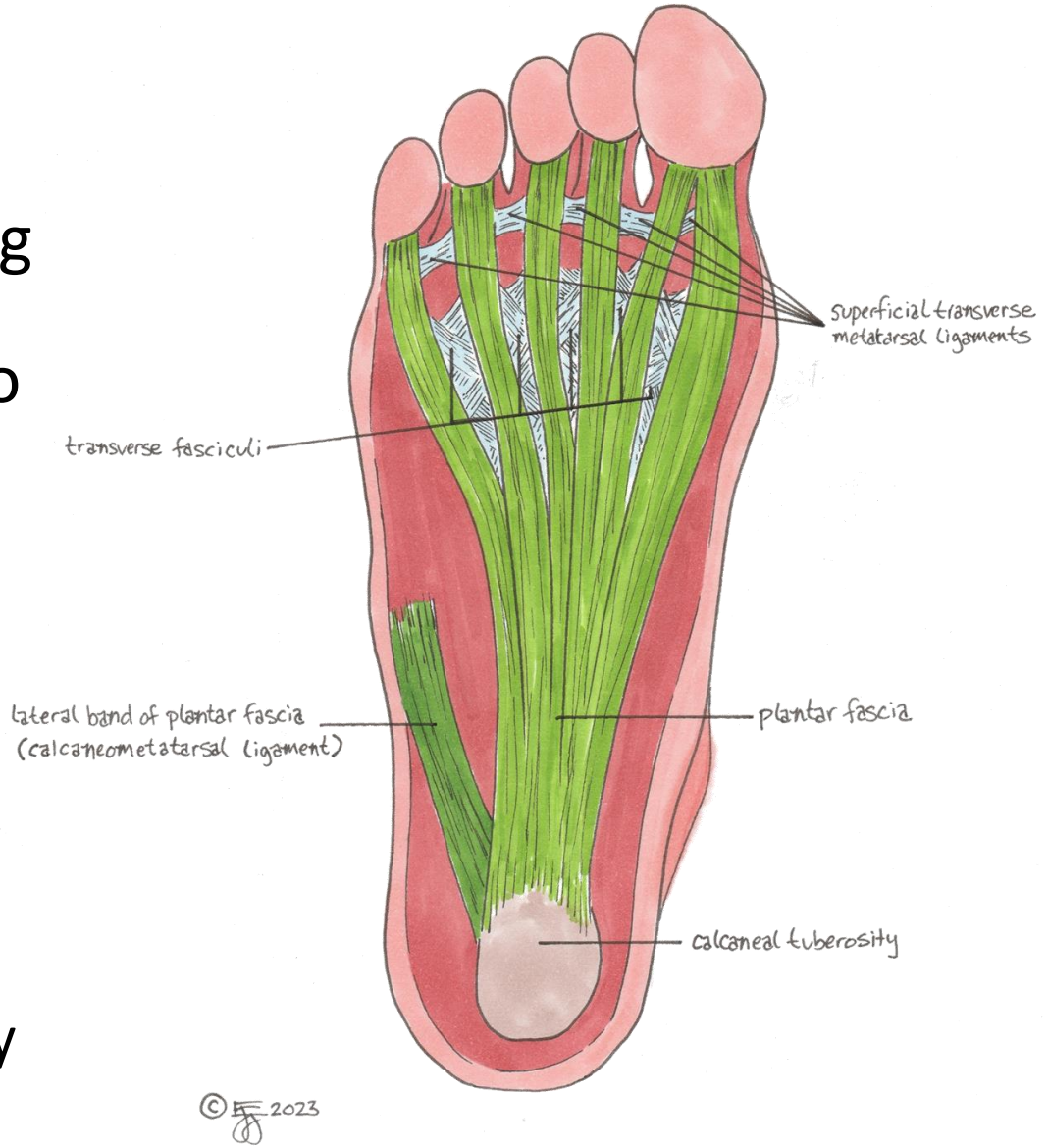
- Extensor Digitorum Longus
  - Proximal attachment: Lateral condyle of tibia, proximal anterior shaft of fibula, interosseus membrane
  - Distal attachment: Middle and distal phalanges of 2nd through 5th toes
  - Action: Extension of toes, dorsiflexion, eversion
- Extensor Hallucis Longus
  - Proximal attachment: Middle anterior surface of fibula, interosseus membrane
  - Distal attachment: Distal phalanx of 1st toe
  - Action: Extension of 1st toe, dorsiflexion, inversion



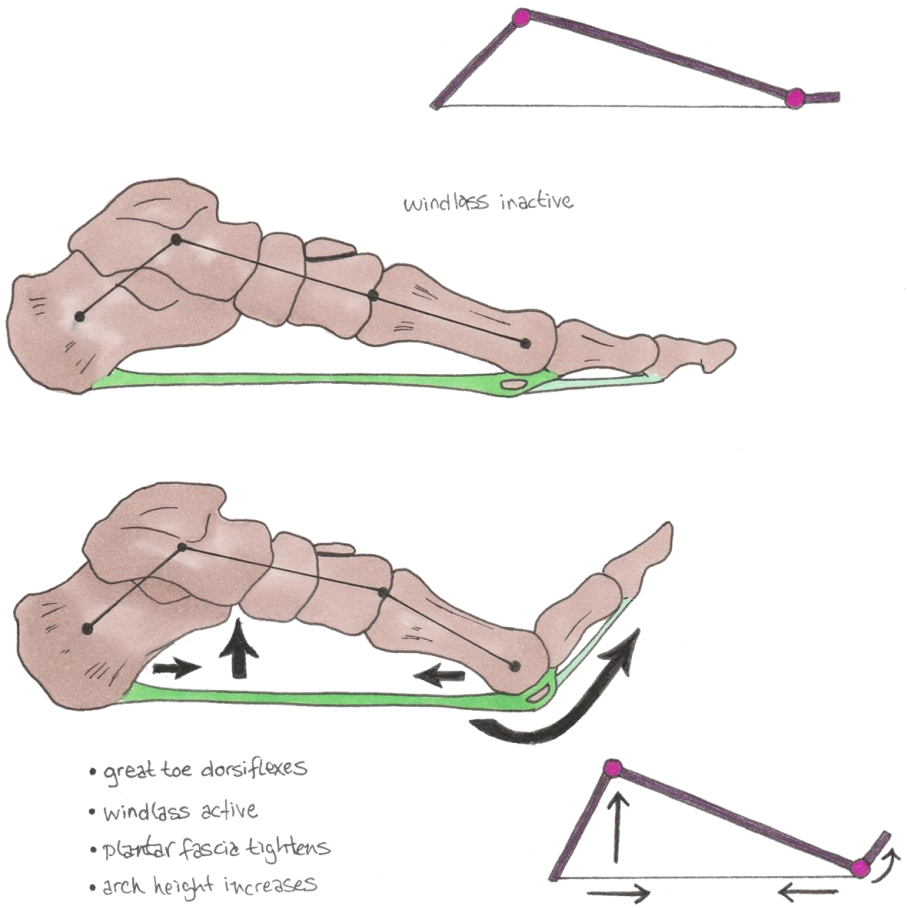
Not a tendon, but still important…

Plantar Fascia

- The plantar fascia is a very thick, strong band of connective tissue (fascia) that covers the bottom of the foot. It is also called the *plantar aponeurosis*.
  - Proximal attachment: Medial tubercle of the calcaneus
  - Distal attachment: Inserts into the deep transverse ligaments of the metatarsal heads
  - Action: Utilizing its inherent tensile strength, it prevents the collapse of the arch of the foot upon vertical load transmission from the weight of the body



Plantar Fascia



- The action of the plantar fascia is often described using the mechanical model known as a *windlass mechanism*.
- The term "windlass" refers to the tightening of a rope or cable. The plantar fascia forms the supportive truss, with its corresponding arch consisting of the calcaneus, transverse tarsal joint, and the metatarsals (aka the medial longitudinal arch).
- As the ankle dorsiflexes in preparation for the "toe-off" phase of the gait cycle, this “winds” the plantar fascia around the head of the metatarsal to further tighten the fascia and prevents an increase in the distance between the calcaneus and metatarsals (from-front-to-back), which minimizes collapse of the arch.

Plantar Fascia

- When the plantar fascia becomes inflamed, this is a condition known as *plantar fasciitis*.
- Plantar fasciitis has many causes and is a very common foot condition.
- Pain is most often felt in the plantar medial heel, where the fascia inserts into the calcaneal tubercle.

Summary

- Skeletal muscles facilitate motion and provide postural stability
- Tendons attach muscles to bones
- Strains are tendonous injuries, while sprains are ligamentous injuries
- Tendinitis and tendinosis are not interchangeable terms
- Loss of PTT function - while indeed problematic - is not the sole cause of an acquired flatfoot deformity
- Achilles tendon is the strongest tendon in the human body

The End