Evaluation/Intervention for Common Conditions of the Foot and Ankle

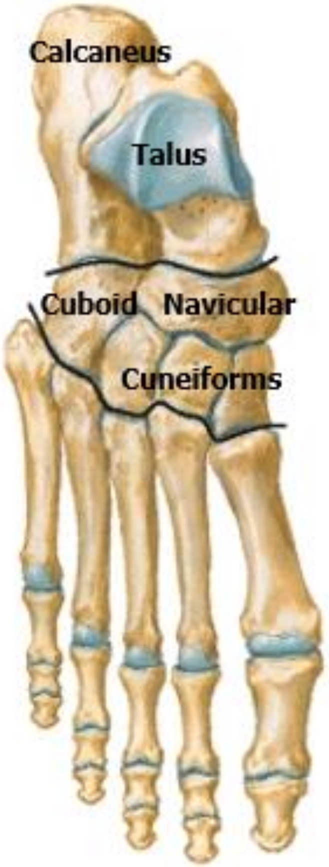
BY: CONNER HEERMANN

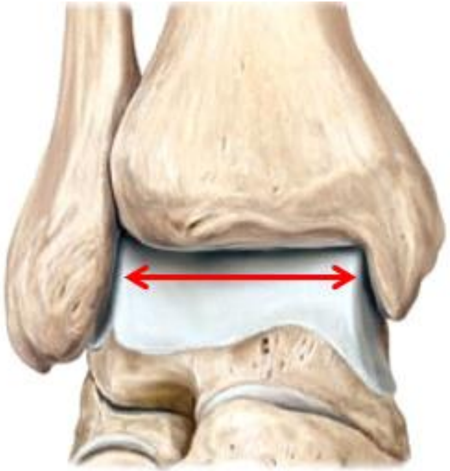
Objectives

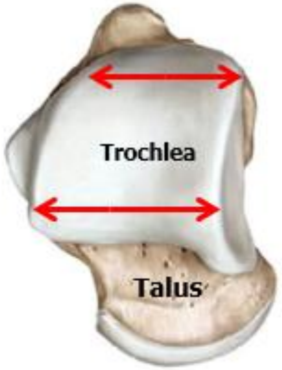
1) Review pertinent anatomy and biomechanics of the foot/ankle.
2) Consider implications of foot/ankle anatomy on structures up the kinetic chain.
3) Review biomechanics of the foot/ankle during gait.
4) Define and discuss "drivers" of musculoskeletal pathology at the foot/ankle.
5) Consider evaluation strategies of the foot and ankle.
6) Review important components of the lower quarter screen.
7) Develop a framework for understanding the "optimal foot" and the role of footwear and orthoses in achieving it.
8) Discuss anatomical/biomechanical features, clinical presentation, potential drivers, and PT intervention for 5 common pathologies of the foot/ankle: plantar fasciitis, midfoot OA, hallux rigidus, ankle mortise OA, and insertional/mid-substance Achilles tendinopathy.

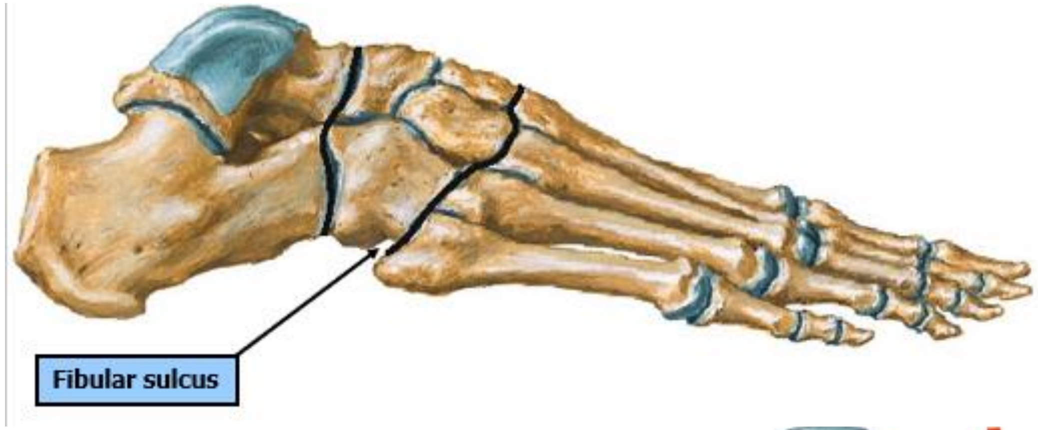
Introduction

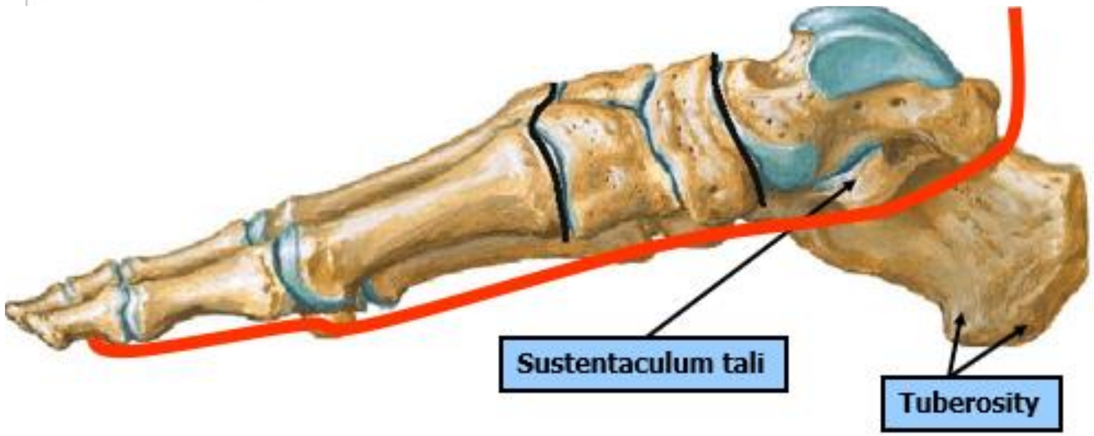
Anatomy of the Foot and Ankle











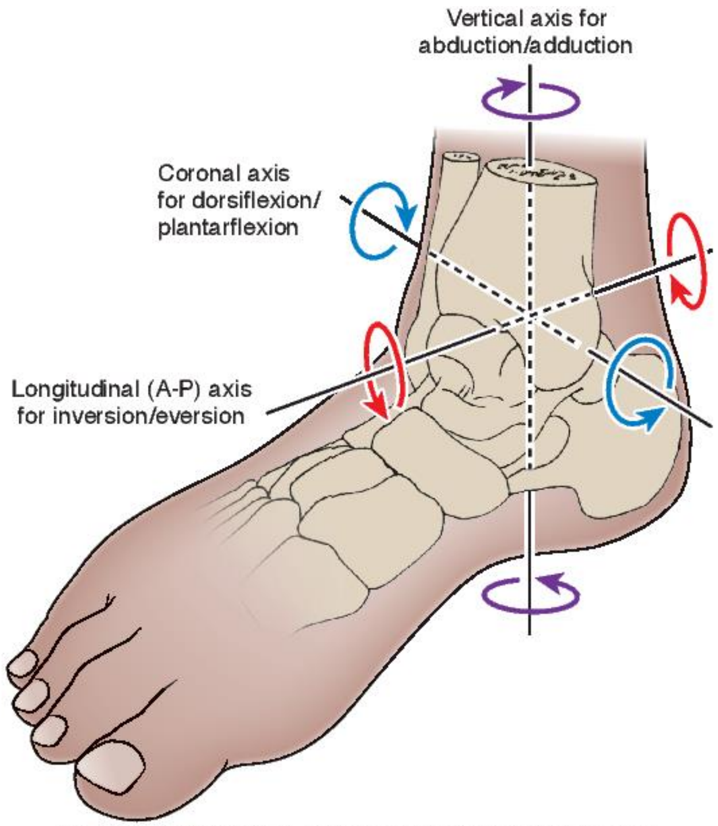
Foot/Ankle Biomechanics

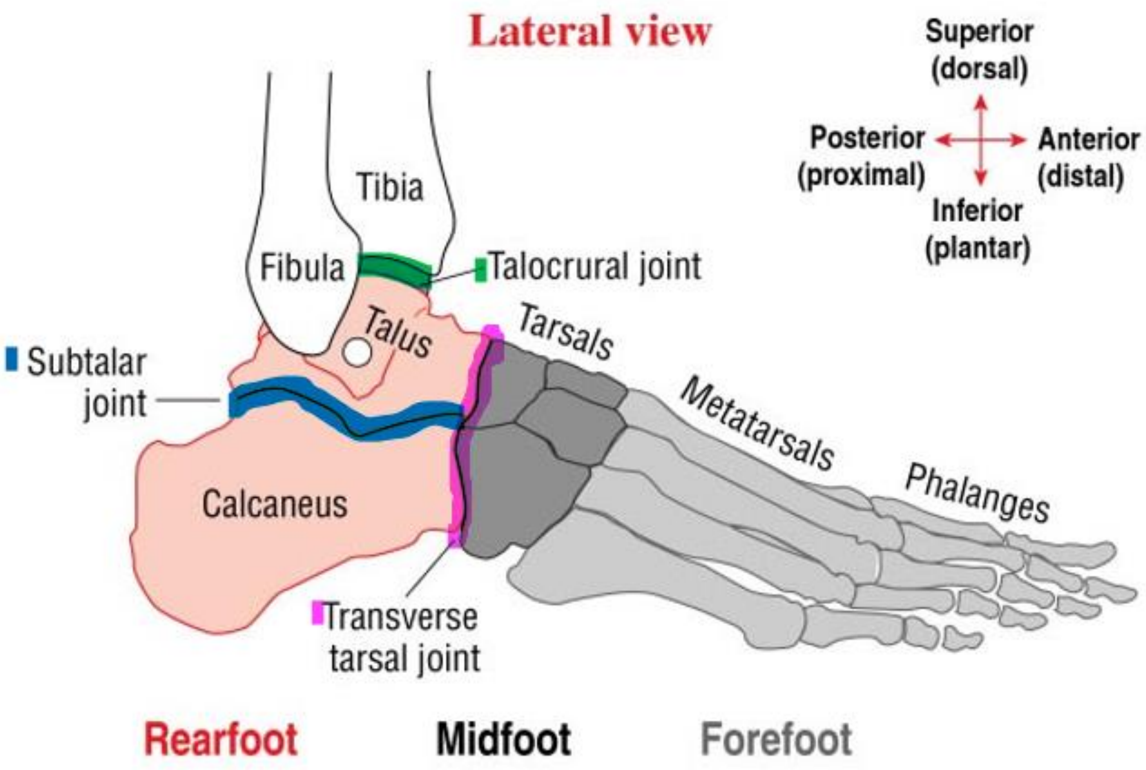
Triplanar Motion: pronation and supination have an oblique axis that incorporates movement elements in *multiple planes* from *multiple joints*

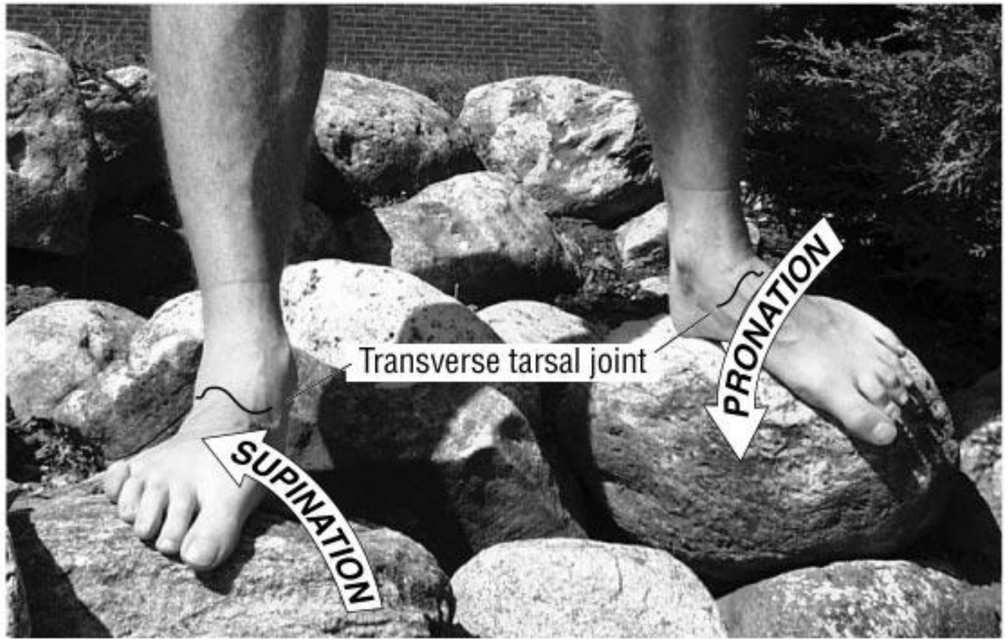
- **Pronation** – eversion, abduction, dorsiflexion
- **Supination** – inversion, adduction, plantar flexion

Each joint in the foot and ankle is designed to do business in one or more of these 3 planes. When they all work together properly, the foot and ankle unit is a structural miracle for stability with propulsion, shock absorption, and mobile adaptation to environmental challenges. When one or more joints aren't pulling their weight and compensatory measures are either exhausted or unavailable, problems arise.

- Talocrural – **PF/DF**
- Subtalar – 1) **INV/EV**, 2) ABD/ADD, 3) PF/DF
- Transverse Tarsal – 1) INV/EV, 2) ABD/ADD, 3) PF/DF
- Midfoot – should not move; keystone wedging with truss support to achieve rigid foot




Lateral view
Superior (dorsal)
Posterior (proximal)
Anterior (distal)
Inferior (plantar)
Tibia
Fibula
Talocrural joint
Talus
Tarsals
Subtalar joint
Metatarsals
Phalanges
Calcaneus
Transverse tarsal joint
Rearfoot
Midfoot
Forefoot

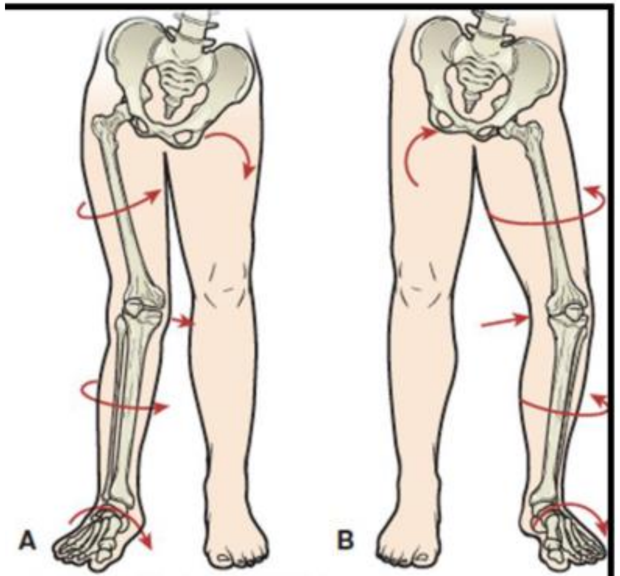

Transverse tarsal joint
PRONATION
SUPINATION

Considerations Up the Chain…

- Just as anatomical deviations in pelvic, hip, knee, or long bone structure can drive foot/ankle structure and pathology, foot/ankle anatomy and biomechanics can drive structural anatomy and pathology up the kinetic chain – Sub-Talar joint neutral considered "optimal"

Pronated foot in the closed chain MAY drive one or more of the following:

- Calcaneal eversion
- Adduction and PF of the talus
- Medial rotation of the talus
- Medial rotation of the tibia/fibula
- Valgus at the knee
- Medial rotation of the femur
- Anterior tilting of the pelvis



Source: Peggy A. Houglum, Dolores B. Bertoti: Brunnstrom's Clinical Kinesiology, Sixth Edition

Supinated foot in the closed chain MAY drive one or more of the following:

- Calcaneal inversion
- Abduction and dorsiflexion of the talus
- Lateral rotation of the talus
- Lateral rotation of the tibia and fibula
- Varus at the knee
- Lateral rotation of the femur
- Posterior tilting of the pelvis

Brainstorm: what are implications for pathology with alteration of position of bony anatomy?

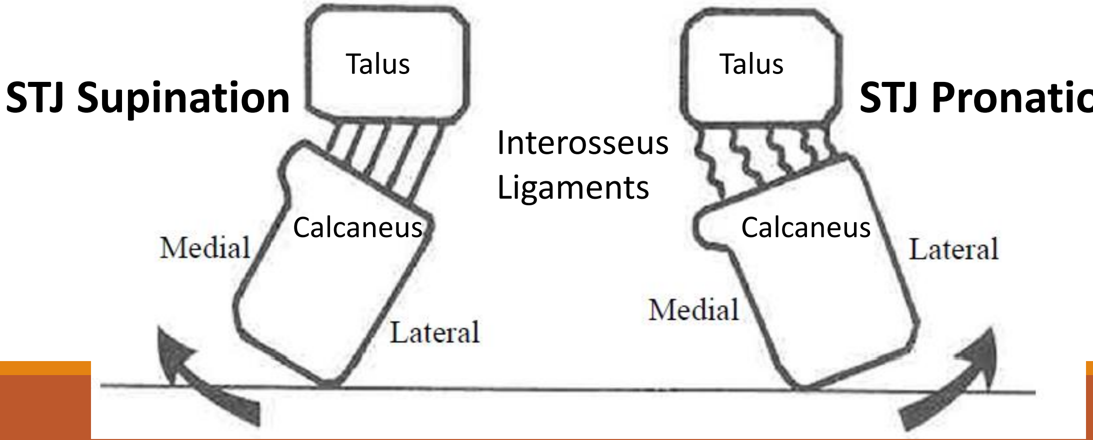
Foot/Ankle Biomechanics During "Normal" Gait

Landing

- The subtalar joint should be in slight inversion ("locked") as it makes contact with the ground
- Subsequent pronation "unlocks" mobility around the midfoot for shock absorption
- <u>Contributors to shock absorption during landing which increase ΔT for attenuation of GRF:</u>
  - Hip/knee flexion, ankle plantar flexion, subtalar joint pronation, calcaneal fat pad deformation, deformation of other soft tissues, footwear

Push-Off

- From midstance to push-off, subtalar joint supination "re-locks" mobility around midfoot to create a rigid lever for push-off - GRF typically shifts from lateral rearfoot to medial forefoot through stance phase



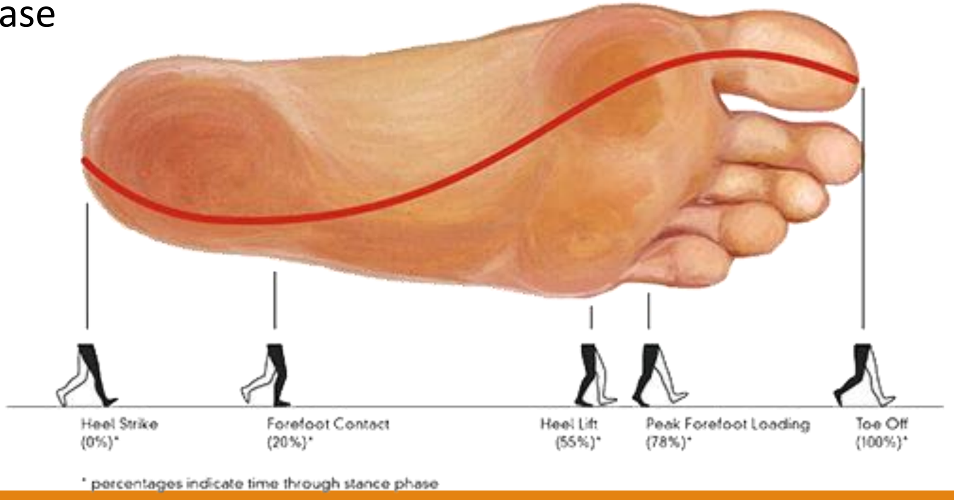


Figure 2.5

Personal Related Drivers

Equipment Related Drivers

Anatomical Drivers

Biomechanical Drivers

Activity/Training Related Drivers

Drivers of Musculoskeletal Pathology

Environmental Drivers

Anatomical Drivers

Static positions of joints at rest which MAY predispose tissues to excess stress/strain

Bony Anatomy – leg length discrepancy, tibial varum, femoral torsion

Hip Structure – anteversion/retroversion, coxa varum/coxa valgum, leg length discrepancy

Knee Structure – genu valgus, genu varus, genu recurvatum,

Ankle/Foot Structure – pes planus, pes cavus, rearfoot varus/valgus, forefoot varus/valgus, foot equinus, hallux valgus, hallux rigidus, hammer toes, turf toe

So, if I find one or more of these on an exam, it's a problem right?

It depends…

a) "Normal" or "optimal" foot anatomy is a spectrum
b) If it ain't broke, don't fix it; the optimal foot is the foot that does what you want it to without excessive or endurant pain
c) Normally only a problem if compensations are exhausted or unavailable
d) After skeletal maturity, we can't change bone structure, but we can attenuate and alter forces around joints to relieve excess stress/strain in ornery musculoskeletal tissues

Biomechanical Drivers

Mechanical constraints or mechanical behavior of musculoskeletal tissues under dynamic or loaded circumstances

ROM constraints – inadequate ROM to manage internal and external forces, constraints, and conditions

Muscular strength – inadequate muscle shielding of passive joint structures

Ligamentous laxity – excess joint play or overly rigid joint/joint capsule

Neurological Input – speed of neurological input to muscle providing shielding

Mechanics – movement patterns, body mechanics, gait patterns, running mechanics, jumping/landing mechanics, etc.

Activity/Training Related Drivers

The intensity, frequency, duration, and/or mode of performed activities that may or may not place soft tissues at a disadvantage to manage forces imposed

Training Errors:

Intensity – too heavy or too intense too soon?

Frequency – too often too soon?

Duration – too long too soon?

Mode – what are the anatomical/biomechanical demands of a potentially offensive activity?

Thoughts:

A) Are the bodies tissues fit to handle the demands of a regular or desired activity?

B) If not, consider rest (4 wks), manage drivers of pathology, and gradually progress training to return to activity

C) Alter activity/training parameters to find “Goldilocks Zone”

Environmental Drivers

Environmental conditions which alter active/passive force attenuation

With foot and ankle, we are thinking primarily of activity/training surfaces…

- **Surface type** – hard, soft, springy
- **Surface grade** – hilly terrain, road pitch, flat grade
- **Surface variability** – even or uneven; track running vs trail running

<u>Consider how each of these conditions:</u>

a) Might "ask" more of anatomical/biomechanical structures

b) Might challenge or aid shock absorption (attenuation of GRF)

Personal Related Drivers

Characteristics relating to a persons physical/mental health and accompanying comorbidities or medical history

Physical health – BMI/weight status, hydration, nutrition

Mental health – anxiety/depression

Comorbidities – diabetes, neurological impairment, etc.

Medical history – Hx of illness, injury, traumatic injury, surgical history, etc.

Consider how personal factors relating to physical health, mental health, and medical Hx affect soft tissue structures…

Equipment Related Drivers

Any external device fixed to the body affecting joint position and/or attenuation of static/dynamic forces imposed on musculoskeletal structures

At the foot/ankle, we're thinking primarily of…

Footwear – does the shoe alleviate, aggravate, or do nothing to deal with identified drivers?

Orthoses – inserts, AFO, etc.

Bracing – ankle brace

Equipment is typically used for protection, stability, and/or function…

Evaluation of the Foot and Ankle

Strategy for Evaluation

1) **Gather a subjective historical timeline of the patients CC**

2) **Pinpoint the <u>EXACT</u> location of pathology** – establish differential

3**) Investigate subjective behavior of the pathology**
   - 24 hr cycle, intensity, irritability, pain descriptor, aggs, eases, medical management?, etc.

4) **Investigate "drivers"**
   - Anatomical, biomechanical, activity/training related, environmental, equipment related, personal related

5) **Use objective exam components to gather more information related to drivers**

6) **Synthesize findings to establish a working hypothesis** – communicate this to the patient

7) **Address drivers with initial interventions**
   - Education (activity modification), manual, modalities, orthotics, footwear recommendations, therapeutic exercise, referral, etc.

Evaluation Template for Foot/Ankle

- **Subjective Interview** – doesn't end when the objective exam starts!
- **Palpation**
- **Investigate Shoe Wear** – wear patterns, subjective comfort/pain, shoe characteristics
- **Observation** – appearance, alignment, posture
- **Lower Quarter Screen**
- **Gait Analysis**
- **ROM/Muscle Testing**
- **Additional Objective/Special Tests**
- **Synthesis** – use subjective/objective information to assemble a "story" that the patient will understand – use models and/or images to facilitate learning
  - What is the problem?
  - What is driving the problem?
  - How can PT manage drivers contributing to the problem?

Subjective Interview

<u>Important Topics to Cover:</u>

- Gather a thorough **history of the problem** – when did it start, what has/hasn’t worked?
- Investigate **daily activity** – work, leisure, sport, sleep, etc.
  - If you don’t know, ask!
- Ask about **changes in activity or training parameters**: frequency, intensity, and volume
- Ask about **footwear** – which feel good, which don’t, which do they wear at work, do they ever walk barefoot, any problems with barefoot walking?
- When applicable ask about home and/or training **environment** – ex: running on asphalt or trails? Stairs in home?
- Always **assess goals** – this will guide and prioritize interventions and can help narrow the scope of PT POC in patients with lots of issues/comorbidities; what is most important to the patient?
- Be a Dynamic Interviewer!

Palpation – What "lives" there?

Match the condition to the color: A) Plantar fasciitis, B) mid-substance/insertional Achilles tendinopathy, C) lateral metatarsalgia, D) midfoot OA, E) hallux rigidus, F) anterolateral ankle mortise OA, G) tibialis posterior tendinopathy

Lower Quarter Screen

Seated

- Equinus foot
- Patellofemoral position (patella alta/baja)

Prone

- Forefoot-rearfoot alignment (varus/valgus)
- Triceps surae extensibility
- Rearfoot motion (inversion/eversion)
- Craig's Test (anteversion/retroversion)

Supine/Side-Lying

- Thomas Test (quadriceps flexibility)
- Obers Test (ITB extensibility)
- Patellar mobility (glides)

Standing

- Navicular drop
- Medial talonavicular bulge
- Arch height in WB
- Sagittal alignment of the legs (genu recurvatum)
- Frontal alignment of the legs (genu varus/valgus)
- Frontal orientation of the patellae
- Limb length inequality
- Gait (foot/ankle, knee, hip)

ROM Considerations

Assessment:

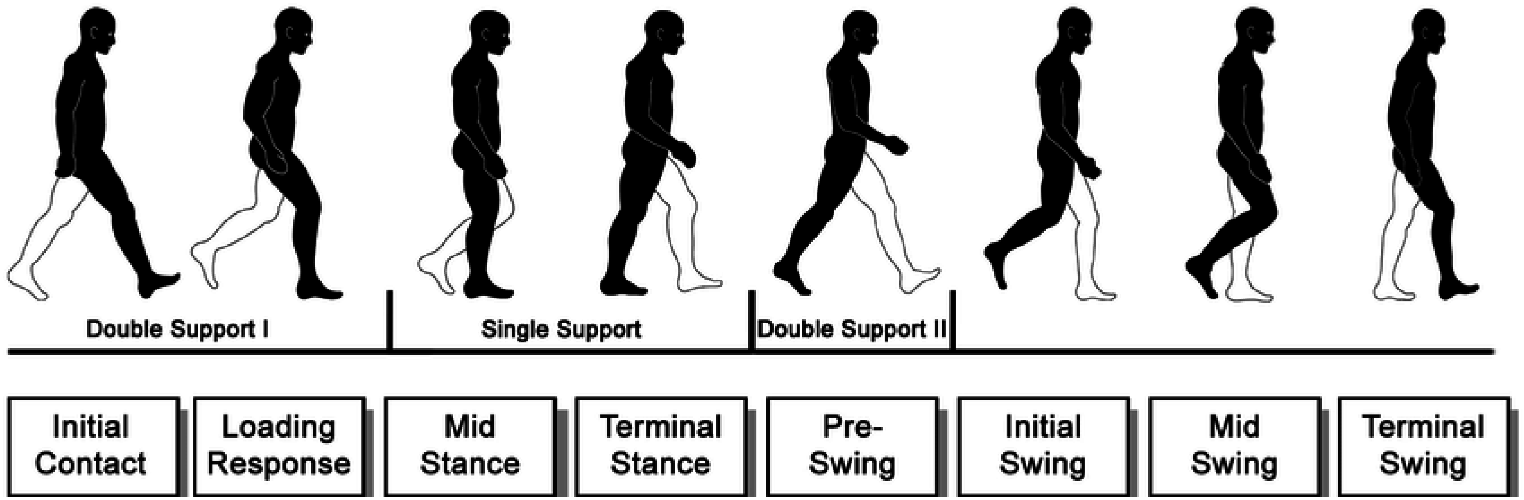
- Triceps surae extensibility
- Soleus extensibility (bent knee)
- PROM/AROM/Resisted Motion – end feel, pain with active/resisted motion, pain with passive stretch/overpressure

Considerations:

- Muscular or capsular limitation or both? – assess joint play at the talocrural joint
- 10 degrees dorsiflexion required for terminal stance with extended knee during gait just prior to heel off
- Dorsiflexion ROM "debt" at the talocrural joint is "paid" by excess motion in other joints of the foot (midfoot) or by compensatory patterns up the kinetic chain
  - Gait deviations (ex: reduced step length)
  - Mobility: stairs, squat, sit to stand, lunge, etc. (ex: forward trunk lean)

Gait Analysis

Use **stages of gait** to help identify pathology and plan interventions… does stage of gait elicit the patients CC?



Break it down for the patient before they walk… "You have 4 options; at what point do you feel your pain while walking, when…" (demonstrate)

A) The heel hits the ground **(Initial Contact)**
B) You stand directly over your foot **(Mid-Stance)**
C) Right before the heel comes off the ground **(Terminal Stance)**
D) As you push off your toes to step forward **(Pre-Swing)**

If possible, assess gait with shoes on <u>AND</u> shoes off…

Be a Shoe Detective

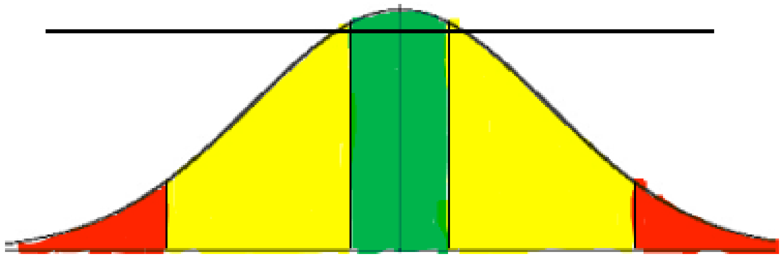
If you are seeing someone for a foot/ankle issue, ask them to bring the 4 pairs of shoes they wear most often…

Determine:

- Which shoes feel good, if any? Which do not? Did they change shoes recently? Did the change coincide with onset of CC?
- Look for **wear patterns** (insole, outsole, heel counter) – offers clues for behavior of foot in shoe
- Look for **areas of deformation** of the shoe – bulging heel counter, abrsions
- Remove and assess inserts – based on drivers for pathology, are they helping, hurting, or neither?
- Look at **shoe characteristics** – heel lift, heel counter, toe break, sole width, toe box etc.
  - Are these characteristic right for THIS foot?
  - Know how each of these shoe characteristics affect biomechanics of the foot and ankle
  - What are the characteristics of the pair of shoes that feel the best to the patient? The worst?

Common Exam Findings and Management of Common Foot/Ankle Pathology

The “Optimal” Foot



Subtalar joint neutral, right? It depends…

- **Idealist Perspective** – yes; a neutral rearfoot with a perfectly aligned/balanced foot structure in absence of any kind of motion restrictions, strength limitations, or instabilities creates optimal bony contact for handling internal/external loads
- **Realist Perspective** – it doesn’t have to be; the optimal foot is the foot that allows you do what you want it to, when you want it to, for as long as you want it to without excessive pain or injury

<u>Optimal feet are somewhere between two extremes:</u>

Overly “**flimsy**” foot (**pes planus**) = too much pronation/deformation of soft tissues → structural collapse of bony anatomy → injury to soft tissue structures in the foot + arthritic changes in foot or up the chain due to malignment/structural collapse

Overly “**rigid**” foot (**pes cavus**) = not enough pronation to give for shock absorption → decreased potential for shock absorption in foot/ankle → increased stress fractures + arthritic changes + compartment syndromes up the chain due to reduced potential to attenuate forces in the foot/ankle

**Both extremes can be moved towards the green by managing drivers through activity modification, external support, and/or tissue adaptation – after 11-12 yo, you aren’t going to modify bony anatomy with your interventions, so how can you work with what the patient has to move them toward the green?

A word on foot orthoses…

“In all instances, orthotics can be thought of as either potentially load sharing, corrective, or accommodative.”

Orthotic: *adjective* describing a device used to correct an orthopedic problem (orthotic device)

Orthosis: *noun* describing a single externally applied device used to influence characteristics of orthopedic structures

Orthoses: plural form of the *noun* orthosis

“But orthoses are a crutch, right?”

- Yes; but consider the alternative… what is the patients goal?

“Yes, but if I give them a crutch, won’t they always have to rely on that?”

- It depends; orthoses offer support that relieves drivers of tissue stress – time frame for use of orthoses depends on the patient in front of you…

Orthoses continued…

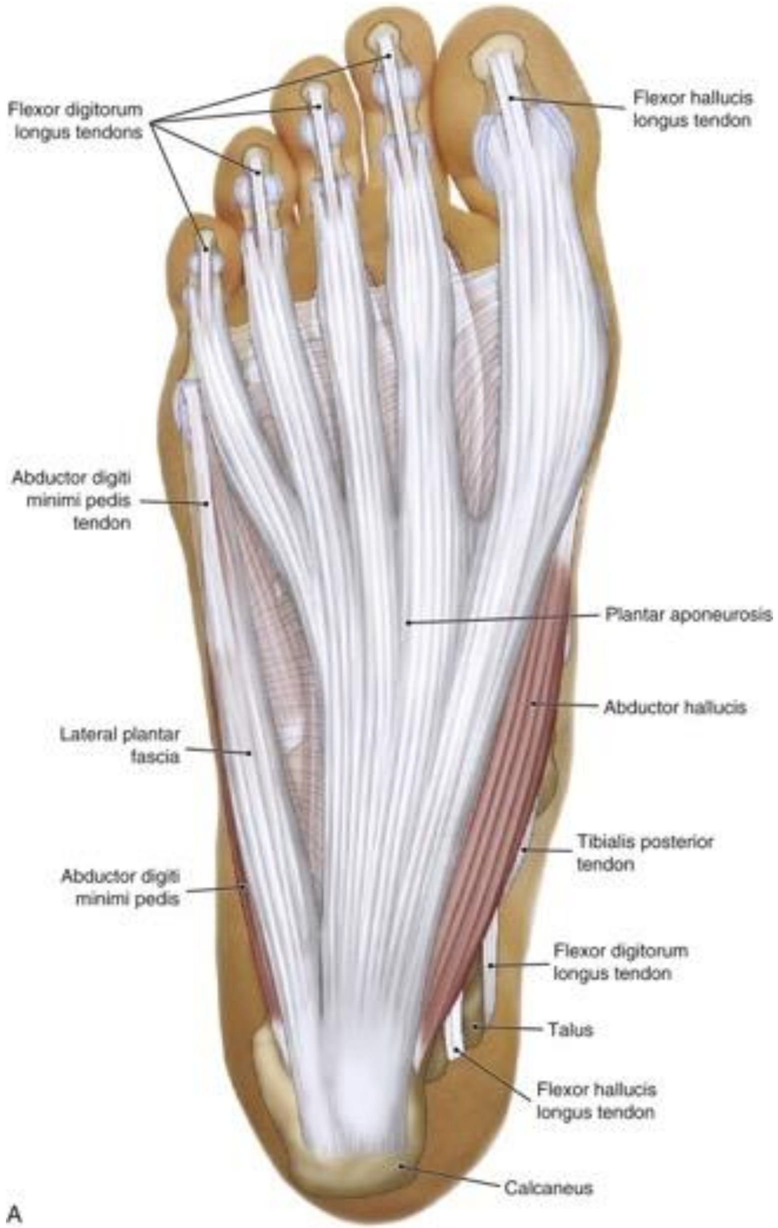
How to use orthoses:

- Should always be custom to the anatomical/biomechanical characteristics of the patient – there is no one-size-fits all approach
- Complete lower quarter exam to determine what kind of support may help to relieve tissue stress
- Trial orthoses in clinic in best pair of shoes for that patient – expect to make modifications
- Orthoses DO NOT "wear-in" – if they don't feel right to the patient in clinic, this will not improve; strive for complete relief
- Allow tissues time to heal with orthotic use; use other interventions to address drivers
- Follow up with the patient (2 wks)

A word on footwear…

- Think of footwear on a continuum from “concrete” to neutral to “marshmallow”
- Most people best off somewhere between the two extremes
- Too simplistic to say that “concrete” shoe is best for everyone with flat feet that pronates – how do the characteristics of the shoe “get along” with anatomical/biomechanical characteristics of the patient?
- Ask yourself what does this patient need in terms of protection/support from a shoe to accomplish the desired activity?
- Best shoe is often the one that feels best to the patient
- Do not disregard footwear; not always the culprit but can very often present as a contributing driver for foot/ankle pathology

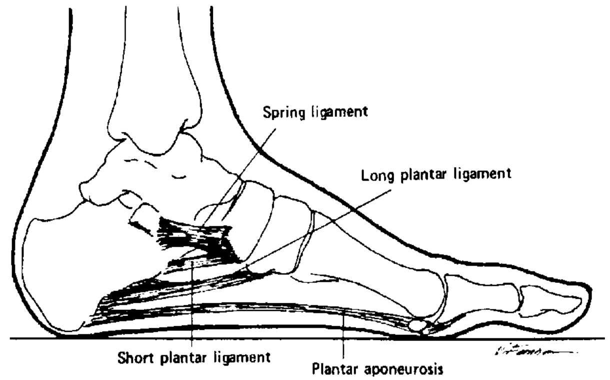
Plantar Fasciitis (PF)



Anatomy and Biomechanics

<u>Medial Longitudinal Arch Support:</u>

- Plantar aponeurosis
- Posterior tibialis tendon
- Spring ligament
- Short and long plantar ligament
- Some support from flexor intrinsics

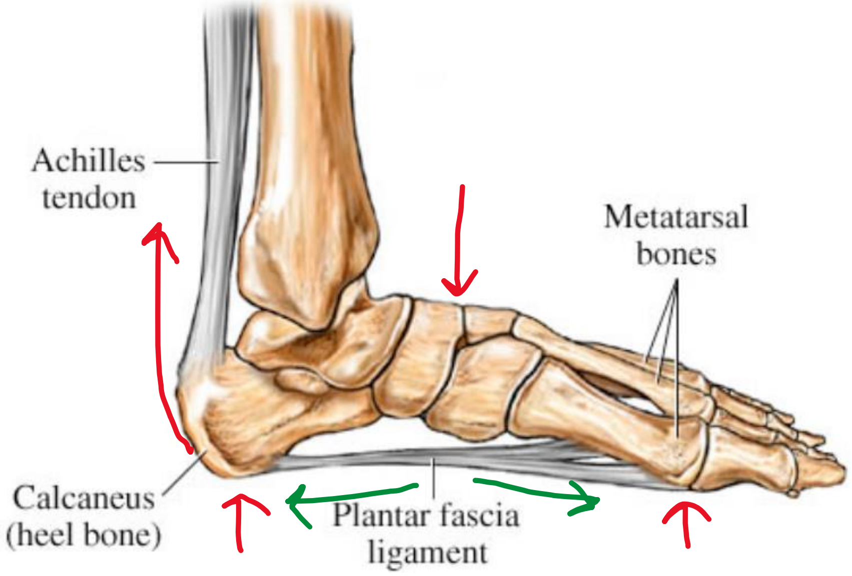


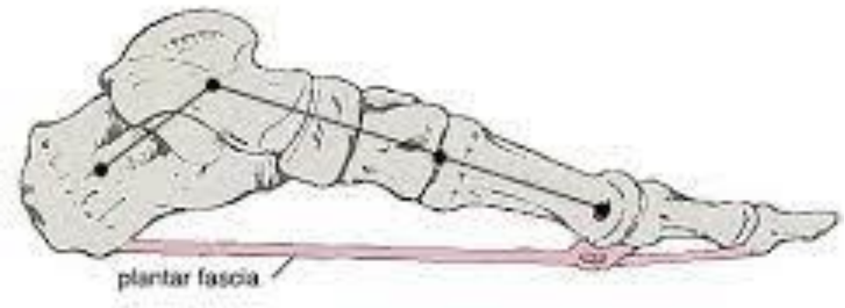
<u>Characteristics:</u>

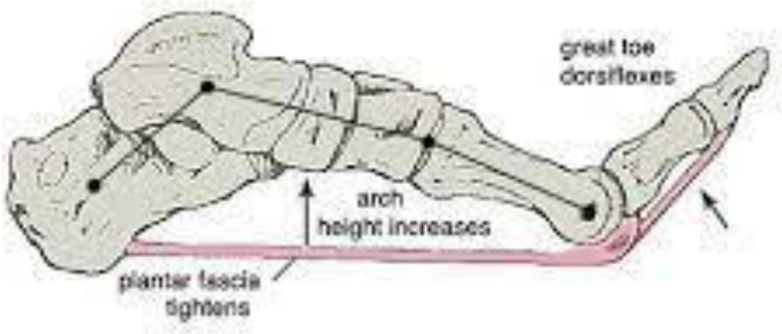
- Originates on calcaneus and inserts onto proximal phalanges
- Medial bands of aponeurosis are thickest and under most stress d/t concentration of forces from medial forefoot during concentric propulsion and eccentric shock absorption; also highest part of the arch
- Composed of Type 1 Collagen Fiber

Biomechanical Function of the Plantar Fascia:

- Elevates medial longitudinal arch, stabilizing the midfoot and increasing overall rigidity of the foot
- Regulates ankle movement
- Distributes forces evenly across the foot in response to loading
- Stores mechanical energy during shock absorption for increased force output during propulsion







Influence of Triceps Surae:

- Triceps surae pull superiorly on the calcaneus, increasing tensile load on the plantar fascia – when tight, exerting this load all day long

Windlass Mechanism:

- Elevation of the medial longitudinal arch occurring with increased tension in the plantar aponeurosis from dorsiflexion that occurs around the metatarsal heads during the propulsion stage of gait
- Increases rigidity of the foot for propulsion of the body during gait, running, jumping, etc.

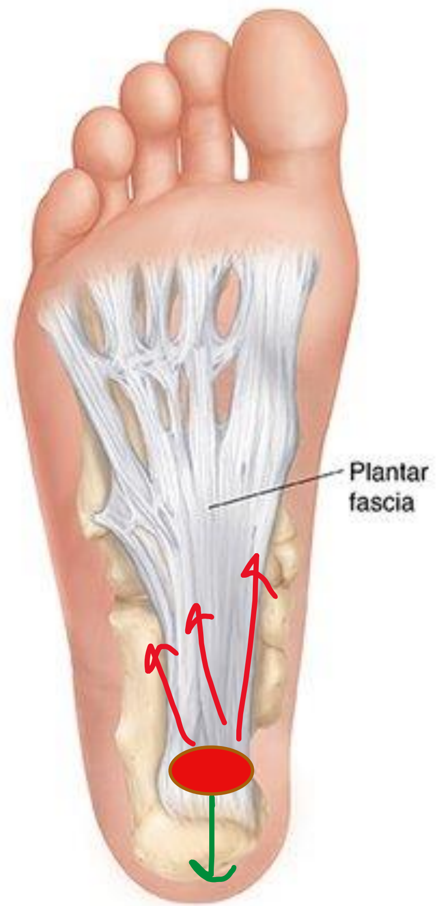
Tissues Affected…

The plantar fascia is essentially a large ligament composed primarily of water and Type 1 collagen fiber with some elastin to allow for some deformation

Primary functions of ligaments:

1) Joint stability with tension
2) Protection of other joint structures
3) Force attenuation with deformation
4) Protective reflexes and position sense

Problems arise when the plantar fascia is exposed to excess stress/strain causing microtears to vulnerable areas of the tissue



The plantar aponeurosis originates on the medial calcaneal tubercle then fans out and attaches to met-heads and proximal phalanges of all 5 rays; concentration of forces just distal to the medial calcaneal tubercle - consequently, this is the most common site of pain

Plantar Fasciitis and Gait

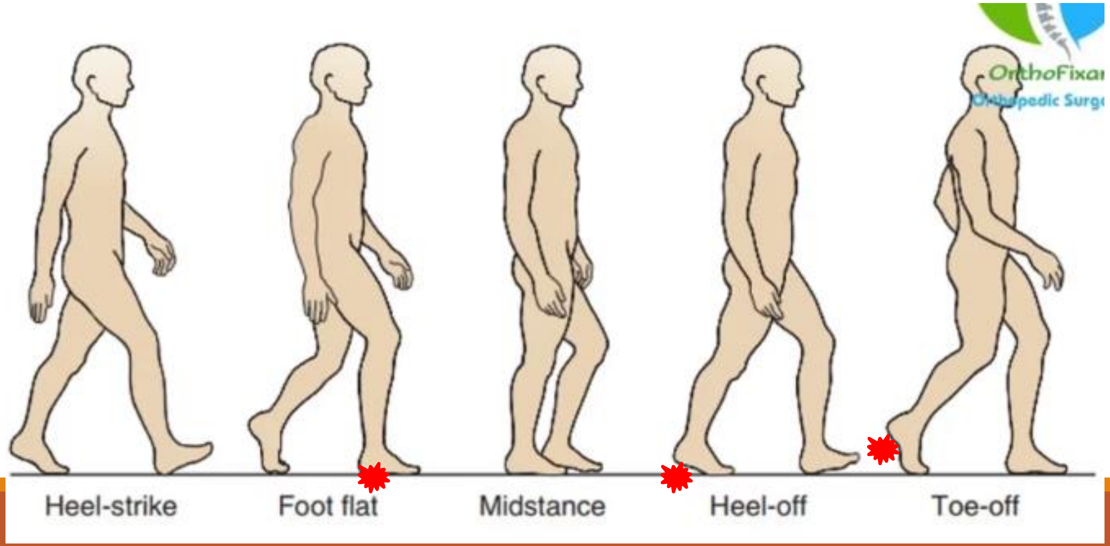
2 Instances during gait in which tension in the plantar fascia is highest:

1) During **max ankle pronation** occurring during weight acceptance **between heel strike and midstance**

- Tensile stress due to flattening of longitudinal arch with pronation + acceptance of body weight + absorption of GRF (dealing with forces in lengthened state)

2) During **max ankle supination** occurring during propulsion **between midstance and toe-off**

- Tensile stress due to elevation of longitudinal arch with supination + Windlass mechanism + influence of tension in triceps surae is position of max ankle DF (dealing with forces in shortened state)



Clinical Presentation

From 2014 CPG for Plantar Fasciitis:

- Plantar medial heel pain: most noticeable with initial steps after a period of inactivity but also worse following prolonged weight bearing
- Heel pain precipitated by a recent increase in weight bearing activity
- Pain with palpation of the proximal insertion of the plantar fascia
- Positive Windlass test
- Negative Tarsal Tunnel tests
- Limited active and passive talocrural joint dorsiflexion range of motion
- Abnormal Foot Posture Index score
- High BMI in non-athletic individuals

Potential Pathological Drivers

Anatomical

- Pes cavus, pes planus, foot Equinus, rearfoot valgus, forefoot varus, tibial varum, knee valgus, leg length discrepancy, etc.

Biomechanical

- Tight triceps surae, reduced ankle ROM (DF, eversion), reduced strength in muscles supporting the arch, pronation too early/late/long

Activity/Training

- Occupational demands (standing/carrying weight/squatting), excessive walking or running (too much too soon or too much period)

Environmental

- Running/walking uphill, uneven terrain, running/walking on grade (lateral aspect of shoe on high side – driving pronation without pronation to give)

Equipment

- Shoes with no heel lift in the presence of reduced DF ROM, shoes with inadequate arch support in deficient foot, shoes with inadequate cushion under heel, no shoes - “Covid foot”

Personal

- Sedentary lifestyle, high BMI (>27 kg per m^2), diabetes

Intervention

<u>Activity Modification:</u> – "put out the fire before you rebuild the house"

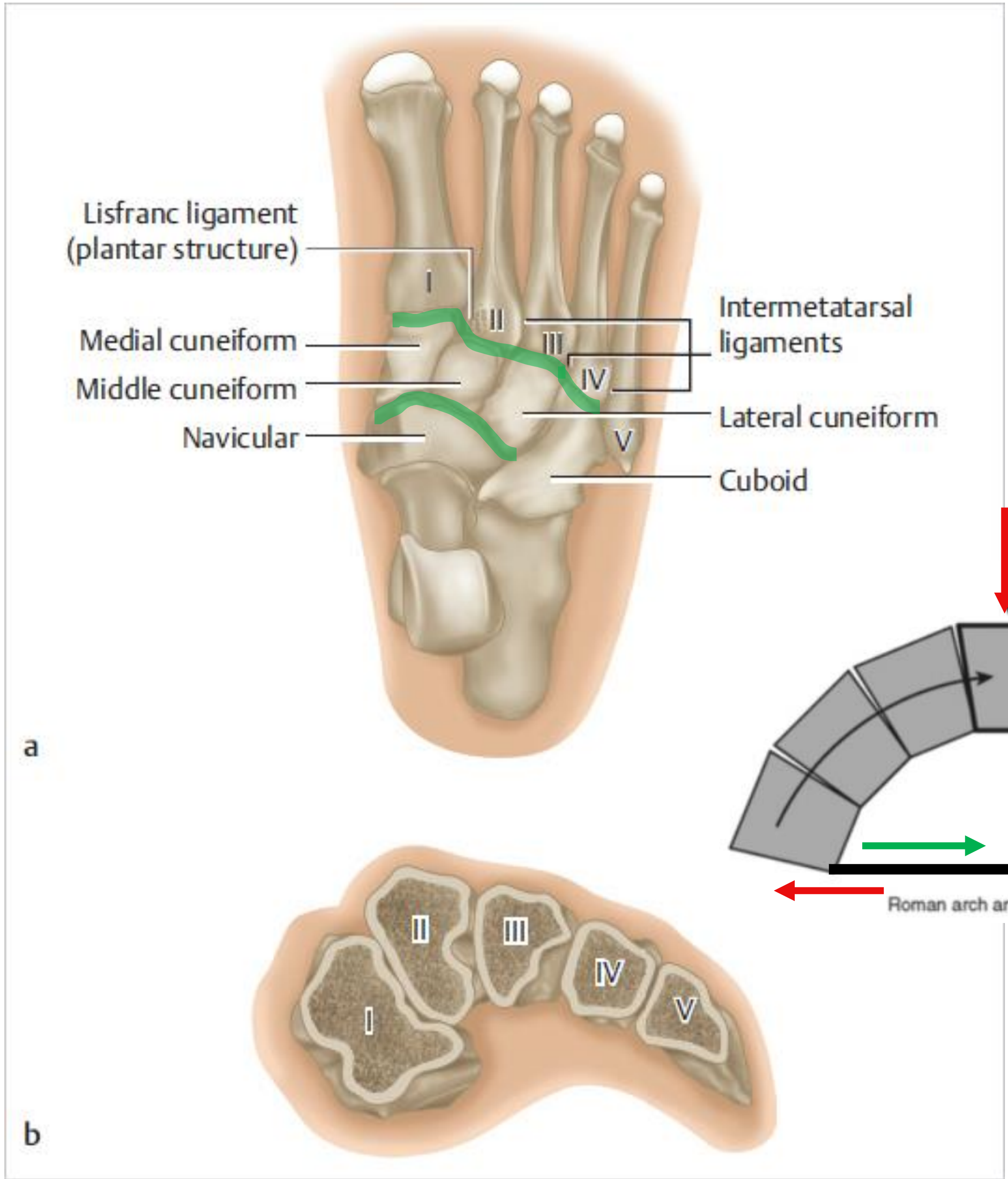
- **Rest** – manage activity/training loads to break up long period of static/dynamic loads; education addressing rapid changes or excessive training loads in athletic populations – considering cycling or swimming to maintain CV capacity
- Vigorously stretch calves before stepping out of bed
- AVOID barefoot walking while tissue heals (Oofos shower sandals with heel lift)
- If runner, avoid hills/uneven terrain while recovering (sagittal/frontal plane challenges), graded reintroduction later in rehab
- **Night splints** – 1-3 months for patients with reduced DF and irritable pain first thing in morning

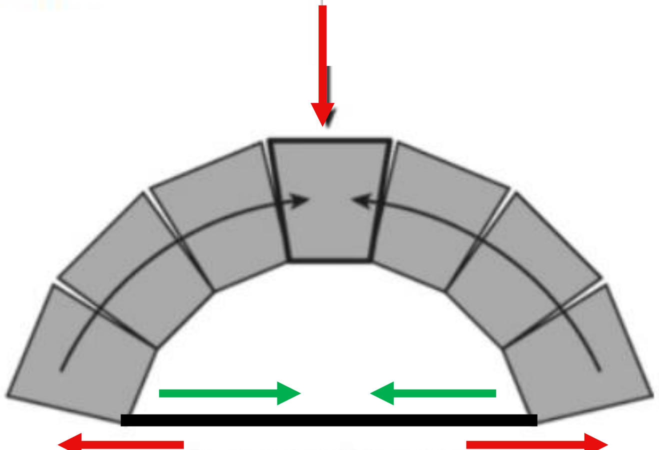
Martin et al , Morrissey et al and clinical commentary

<u>Interventions:</u> – manage "drivers"

- **Manual therapy** – STM to reduce pain or improve calf flexibility, mobilizations to increase DF ROM (talocrural glides)
- **Stretching** – standing calf stretch (straight knee/bent knee), PF stretch with towel roll – 3x 1 min each at least 2x/day
- **Taping** – immediate pain reduction and improved function with taping to "support" the longitudinal arch
- **Footwear** – temporarily avoid shoes with no rearfoot to forefoot drop (Hokas); shoe wear should help manage anatomical drivers of stress to plantar fascia (ex: heel lift, medial arch support, firm heel counter, etc.)
    - Rocker bottom could be useful to limit great toe DF…
- **Exercise** – (expert opinion*) strengthening/movement training for muscles controlling pronation; progressive loading/return to activity, monitor symptoms
    - Also consider strengthening/stabilization up the chain – make each joint "pull its weight" (hips, quads, hamstrings)
- **Orthoses** – custom foot orthoses are best, but prefabricated can work for some
    - Heel lift to allow more "relative" DF ROM
    - Medial forefoot post to manage pronation driver from forefoot varus
    - Medial rearfoot wedge to manage pronation driver from genu valgus
- **Corticosteroid Injections** – can be helpful but only for short term with potential for long term consequences; conservative management first…

Midfoot OA

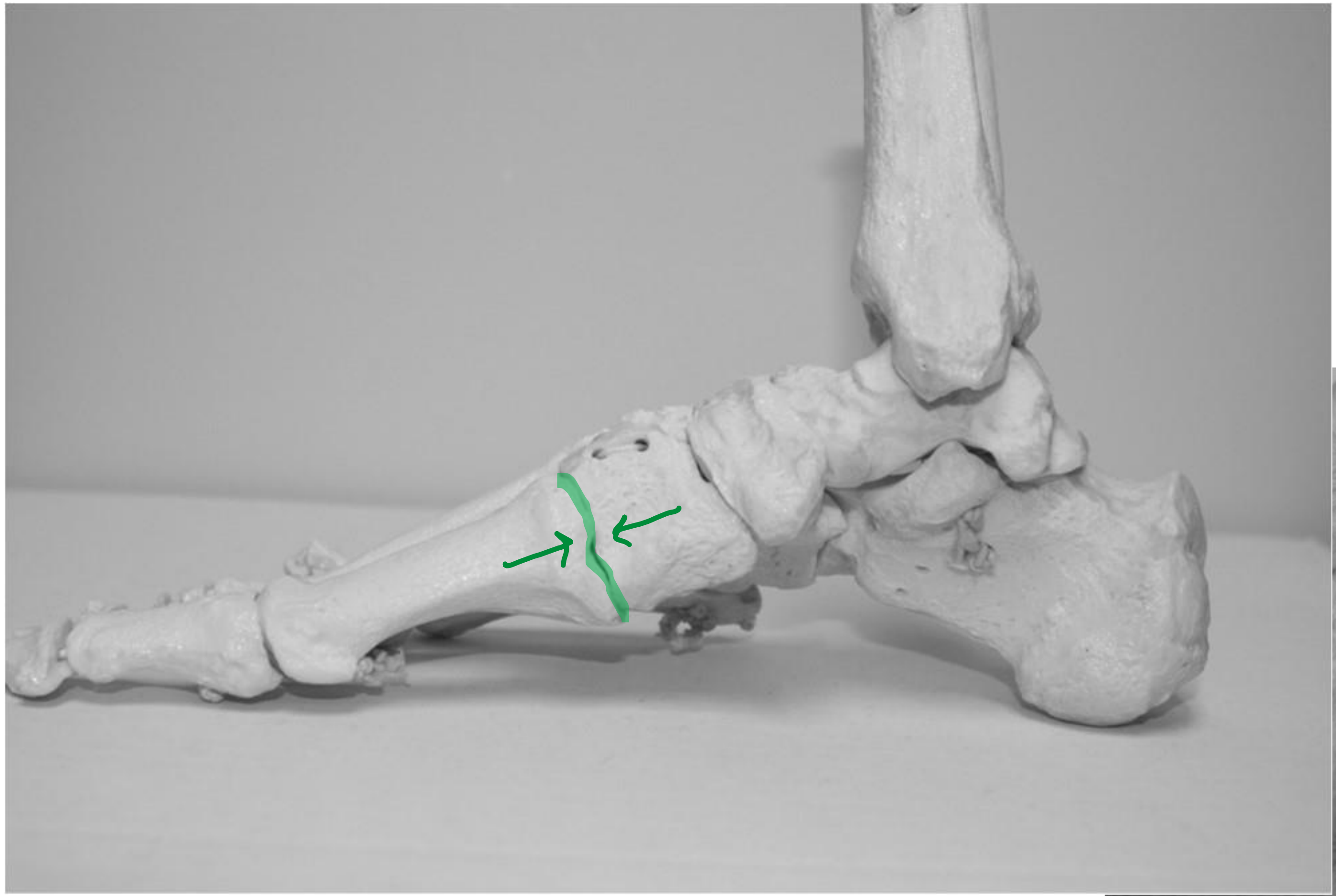



Roman arch and force vectors

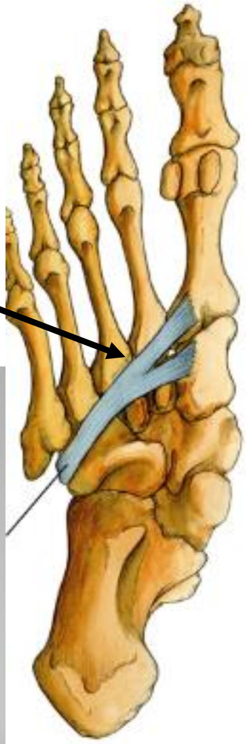
Anatomy/Biomechanics:

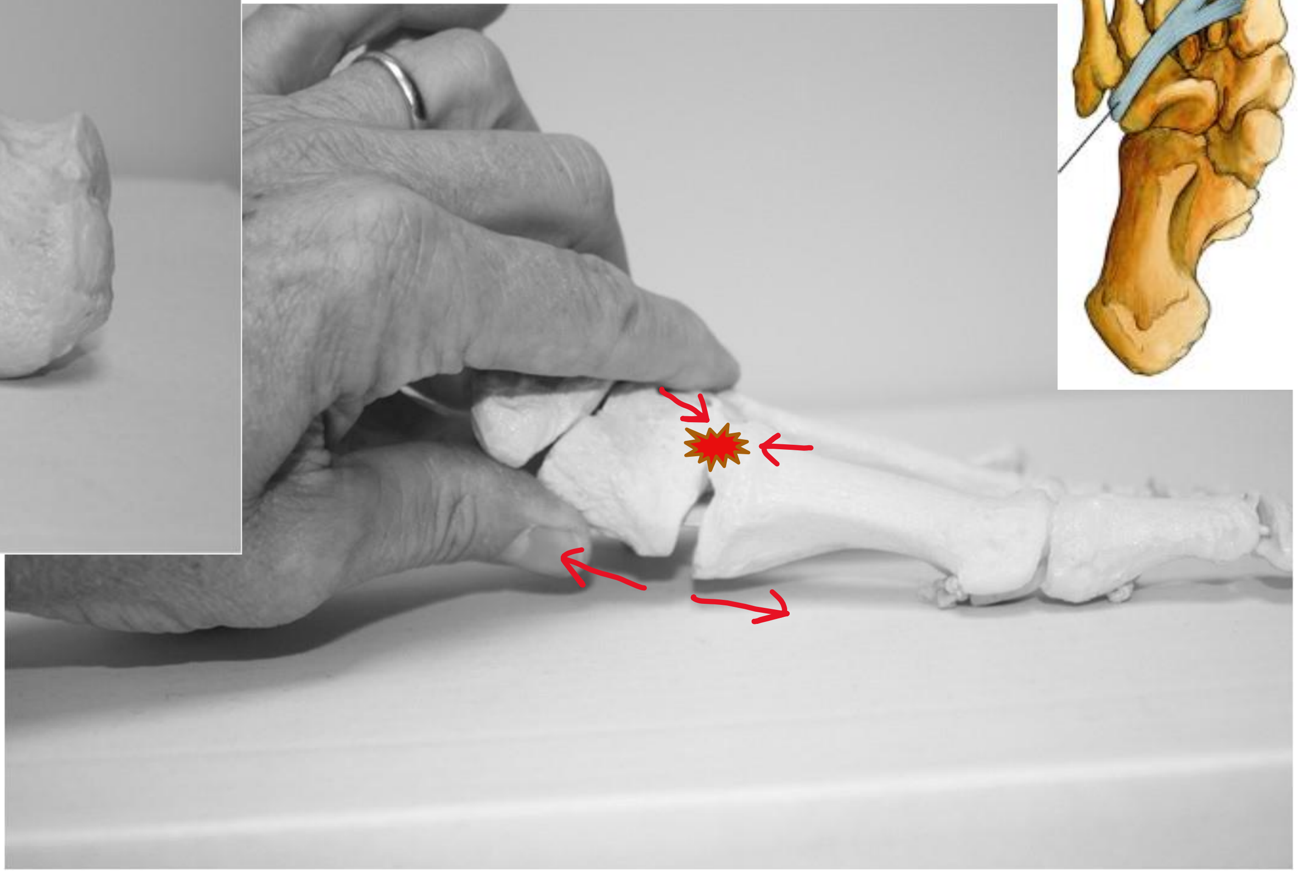
- Wedged shaped cuneiforms wider superiorly – Roman Arch
  - Arch is supported by soft tissue truss in the human foot
  - Incredible stability with normal contact area
  - Receives support from peroneus longus tendon
- The midfoot acts as a stable beam connecting FF to HF – rigid lever for push off
- Less mobile than other joints – should not move – job is to transfer forces from FF to HF
- Elevated tensile stress in soft tissue “truss” structures drive midfoot collapse
  - Decreased contact pressure
  - Increased contact force
  - Double Whammy!

Kurup et al and clinical commentary



Peroneus Longus Tendon





$$CP = \frac{CF}{CA}$$

Tissues Affected…

Etiology:

- Degenerative
- Post-Traumatic
- Inflammatory (ex: RA)
- Neuropathic (ex: diabetes)
- Post Hindfoot fusion

Location:

- Loss of articular cartilage at dorsal surface of midfoot with calcium deposition forming osteophytes
- 2nd and 3rd TMT joints most common joints for development of midfoot OA

Clinical Presentation

<u>From Kurup et al and clinical commentary:</u>

- May have Hx of trauma or foot/ankle Sx
  - Lisfranc injuries, fracture, etc.
  - Ankle/hindfoot fusion – loss of ROM
- Hx of RA or diabetes (neuropathic Charcot foot)
- Pain over area of the midfoot
- Pain with walking, typically worst at terminal stance to toe-off; also aggravated by stairs or uneven terrain
- May have palpable osteophyte formation over area of the midfoot; may display osteophyte formation on radiographs
- May present with swelling in the area
- May demonstrate arch collapse in stance during barefoot gait trial
- Anatomical/biomechanical drivers limiting sagittal/frontal plane motion

**If the talocrural joint can't produce enough DF, it will look for it at the subtalar and transverse tarsal joints; if it can't find it there or motion at these joints is insufficient to manage activity/environmental demands, it will look for motion at the midfoot which is not designed to move…

Potential Pathological Drivers

Anatomical

- Pes cavus, pes planus, foot Equinus, rearfoot valgus, forefoot varus, tibial varum, knee valgus, leg length discrepancy, etc.

Biomechanical

- Tight triceps surae, reduced ankle ROM (DF, eversion, pronation), reduced strength in muscles supporting the arch (peroneus longus tendon), pronation too early/late/long

Activity/Training

- Occupational demands (standing/carrying weight/squatting), chronic excessive walking/running

- **Environmental**

- Running/walking uphill, uneven terrain, running/walking on grade (lateral aspect of shoe on high side – driving pronation without pronation to give)

Equipment

- Shoes with no heel lift in the presence of reduced DF ROM, shoes with inadequate arch support in deficient foot to prevent collapse

Personal

- Sedentary lifestyle, obesity, diabetes, Sx history

Intervention

Activity Modification

- If highly irritable/edematous, rest from offending activities x4 weeks, manage drivers
- Education to remain active outside of aggravating activities (low impact – swimming, biking); adjust activity/training parameters
- Graded return to activity; monitor response

Environmental Modification

- Similar to plantar fasciitis, avoid running on hills/uneven terrain until managed; challenges in the sagittal/frontal plane can aggravate symptoms without management of drivers

Manual Therapy

- Mobilizations to improve DF ROM

Stretching

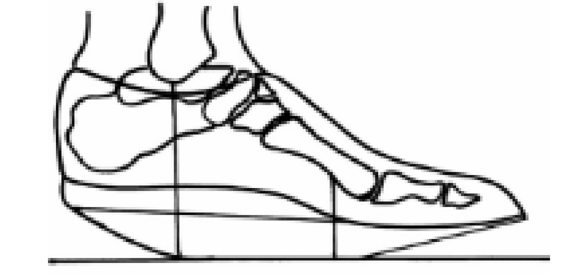
- Stretch triceps surae (wall stretches) to increase DF ROM

Footwear

- Heel to toe rocker sole shoe allows for natural rolling of the foot without bending through the middle of the arch
- Shoes with arch support, heel lift and firm heel counter to prevent arch collapse with sagittal plane challenges
- Tie shoelaces to avoid pressure over the site of osteophytes (skip eyelets)

Orthoses

- Heel lift to allow more “relative” DF ROM
- Medial forefoot post to manage pronation driver from forefoot varus
- Medial rearfoot wedge to manage pronation driver from genu valgus



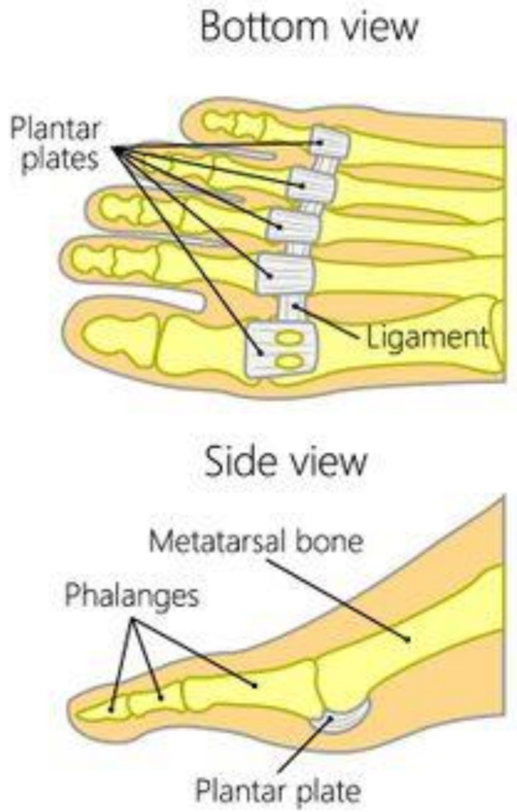
Hallux Rigidus

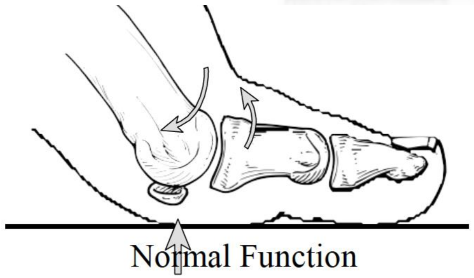
Anatomy/Biomechanics:

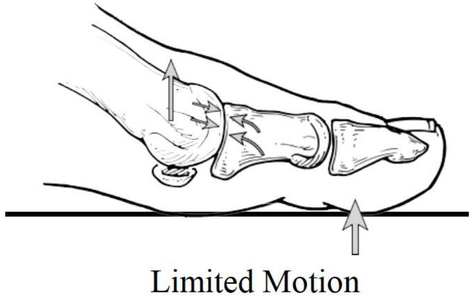
- Occurs at the first metatarsophalangeal (MTP) joint
- 2 sesamoid bones on plantar plate as part of a capsuloligamentous complex
  - Functions to protect AC and allow gliding of met head along the joint capsule
- Resting position relative to axis of 1st metatarsal = 16˚ DF
- Need about 70˚ to clear heel for normal gait w/o compensation

- <u>Critical Functions of 1st MTP Joint:</u>
  - Load bearing (twice the load of other toes) – as much as 8x BW during athletic activities
  - Site of Windlass mechanism for arch stiffening (prevents collapse, aids in stiffness)
  - Static/dynamic balance

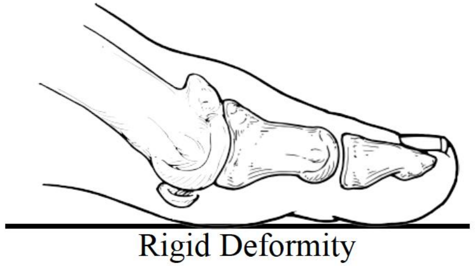
Hallinan et al







Hallux Limitus



Hallux Rigidus

Tissues Affected…

- Degenerative arthritis of articular cartilage of first MTP joint
- Arthritis changes typically begin at dorsal surface then progress to involve the whole joint
- Painful osteophyte formation at dorsal surface as pathology develops

Clinical Presentation

From Patel et al:

- C/o pain at 1st MTP joint with walking; gait may be altered (walking on lateral foot to avoid 1st MTP extension)
- May observe increased bulk of 1st MTP joint with c/o difficulty with shoe wear
- May present with numbness/tingling along medial border of great toe d/t compression of dorsal medial cutaneous nerve
- 1st MTP swollen and/or TTP
- Increased bulk of 1st MTP or palpable dorsal osteophyte formation
- Decreased ROM in 1st MTP: DF limitation > PF limitation; pain at terminal ROM, progressing to mid-range with more severe arthritic changes
- Pain reproduction with forced DF, (+) grind test

** Hallux Limitus = functional pain d/t soft tissue tightness or elevated/long 1st metatarsal; Hallux Rigidus = pain d/t an arthritic joint

Pathological Drivers

Anatomical

- Hallux valgus, long 1st metatarsal, elevated 1st metatarsal

Biomechanical

- Tight triceps surae, reduced ankle ROM, prolonged or excessive foot pronation with gait

Activity/Training

- Repetitive stress, training errors, sport/activity specific (ballet dancers)

Environmental

- Running/walking uphill, or on hard terrain

Equipment

- Shoes with tight toe box, inadequate arch support in deficient foot

Personal

- Female gender, Hx of trauma to the area, Hx of OA, iatrogenic (Sx), inflammatory conditions (gout, RA, metabolic conditions, osteochondritis dissecans)

Patel et al, Lam et al, Senga et al, clinical commentary

Intervention

Activity Modification
- If highly irritable/edematous, rest from offending activities x4 weeks, manage drivers
- Avoid wearing high heels
- Education to remain active outside of aggravating activities (cycling/aquatic therapy); adjust activity/training parameters
- Graded return to activity; monitor response

Environmental Modification
- Walking/running on grass or dirt instead of concrete

Manual Therapy
- Distraction of 1st MTP with dorsal/plantar glides, Grade III mobilization to medial/lateral sesamoids (probably only effective in those with hallux Limitus vs rigidus), talocrural glides to maintain or improve ROM at the ankle joint

Stretching/Exercise
- Stretching of triceps surae to maintain or improve ROM at ankle joint
- Isometric/isotonic strengthening of flexor hallucis longus and plantar intrinsics to improve 1st MTP stability
- Progression to single leg exercises to improve functional stability (single leg balance, rocker board, BOSU, star excursion)

Footwear
- Shoes with rocker bottom and stiff toe break to avoid painful DF of first MTP
- Shoes with a high/wide toe box to avoid contact pressure over osteophytes

Orthoses
- 1st Metatarsal pad or arch just proximal to head to place joint in more PF position (less compression dorsally)
- Carbon fiber shank as splint to limit dorsiflexion of 1st MTP and decreased forces acting on the forefoot
- Make sure that inserts don't limit space in the toe box too much

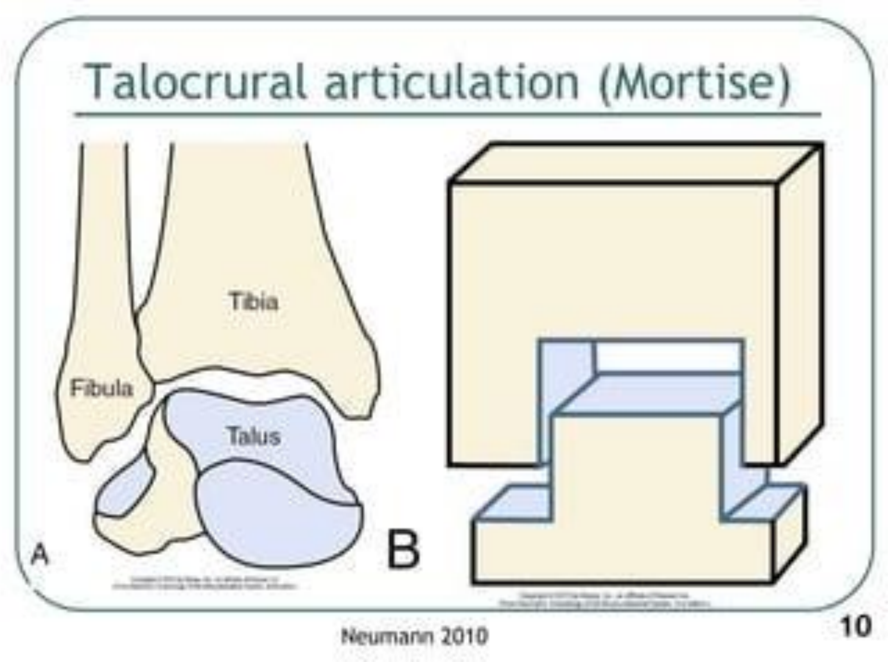
Patel et al, Shamus et al, Finch et al, Colo et al

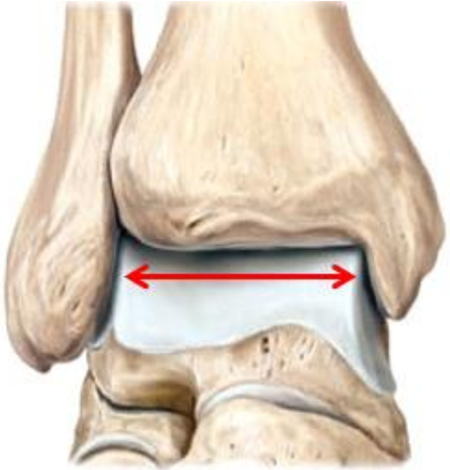
Ankle Mortise OA

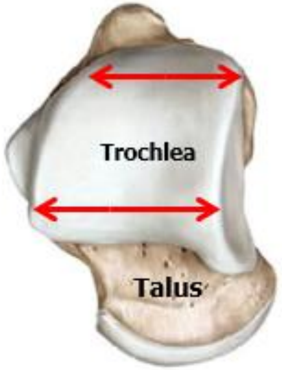
Anatomy and Biomechanics

Talocrural Joint:

- Distal tibia/fibula form ankle "mortise" in which the trochlea of the talus articulates
- Greatest congruency in max dorsiflexion in WB; closed packed position
- Majority of load transferred through the talar dome (tibia)
- Talus is wider anteriorly – with dorsiflexion, increase in load distribution to medial and lateral surfaces of the mortise
- Mortise extends further laterally
- Large contact area in joint makes this a rarer site for arthritis than other major LE joints - alignment issues inc. risk
- Congruency within the mortise is greatest in subtalar joint neutral



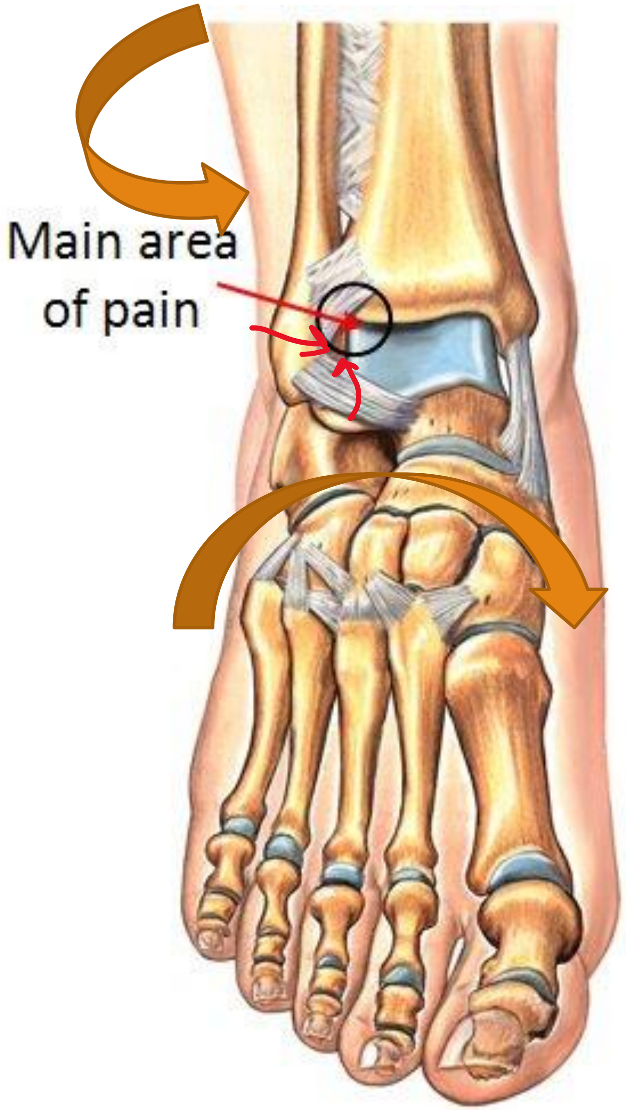


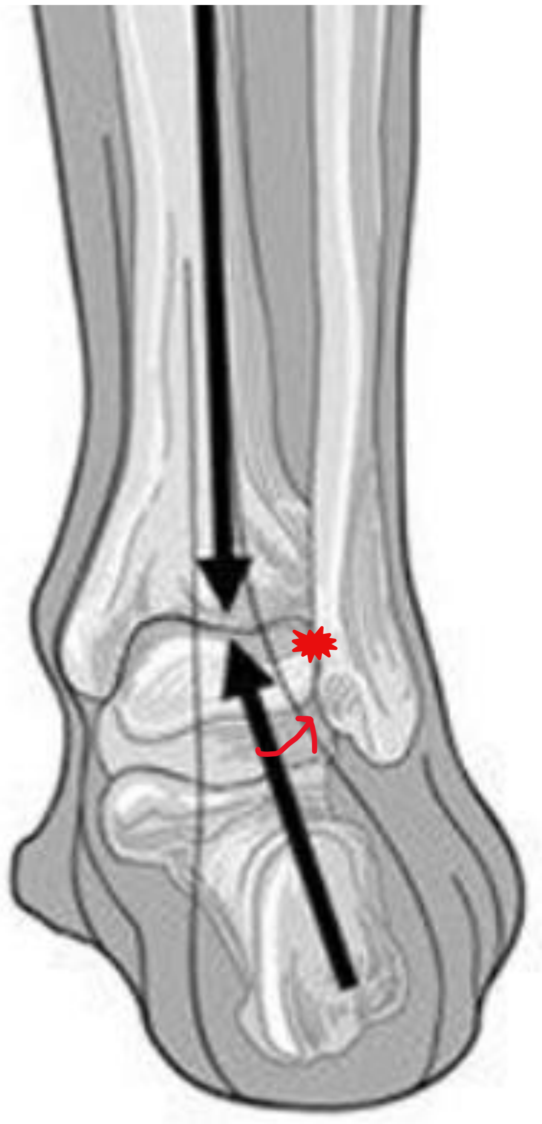


Brockett et al, Dr. Mike Lewek, Biomechanics, *Foot and Ankle*

Ankle Impingement:

- Anterior, anterolateral, anteromedial, posterior, posteromedial
- Anterolateral most common
- Subtalar joint pronation results in increased contact forces to anterolateral aspect of the mortise, especially as the ankle goes into dorsiflexion and the wide part of the talus is driven up into the mortise
- Anatomical deviations that increase eversion/pronation at the ankle joint increase risk for anterolateral ankle mortise impingement and OA
- Degradation of AC may cause osteophyte formation in this area, increasing pain and reducing ROM of the ankle joint, especially into dorsiflexion
- May be primary or secondary OA





Posterior View of Right Foot

Typical Presentation

From Khlopas et al:

- Typically > 60 yo
- Insidious onset joint pain; relieved by rest in early stages
  - Night pain as disease progresses
- May c/o short term stiffness that improves with activity; morning stiffness described as deep pain with crunching or clicking noises
- Pain is activity related; aggravated with WB, especially stairs (end range DF) and overactivity
- May have swelling over area

Pathological Drivers

Anatomical
- Genu varus/valgus, tibial varum, pes planus, hindfoot malignment; drivers of pronation

Biomechanical
- Tight triceps surae, reduced ankle ROM, prolonged or excessive foot pronation with gait

Activity/Training
- Repetitive stress, training errors, sport/activity specific (ballet dancers)

Environmental
- Running/walking uphill, or on hard terrain

Equipment
- Shoes with inadequate support in deficient foot

Personal
- Hx of ankle trauma, inflammatory conditions (RA), metabolic disease, obesity

Intervention

Physical Therapy most successful as intervention in early stages of the disease…

Education and Activity/Training Modification

- Weight loss if pertinent (each pound lost = 4-fold reduction in load!)
- Education to manage aggravating activities

Orthoses

- Custom inserts to improve biomechanical loading/alignment of the talus in the mortise and to reduce demand for end range DF; address drivers of pronation/rearfoot valgus

Footwear

- Stiff heel counter – limits rearfoot motion
- Arch support – limits arch collapse/pronation
- Forefoot/rearfoot wedging – manages anatomical malignments by realigning forces

Achilles Tendinopathy (Mid-substance and Insertional)

Anatomy and Biomechanics

- Largest and strongest tendon in the body; distal joining of the triceps surae on the calcaneus
- Composed mostly of strong Type I collagen fibers
- Mid-substance is most avascular portion of the tendon

Terminology

Tendinopathy: broad term meaning degeneration or failed healing of tendon as a result of continuous overload with inadequate recovery

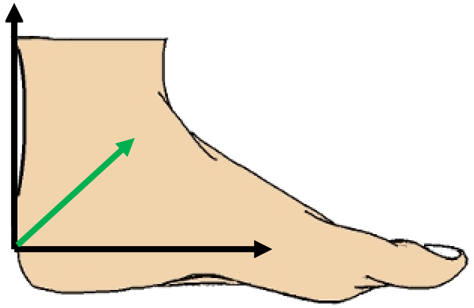
Tendonitis: acute inflammatory response of tendinous tissue due to microtrauma

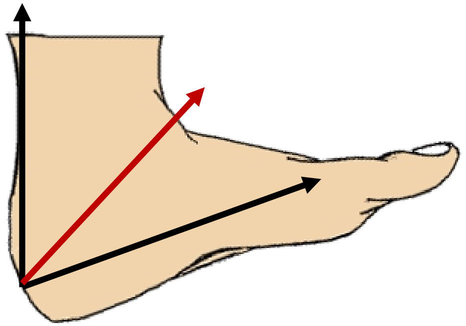
Tendinosis: localized or diffuse increased thickness and/or alteration of normal architecture of the tendon due to chronic tissue degradation

**Commonly held supposition that tendonitis precedes tendinosis; however, it is likely the other way around..

- Healthy tendon is twice as strong as muscle; unlikely microtearing would be occurring in healthy tendon
- Incorrect to assume microtears and inflammation are a precursor to collagen degeneration
- Collagen degeneration more likely due to excessive and/or repetitive tensile forces which instigates degrative changes which THEN predispose tendon to micro-tearing (tendonitis)

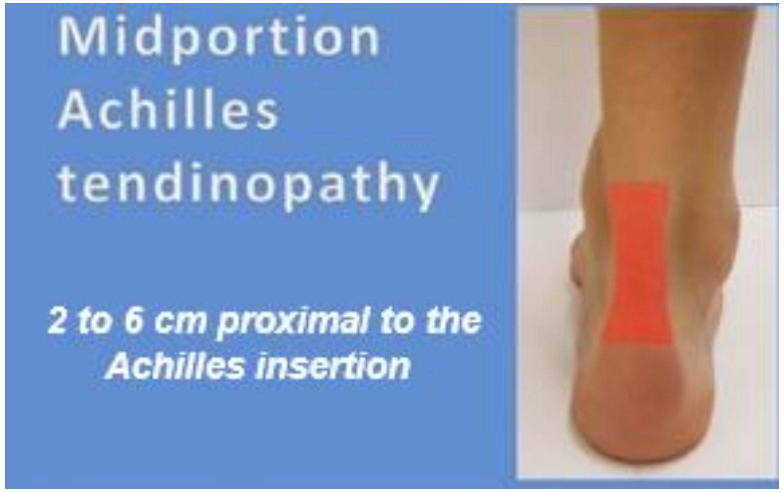
Mid-Substance vs. Insertional Tendinopathy





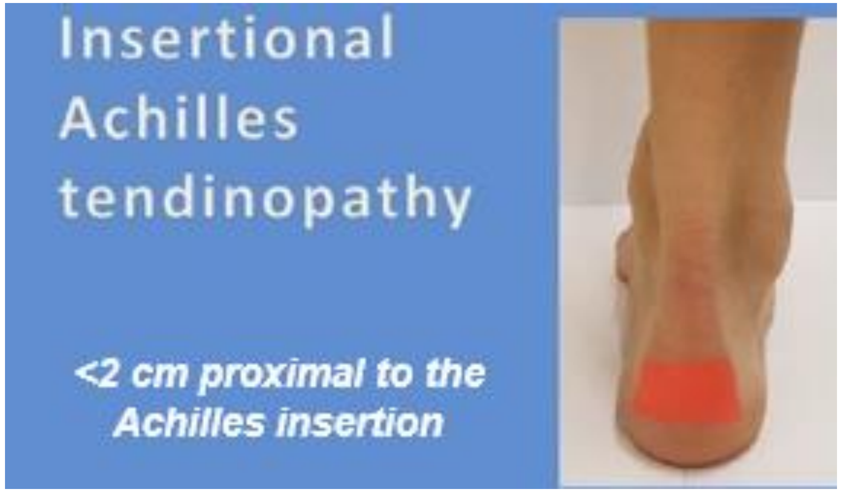
MID-SUBSTANCE

- 55-66% of cases
- Tensile loads are primary culprit
- Most avascular portion of tendon



INSERTIONAL

- 20-25% of cases
- Compressive loads are primary culprit
  - End range DF; hard/tight shoes



Pathophysiology and Diagnosis

Pathophysiology:

- Multifactorial; intrinsic/extrinsic drivers that **decrease load tolerance** of the tendon or movement/activity patterns that **overload** the tendon
- Degenerative changes (-osis) and/or microtrauma (-itis) to the tendon without adequate recovery weakens tendon over time
- Compression from high frequency/duration of end-range DF activity or from footwear increases risk of insertional Achilles tendinopathy

Diagnostic Cluster From Martin et al (mid-substance):

- Pain 2-6 cm proximal to the Achilles tendon insertion
- gradual onset
- TTP at midportion of tendon
- (+) arc sign
- Royal London Hospital Test

Martin et al, Silbernagel et al

Typical Presentation

From Silbernagel et al and Aicale et al:

- Gradual onset of symptoms
- Stiffness in the morning or after long periods of sitting
- Pain with activity (running/jumping/stairs); usually worst at the beginning and shortly after the end of an exercise session; pain during whole activity in progressed stages

Pathological Drivers

Anatomical

- Any anatomical deviations leading to excessive foot pronation (increased tensile stress on Achilles with arch collapse)

Biomechanical

- Tight and weak triceps surae, reduced ankle ROM, prolonged or excessive foot pronation with gait, reduced hip/knee neuromuscular control

Activity/Training

- Repetitive stress/strain with inadequate recovery for tissue remodeling, active populations, running/jumping sports, “too much too soon,” poor technique

Environmental

- Running/walking uphill, or on hard/uneven terrain

Equipment

- Shoes that are too tight, inadequate heel lift in presence of ankle ROM deficit, shoes that are too hard or compress Achilles tendon, switch from shoe with heel lift to zero drop w/o adequate progression

Personal

- Increased body weight, family Hx, inflammatory conditions, diabetes, corticosteroid use

Silbernagel et al

Use this for pain monitoring/progression with tendinopathies!

1. The pain is allowed to reach 5 on the NPRS during the activity.
2. The pain after completion of the activity is allowed to reach 5 on the NPRS.
3. The pain the morning after the activity should not exceed a 5 on the NPRS.
4. Pain and stiffness are not allowed to increase from week to week.

Intervention

Education/Activity Modification
- Education on purpose of exercises, pain monitoring (teach NPRS), and expected prognosis
- Discussion of load management – complete rest is not indicated (continue activity within "acceptable" pain tolerance)
- Temporarily avoid running on hard, uneven, or slanted surfaces

Modalities
- **Iontophoresis** – effective in reducing acute pain
- **Taping** – no significant effect on pain but may reduce strain on Achilles with rigid taping techniques
- **Manual** – if restrictions present, consider using joint mobes and STM to increase ROM
- **Extracorporeal shockwave therapy** – effective for acute pain relief and tissue healing; best combined with exercise

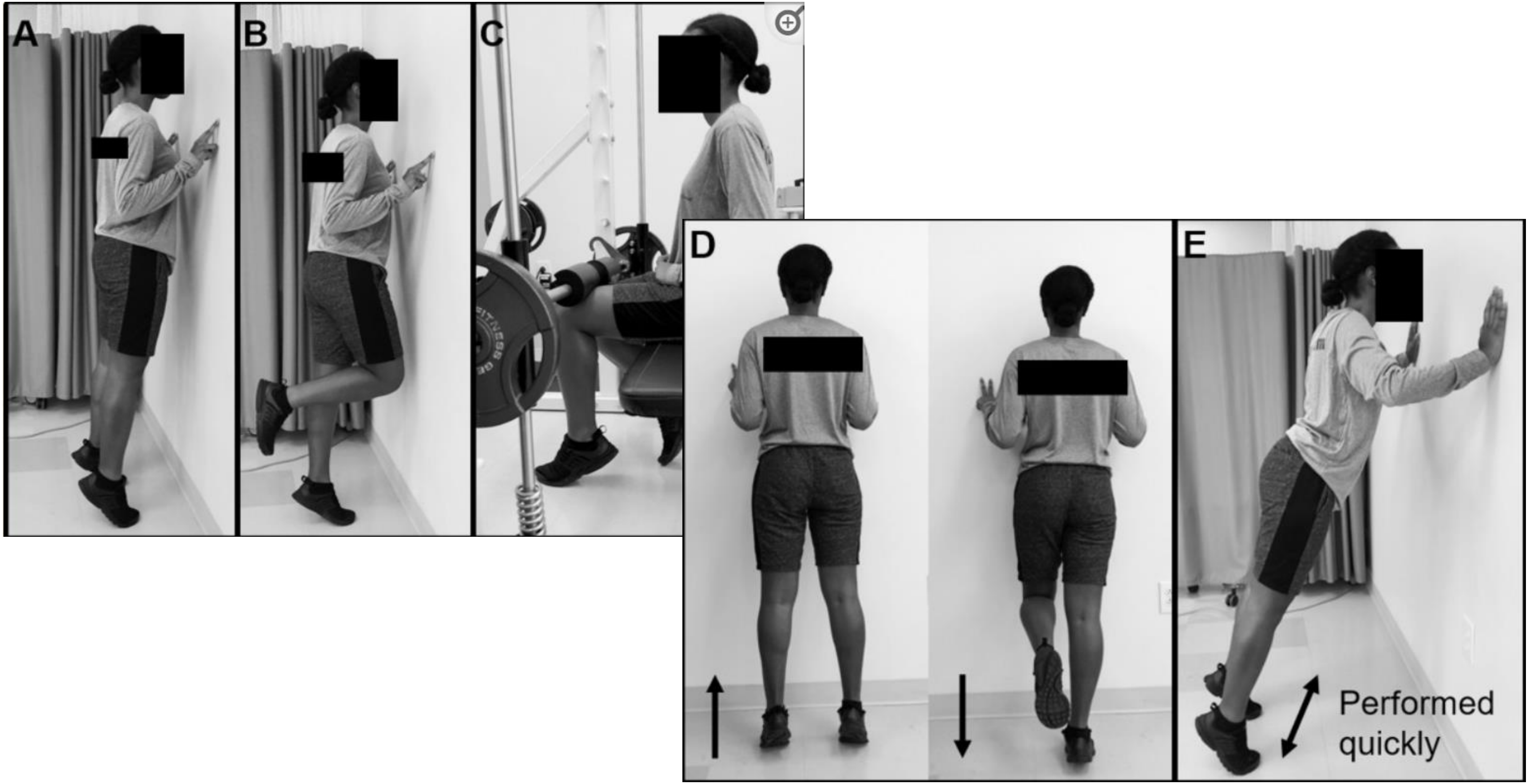
Orthoses
- Generic or custom inserts may reduce strain on Achilles but not supported in the literature for pain reduction (ex: heel lift/arch support); clinical commentary – success alleviating pain with custom inserts to manage drivers of pronation if present

Footwear

- Properly fitting footwear to avoid irritation of the Achilles tendon (padded heel?)
- Neutral shoe with arch support to prevent arch collapse with pronation, driving increased tensile loads
- Use heel lift, especially in insertional to prevent high compressive loads b/t Achilles tendon and calcaneus in end range DF during gait

Exercise

- Cornerstone of treatment for Achilles tendinopathy
- 4 Phases as Described in Silbernagel et al:
  1) **Symptom Management and Load Reduction**
     - Halt negative cycle of overloading and injury progression (manage drivers)
     - Consider cycling/swimming to maintain cardiovascular fitness
     - Begin loading using NPRS as guide; consider initiating hip/knee strengthening/stability exercises in this phase
       - Isometrics, 2 up 1 down eccentrics, Concentrics in modified plantigrade
  2) **Recovery**
     - Regain strength in calves and improve Achilles tolerance to loads (frequency/duration/velocity); exercise daily
  3) **Rebuilding**
     - Heavier strength training of calf muscles; initiate running/jumping activities (3x15)
     - Progress jumping bilateral to unilateral
  4) **Return to Sport**
     - Resolution of symptoms with sport or goal specific training



Silbernagel et al

Conclusion

Ask yourself these 3 questions:

1) What is the desired activity (goal) "asking" of the foot and ankle?
2) What is the foot and ankle able to give based on anatomical/biomechanical "resources?"
3) Is the "ask" too big, are the "resources" inadequate, or both?

Intervention: Decrease the "ask" and increase the "resources" to achieve the goal. The "ask" can increase once the "resources" have. "Resources" can be increased with tissue adaptation through rest/training and/or external support.

Both the great challenge and the great joy of our line of work lie in the complexity of the people to whom we provide our services. Growing as a therapist means embracing that challenge. Use the subjective/objective exam to paint a clinical picture. This should reveal the origin site and tissue causing the problem and the internal/external conditions "driving it." Manage the condition by addressing the drivers. CPGs should *inform* practice, but foundational knowledge and investigative skills should *guide* it.

Special Thanks

Dr. Mike Gross

Dr. Jeff O'Laughlin

References

1) Slides adapted from Dr. Mike Gross, MSK II, *Foot and Ankle Biomechanics*
2) Slides adapted from Dr. Mike Lewek, Biomechanics, *Foot and Ankle and Lower Quarter Screen*
3) Babu D, Bordoni B. Anatomy, Bony Pelvis and Lower Limb: Medial Longitudinal Arch of the Foot. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; November 11, 2022.
4) Dubin A. Gait: the role of the ankle and foot in walking. *Med Clin North Am*. 2014;98(2):205-211. doi:10.1016/j.mcna.2013.10.002
5) Trojian T, Tucker AK. Plantar Fasciitis. *Am Fam Physician*. 2019;99(12):744-750.
6) Martin RL, Davenport TE, Reischl SF, et al. Heel pain-plantar fasciitis: revision 2014. *J Orthop Sports Phys Ther*. 2014;44(11):A1-A33. doi:10.2519/jospt.2014.0303
7) Morrissey D, Cotchett M, Said J'Bari A, et al. Management of plantar heel pain: a best practice guide informed by a systematic review, expert clinical reasoning and patient values. Br J Sports Med. 2021;55(19):1106-1118. doi:10.1136/bjsports-2019-101970
8) Kurup H, Vasukutty N. Midfoot arthritis- current concepts review. J Clin Orthop Trauma. 2020;11(3):399-405. doi:10.1016/j.jcot.2020.03.002
9) Hallinan JTPD, Statum SM, Huang BK, et al. High-Resolution MRI of the First Metatarsophalangeal Joint: Gross Anatomy and Injury Characterization. *RadioGraphics*. 2020;40(4):1107-1124. doi:https://doi.org/10.1148/rg.2020190145
10) Senga Y, Nishimura A, Ito N, Kitaura Y, Sudo A. Prevalence of and risk factors for hallux rigidus: a cross-sectional study in Japan. BMC Musculoskelet Disord. 2021;22(1):786. Published 2021 Sep 13. doi:10.1186/s12891-021-04666-y

References

11) Shamus J, Shamus E, Gugel RN, Brucker BS, Skaruppa C. The effect of sesamoid mobilization, flexor hallucis strengthening, and gait training on reducing pain and restoring function in individuals with hallux limitus: a clinical trial. *J Orthop Sports Phys Ther*. 2004;34(7):368-376. doi:10.2519/jospt.2004.34.7.368
12) Finch R. Hallux Rigidus. Plus Course 2023 via Physiopedia
13) Colò G, Fusini F, Samaila EM, et al. The efficacy of shoe modifications and foot orthoses in treating patients with hallux rigidus: a comprehensive review of literature. *Acta Biomed*. 2020;91(14-S):e2020016. Published 2020 Dec 30. doi:10.23750/abm.v91i14-S.10969
14) Zbojniewicz AM. Impingement syndromes of the ankle and hindfoot. Pediatr Radiol. 2019;49(12):1691-1701. doi:10.1007/s00247-019-04459-5
15) Brockett CL, Chapman GJ. Biomechanics of the ankle. *Orthop Trauma*. 2016;30(3):232-238. doi:10.1016/j.mporth.2016.04.015
16) Khlopas H, Khlopas A, Samuel LT, et al. Current Concepts in Osteoarthritis of the Ankle: Review. Surg Technol Int. 2019;35:280-294.
17) Silbernagel KG, Hanlon S, Sprague A. Current Clinical Concepts: Conservative Management of Achilles Tendinopathy. J Athl Train. 2020;55(5):438-447. doi:10.4085/1062-6050-356-19
18) Martin RL, Chimenti R, Cuddeford T, et al. Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy Revision 2018. J Orthop Sports Phys Ther. 2018;48(5):A1-A38. doi:10.2519/jospt.2018.0302
19) Aicale R, Oliviero A, Maffulli N. Management of Achilles and patellar tendinopathy: what we know, what we can do. J Foot Ankle Res. 2020;13(1):59. Published 2020 Sep 29. doi:10.1186/s13047-020-00418-8
20) Bass E. Tendinopathy: why the difference between tendinitis and tendinosis matters. Int J Ther Massage Bodywork. 2012;5(1):14-17. doi:10.3822/ijtmb.v5i1.153