The Foot:
Functional Evaluation & Treatment for the Active Patient
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Welcome!

• Instructor: Chance Unger PT, DPT, OCS, ATC
• Education:
  ○ UNL (Athletic Medicine)
  ○ UNMC (Doctor of Physical Therapy)
  ○ ABPTS (Orthopedic Clinical Specialty)
• Things I like:
  ○ Being with my wife & 3 kiddos
  ○ Running, writing, reading, hiking, travel
  ○ Good craft beer & coffee
• Lesser known facts:
  ○ Skydiving in 2009
  ○ Mountain climber
  ○ Operate a non-profit
Objectives

- Confidently define the functional anatomy and biomechanics of the foot.
- Differentiate between primary musculoskeletal disorders of the foot to secondary & tertiary types.
- Properly explain the primary differences in shoe wear to the active patient and it's meaning on foot biomechanics.
- Successfully evaluate most musculoskeletal disorders of the foot and/or lower leg.
- Successfully set out a treatment plan specific to foot care for most musculoskeletal disorders.
What to expect from this course

1. Gain more tool skills in your objective skillset
2. Learn a more dynamic, holistic approach to foot (and ankle) care for the active patient
3. Get practical "hands on" tools for the 'toolkit' in treating the foot & ankle.
4. Learn a greater understanding in an evidence-biased approach to think critically about treating the foot for the active patient.

Introducing...

- What is the foot?
- One of the most dynamic, functional, and complex musculoskeletal areas of your body is often underappreciated, unaddressed, and poorly understood.
- The foot is what makes humans capable of performing almost every normal and extraordinary task in life. It is the foundation of the rest of the body.

Things we can do because of our feet

- Walk
- Run
- Jump
- Hike
- Dance
- Shovel snow
- Ski
- Compete in athletics
- Drive
- Chase kids in the yard
- Swim
- Play
- __________
Relative Anatomy

- **Muscles: Plantar Surface**
  - Superficial (First) Layer
  - Intrinsic:
    - Second layer
    - Third layer
    - Fourth layer

- **Muscles: Dorsal Surface**
  - Extrinsic

- **Joints & Ligaments**
  - Quite a few

- **Bones**
  - 28 in all

Plantar Foot Muscles

- **Extrinsic: First Layer**
  - Your great toe, and your fifth digit, as well as the crew helping to control digits 2-4.
  - Most superficial
  - Innervated by medial/lateral plantar ns.

Plantar Foot (cont.)

- **Intrinsic: Second Layer**
  - Assist with digits 2-4, mostly.
  - Especially helpful in flexion of digits and working like lumbricals of the hands (ext. IPJ; flex MPJ)
  - Medial & lateral plantar ns.
Plantar Foot (cont.)

- **Intrinsic: Third Layer**
  - 3 associated w/ hallux, 1 w/ mini
  - Appreciate the “triangular” shape of how in-trinsics assist the midfoot
  - Medial & lateral plantar ns.

Plantar Foot (cont.)

- **Intrinsic: Fourth Layer**
  - Assist w/ digits of adduction, abduction, and MTP flexion
  - Lateral plantar n.

Dorsal Foot Muscles

- **Extrinsic**
  - Appreciate everything going on here!
  - Lots of extrinsic attachments from lower leg
  - Assistance with digits 1-5, midfoot, and mortise joint function.
Dorsal Foot Muscles

- **Intrinsic**
  - Both aid in extension of the hallux and digits 2-5.
  - Deep fibular n.
  - Hidden, underneath longusms.

Bones & Joints

Repeat:
The foot is a complex structure.
Geography of the Foot

- Regions
  - Hindfoot
  - Midfoot
  - Forefoot

- Columns
  - Medial column
  - Lateral column

- Arches
  - Medial
  - Lateral
  - Transverse

Arches

- Regions & columns relate sections of the foot in one way, but arches help unite a functional pattern in how the foot is designed to function.

- Similar to a bridge arch, those in our foot are properly designed to dynamically absorb and reproduce forces that can be used functionally.

- Arches can be seen as the functional unity & connection between specific muscles, tendons, ligaments and bones.

Biomechanics

- Foot Mechanics
  - Digits, forefoot, midfoot, heel & mortise work together to obtain dynamic stability.

- Ankle Mechanics
  - 4 cardinal motions
  - Circumduction

- Gait Cycle
  - Walking
  - Running
The foot & ankle are ineffective without one another. All of the joints and regions of the foot combine to orchestrate the possibility to stabilize the body in all 3 primary planes of motion: frontal, transverse, sagittal. As the hip and shoulder are rounded and provided high levels of mobility with less stability, the foot/ankle complex is designed specifically to build off of contact from the ground. In short: contact must be made!

Biomechanics (cont.)

A few functional uses of the foot:
- Propulsion & Gait
- Shock absorption
- Traction & Grip
- Tactility

Even the best artificial designs cannot equal the foot & ankle complex's amazing design, but they will still try.
Open & Close Packed Positions

- Close packed position: "the position in which there is maximum congruency of the articular surfaces and joint stability is derived from the alignment of bones."
- Maximizing optimal joint biomechanics "sets the stage" for best function.

<table>
<thead>
<tr>
<th>Open-packed Position</th>
<th>Close-packed Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position with the least amount joint surface congruency</td>
<td>Position with the most amount of joint congruency</td>
</tr>
<tr>
<td>Capsule and support ligaments are lax</td>
<td>Capsule and supporting ligaments maximally tight</td>
</tr>
<tr>
<td>Accessory motion or joint play is maximized</td>
<td>Accessory motion is minimized</td>
</tr>
</tbody>
</table>

Biomechanics

- **Important factors**
  - Strike pattern
  - Location
  - Step length
  - Stride length
  - Foot angle

About Common Complaints

- Though the foot is common to multiple types of complaints, affecting the skin, nails, and other parts of the foot, this presentation is specific to musculoskeletal conditions that physical therapy & athletic medicine can routinely address.

- Common types of MSK complaints include:
  - Bony: arthritic changes, stress fractures & stress reactions
  - Muscular: tendon, muscles affected
  - Neurological: entrapments, neuropathy
Musculoskeletal Complaints

- Heel
  - Achilles tendinosis/itis
  - Sever's disease
  - Plantar heel pain (fascitis, fasciosis)
- Midfoot
  - Arch pain, Lisfranc, Navicular drop
- Forefoot
  - Morton's neuroma
- Ligament
  - Deltoid or lateral ligaments

Musculoskeletal Complaints

- The region and tissue of the involved problem will often help guide treatment goals, but not without proper understanding of their interconnected relationship.
  - It is essential to know the biomechanical relationships, and external/internal influences of the foot in order to set goals and provide good treatments.

- General questions to consider:
  - What tissue is involved? How malleable is this tissue to treatment?
  - How long has the problem persisted?
  - Are there any systemic influences on the problem?
  - What can I do to persuade a (proper) lifestyle change in this person?

Extrinsic Causative Factors

- Often times, common MSK foot complaints are bundled up under a few different names like “plantar fasciitis”, “plantar heel pain”, etc.
- But what are the reasons we end up with these issues in the first place?
- One great challenge in evidence is standardizing lifestyles and steps to validate and understand etiology.

- Challenge: How many people do you know (of) who rarely wear shoes and have typical foot MSK complaints?
Extrinsic Causative Factors

- Multiple external causative factors influence non-acute disorders of the foot:
  - Shoes:
    - Size
    - Shape
    - Reliance (length of time)
  - Orthotics:
    - Prolonged use
    - Type (rigid vs. semi rigid vs. soft)
  - Time on feet per day
  - Environment
  - Others

"Itis" or "Osis"?


- Summary:
  "Histologic findings are presented to support the thesis that "plantar fasciitis" is a degenerative fasciosis without inflammation, not a fasciitis. These findings suggest that treatment regimens such as serial corticosteroid injections into the plantar fascia should be reevaluated in the absence of inflammation and in light of their potential to induce plantar fascial rupture."

- Indications include an alteration of treatment approaches for allied health providers as well, including addressing more permanent effects on histology over more malleable things like the inflammatory response.
  - How many of us are trained in manual techniques focused on the inflammatory response?
A case for spending less shoe time

- **Feet** are: mobile, stable, strong, and transport power extremely well.
- **Shoes** are: tools, filters, protectors, fashionionables, etc.
  - Shoes influence everything you feel.
- Shoe manufacturing goal: provide shock absorption & pronation (or supination) control, stabilize the foot.
- Are your shoes serving your foot’s functional needs? If not, find a new filter.
- Shoes are temporary, feet are permanent.

What should a foot look like?
Shod & Barefoot walking kinematics

Barefoot vs common footwear: A systematic review of the kinematic, kinetic and muscle activity differences during walking
(Franklen et al.)

- **Findings:**
  - "Footwear particularly affects the kinematics and kinetics of gait acutely and chronically."
  - Footwear can constrict the structure and function of the foot.
  - Short and long-term use of footwear affects the kinematics and kinetics of gait.
  - Habitual barefoot walkers show considerable anatomical and functional differences.

Comparing static foot posture and functional foot abilities

Predicting Dynamic Foot Function From Static Foot Posture: Comparison Between Visual Assessment, Motion Analysis, and a Commercially Available Depth Camera
(Patterson et al, 2015)

- **Summary:**
  - Relationship between static foot posture & dynamic rearfoot & midfoot kinematics were "fair to moderate at best"
  - FPI-6 still has value, but must be used contextually

High heels’ effect on muscles, tendons

On muscle, tendon, and high heels
(Csapo, 2010)

- **Findings:**
  - "We conclude that long-term use of high-heeled shoes induces shortening of the GM muscle fascicles and increases AT stiffness, reducing the ankle’s active range of motion."
  - Both anterior and posterior muscles & tendons were adversely affected from chronic use of high-heeled shoes.
  - No influence of isometric strength between groups
The hallux position and blood flow

Passive hallux adduction decreases lateral plantar artery blood flow: a preliminary study of the potential influence of narrow toe box shoes (Jacobs et al., 2019)

- **Findings:**
  - "Our preliminary findings of decreased blood flow through passive hallux adduction indicate conditions that elicit passive hallux adduction (e.g., wearing narrow-toed shoes) may have important effects on foot blood flow."
  - Nearly 25% reduction in blood flow with passive hallux adduction
  - Testing was at maximal, passive hallux adduction
  - Low arch height index plus hallux adduction correlate with reduced blood flow
Walking barefoot and knee osteoarthritis

Walking barefoot decreases loading on the lower extremity joints in knee osteoarthritis (Shakoor et al.)

- Findings:
  "Shoes may detrimentally increase loads on the lower extremity joints. Once factors responsible for the differences in loads between with-shoe and barefoot walking are better delineated, modern shoes and walking practices may need to be reevaluated with regard to their effects on the prevalence and progression of OA in our society."
  - Peak joint loads at the hips and knees significantly decreased
  - 11.9% reduction noted in the knee adduction moment.
  - Stride, cadence, ROM also increased

When does maximal pronation occur?

Differences in Static and Dynamic Measures in Evaluation of Talonavicular Mobility in Gait (Dicharry et al. JOST, 2009)

- Differences in navicular mobility between foot type groups during walking and running indicate that factors other than static alignment affect dynamic foot mobility.
- Maximal pronation occurs just after midstance
- Shoe industry has made stabilizers in shoes to support at mid-stance. This is important to consider when prescribing shoes:
  - Materials designed in lots of shoes (designed to "stop" pronation/overpronation) are not actually touching the ground when most 'needed'

What about shoewear and intrinsics?

The effect of minimal shoes on arch structure and intrinsic foot muscle strength
Miller et al. (JOSHS, 2014)

- Findings:
  "These results suggest that endurance running in minimal support footwear with 4 mm offset or less makes greater use of the spring-like function of the longitudinal arch, thus leading to greater demands on the intrinsic muscles that support the arch, thereby strengthening the foot."
  - Land with more MFS, FFS
  - Increased intrinsic muscle size
  - Higher/stronger arches
Muscle function, size vs. pain levels

**Muscle Function and Muscle Size Differences in People With and Without Plantar Heel Pain: A Systematic Review**
(Osborne et al, 2019)

- **Their conclusion:**
  
  “People with plantar heel pain have reduced strength and volume of the foot muscles, but there is no discernible difference in calf muscle endurance. Accordingly, the role of muscle strength in plantar heel pain is worthy of further investigation.”

  - Low GRADE ratings of research indicates more change will occur.
  - Muscle volume was lower in those with pain
  - Hallux plantar flexion, lesser toe plantar flexion, ankle dorsiflexion, ankle inversion, and ankle eversion strength values were reduced in those with heel pain

Plantar heel pain and orthotics

**Impaired Foot Plantar Flexor Muscle Performance in Individuals With Plantar Heel Pain and Association With Foot Orthosis Use**
(McClinton et al, 2016)

- **Findings:**
  
  “Ankle plantar flexor and toe flexor muscle performance was impaired in individuals with plantar heel pain and associated with longer duration of self-reported foot orthosis use.”

  - Small sample size (54 total)
  - Strength tests of PF, hallux, and digits 2-5

Foot strengthening in runners

**Foot Core Training to Prevent Running-Related Injuries: A Survival Analysis of a Single-Blind, Randomized Controlled Trial**
(Taddel et al, 2020)

- **Findings:**
  
  - 2 groups had varied RRI specifically dictated by intrinsic strengthening
  - Non-intrinsic strength group was almost 2.5x more likely to obtain RRI (at 12 mo!)
  - Correlations w/ length of time to obtain RRI in those still injured w/ intrinsic training
Intrinsic Causative Factors

- **Primary factors:**
  - Anatomical or Systemic
  - Neuromuscular

- **Secondary factors:**
  - Neuropathies
  - Previous injury/pathology

- **Tertiary:**
  - Shoewear
  - Job style
  - Prolonged positions

Outliers

- Accessory bones are often found on inner/underside of the foot:
  - Os Trigonum (posterior to talus) [1]
  - Os Peroneum (near calcaneocuboid joint) [2]
  - Navicular (off of said bone, 3 types) [3]

- Congenital deformities:
  - Talipes Equinovarus ("club foot")
  - Metatarsus Adductus ("bean foot")
  - Pes planovalgus (pes planus)
  - Bony fusions
Bone Stress Injuries

- Stress reactions and stress fractures have a notable influence in patient populations that can easily be misunderstood to the general person.

- High risk areas of the foot/ankle:
  a. Medial malleolus
  b. Talus
  c. Navicular
  d. Proximal 5th metatarsal
  e. Base of 2nd metatarsal
  f. Hallux sesamoids

- Low risk areas of the foot/ankle:
  a. Lateral malleolus
  b. Calcaneus
  c. Shaft of metatarsals 2-4

Tracking overall load

Session Rating of Perceived Exertion Combined With Training Volume for Estimating Training Responses in Runners
(Napier et al. 2020)

- Findings:
  "We found that the use of an internal training load measure (sRPE) in combination with external load (training duration) provided a more individualized estimate of week-to-week changes in overall training stress. A better estimation of training stress has significant implications for monitoring training adaptations, resulting performance, and possibly injury risk reduction."

  - Tracked time, steps, cumulative shock (and product combined) + sRPE
  - Helps quantify different ways to assess overall loading other than time/distance
Evaluation of the Foot & Ankle

- **SOAP**
  - In addition to standard SOAP evaluation, here are a few good things to add:
    - Shoe history, wear, and preference
    - Shoe variety
    - % of time out of shoes
    - Job/Habit patterns: standing vs. sitting, repetition vs. stand-alone work, length of time during the day.

- **Tests & Measures**
  - **Muscle Tests**
  - **Range of Motion**
    - Gross, PROM, AROM
  - **Ligamentous/Joint**:
    - Subtalar
    - Midfoot
    - Hallux
  - **Specials**
    - Talar tilt
    - Anterior drawer
    - Navicular drop
    - Impingement at Mortise
    - Morton's
    - Windlass

Foot Evaluation Video:
**Evaluation & Screens**
Tests & Measures

- 30/30 Foot & Ankle ROM Screen
- Navicular Drop
- Windlass
- FHB/EHB Isolation
- SLS Test
- Swing Test
- Gait Analysis
  - Walk and/or run
- Single Leg Heel Raise Test (Height)
- SL HR (Total) (cf. Hebert-Losier et al.)
- SL Hop-in-Place Test
- Foot Posture Index (FPI-6)
- Lower quarter screens:
  - St. Squat
  - Squat
  - Jump

Foot Evaluation Video:

Functional Tests

How is therapy being utilized?

Utilization of Physical Therapy Intervention Among Patients With Plantar Fasciitis in the United States
(Fraser et al, 2016)

- Findings:
  - 7.1% of patients with PF diagnosis received physical therapy
  - Manual therapy was largely utilized (87%)
  - 1/10 did not receive treatment following evaluation
Effective Treatment Techniques

- Organizing treatment based on: goals & movement > local deficit. A way of categorizing:
  - What to screen & test
  - How to treat the patient
  - What to record in longevity

- Treatment can be complex, but we can break it down into elements/components:
  - Mobility
  - Stability
  - Strength
  - Power
  - Endurance
Foot Treatment Video: **Strength**

Foot Treatment Video: **Power**

Foot Treatment Video: **Endurance & Function**
Treatment Summaries

**Mobility**
- Kneel & Lunge PF stretch series
- Midfoot pronation & supination stretch
- Heel cup
- Suralis stretch
- Hallux met head JM (AP/PA, lateral glide)
- SCM to intrinsics dorsally (EHB, lumbricals)
- Manual toe splay
- Hallux ABD w/ band

**Stability**
- Hallux ABD w/ band
- Including FHL/SH isolations
- Toe splay
- "Torning"
- SLS Series
- Runner’s SLS
- Half moons, leg swings, zig zags, circles
- SLS under heel (promote PF)
- Surface change: BOSU, DD,
- Others: Airex, rocker, wobble board
- Eyes closed
- INV/EV w/ TB
- FHL/SH isolation (sit, stand, SLS)

**Strength**
- Step up with March and OP
- Donkey kicks w/ PF and resistance
- Eccentric hill-off start
- Side步 HR
- Creepers F/B, S/S
- 3-way lateral lunge
- Goodness
- SL, RL
- Squat to heel raise
- SL Squat (barefoot or w/ band)

**Power**
- Metronome March Progressions
- Skip series:
  - A skip
  - C skip
  - D skip
- Hop series:
  - SL vs. DL (F/B, S/S, diagonal)
  - On
  - On/Off
  - Lateral
  - Lateral slides

**Endurance & Function**
- Jump Rope series (DL, SL, alternating, kicks, lateral hops, scissors, etc.)
- Treatment series (hip extension variations, arm exaggeration, plant and push, SL, reverse)
- Outside play

**Endurance & Function**

**Treatment Tips**
- Know your angles.
- Incorporate real-life demands.
- Use the whole foot.
- Treat locally, regionally, and globally.
- Follow the five (categories).
- Don’t overcomplicate things.
- Play a little bit.
Case Stud(ies)

- **Gregory Chant**
  - **S**- 21 y/o male. Bunionectomy, “Family history” of hallux valgus. No previous conservative care for hallux valgus.
  - **Tx**: Spacer between 1st, 2nd digits. Foot posture intrinsic training in seated, standing, SLS. ABD Hallucis brevis emphasis. Manual care of midfoot intrinsics.
  - **Result**: 6 weeks of post/op PT w/ full recovery.

Case Stud(ies)

- **Carole Singer**
  - **S**- 19 y/o female. Hx of club foot and midfoot problems in youth. Tubing accident resulting in reconstructive midfoot sx.
  - **O**- MMT, AROM, PROM; Gait all from scratch. Narrow foot, closed/compacted phalanges, and pes planus.
  - **Tx**: Implementing intrinsic stabilization, WB w/ proper foot posture. Utilization of lace-up ankle brace w/ arch support.
  - **Result**: Continued improvement, but especially buy-in from the patient through the process.

Case Stud(ies)

- **Justin Thyme**
  - **S**- 30 y/o male. Runner, local PT w/ 10 hour shifts. No injury hx. Medial foot pain w/ work. 6x improve w/ running.
  - **O**- Accessory navicular, and pes planus (R). Hallux valgus (R side). MMT WNL, AROM WNL. Inability to perform FHB/EHB Isolation. Trigger points at post. Tib. SL Squat 4/6, Heel raise max (R- 20, L- 40), HR height L<R.
  - **Tx**: Toe spacers, manual stretching, and intrinsic foot strengthening. New shoewear w/ wide toe boxes, zero heel drop.
  - **Result:**
Conclusion

- The foot is an essential and nearly irreplaceable part of movement for the human person.
- It's vast & dynamic capabilities are the foundation for wellness and functional norms in ordinary circumstances.
- Knowing more about the foot, it’s relationship to the ankle and lower extremity can give tools to the provider and patient that promote speedy recovery of ailments, as well as lowering risk of external causes of ailments.
- A well balanced approach to the foot and above in treatment assists in better results.
- A solid foundation assists to the tip top.

Thanks!
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Other Webinars:
- Essential Clinical Concepts in Biomechanical Analysis, Rehabilitation, & Injury Prevention for the Runner
- Running Rehabilitation Principles: In-Depth Biomechanical Analysis & Treatment
References


Additional references include effects of age on strength and morphology of toe flexor muscles, impaired foot plantar flexor muscle performance in individuals with plantar heel pain and association with foot orthosis use, treatment of progressive metatarsophalangeal and collateral ligament injury, foot core training to prevent running-related injuries, and common accessory ossicles of the foot.