Knee, Foot and Ankle: Treating Walkers, Runners and Athletes that Need to Run

Advanced Interventions focused on treating Foot and Ankle Gait Impairments

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No Disclosures!

Except that I am a Foot Nerd!
Foot and Ankle related Clinical Practice Guidelines linked to the International Classification of Function, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association:


ICF Methodology

The overall strength of the evidence supporting recommendations made in clinical guidelines will be graded according to guidelines described by Sackett.

<table>
<thead>
<tr>
<th>Grades of Recommendation Based On</th>
<th>Strength of Evidence</th>
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<tbody>
<tr>
<td>A</td>
<td>Strong evidence</td>
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<tr>
<td>B</td>
<td>Moderate evidence</td>
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<td>C</td>
<td>Weak evidence</td>
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<td>Conflicting evidence</td>
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<td>E</td>
<td>Theoretical/foundational evidence</td>
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<td>F</td>
<td>Expert opinion</td>
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- A: A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study.
- B: A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation.
- C: A single level II study or a preponderance of level III and IV studies including statements of consensus by content experts support the recommendation.
- D: Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies.
- E: A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion.
- F: Best practice based on the clinical experience of the guidelines development team.

Individual clinical research articles graded according to Center for Evidence-Based Medicine, Oxford, UK.
Potential Causes of Injury to the Foot/Ankle During Running or Walking

- Lower extremity overuse injuries are multifactorial  
  (Taunton et al 2002)
- A function of segment dysfunction and other segment(s) compensation (ie – Pelvis, Hip, Knee, Foot)

**Determinants:**
- Body mass
- Gait speed
- Landing kinematics
- Propulsion kinematics
- Shoe properties
- Surface properties/gradient  
  (Novachek 98)
Landing Phase/Impact: Stance Phase

Potential causes of walking/running injuries

- **Running Technique/ Foot strike index** Napier et al 15
- **Foot and buffering device (shoe, orthoses)**
- **Impact/Vertical loading rate** Napier et al 15
- **Decreased PE/KE** Novachek 98
- **Stability during ground contact**
- **Excessive hindfoot eversion** Napier et al 15
- **Braking response:** body mass center descends and forward speed decreases during early to mid-stance Hamner et al 10
- **Positioning for propulsion**
Running: Stance Phase Kinetics

Hindfoot strike

Forefoot strike

Lieberman DE et al 10
Propulsion Phase: Late Stance Phase

Potential causes of walking/running injuries

• Sagittal and Vertical vector for lift and clearance

• Proximal weakness/ Segment sequencing/efficiency

• The body mass center travels upward and its forward speed increases during mid- to late stance Hamner et al 10

• Sequential pattern of foot motion from pronation (adaptive) to theoretical supinated lever for propulsion in terminal stance

• Increased PE/KE Novachek 98

• Muscular power

• Control foot position during propulsion
Tri-planar Motion of the Foot

**Supination**
- Plantar flexion
- Inversion
- Adduction

**Pronation**
- Dorsiflexion
- Eversion
- Abduction

*The FOOT:*
Adjustable Stiffness
Foot Pronation

**Triplanar** motion consisting of:
- Talar Dorsiflexion
- Talar Adduction
- **CALCANEAL EVERSION**: Easiest to measure clinically and experimentally

**Related Pathomechanics include:**
1. Primarily Frontal and Transverse plane motion
2. Contralateral pelvic drop
3. Femoral IR
4. Knee valgus
5. Tibial internal rotation
6. Foot pronation  

Powers et al. 03
Gait Impairments at the Foot and Ankle

Add video clips to demonstrate each??

• Sagittal- Lack of ankle dorsiflexion, 1st MTP extension
• Frontal- Excessive mid and hindfoot pronation
• Transverse- Forefoot Ab/Adduction

Gait Impairments: Proximal Effects

• Sagittal- Compromised Hip extension, Aberrant Lumbo-Pelvic motion
• Frontal- Lateral translation in stance, Adduction of LE, Pelvic drop
• Transverse- Excessive coupled motion? Femoral / Tibial rotation, Lumbo-Pelvic rotation
Common Deformities/Dysfunction of the **Sagittal Plane**

Lack of Ankle Dorsiflexion and/or Hallux Extension

Reduction in MTP joint motion accommodated by various gait adjustments:
- Foot and leg external rotation
- Shortened stride
- Increased ankle, knee, or hip motion
- No Hallux extension/No preload of PF or loaded excessively,
  Changes Windlass mechanism

Lack of Hip Extension ROM and Power - distal effect or compensation?
Hip Extensors: Forward Propulsion/3rd Rocker
Common Deformities/Dysfunction of the *Frontal Plane*

- Foot Hyper-pronation/supination
- Osseus Morphology: Tibial Varum, Genu Varum/Valgum, Coxa vara/valga
- Strength/ Motor control: Role of *Invertors and Evertors* of the Foot and the Effect of Impairment?
Common Deformities/Dysfunction of the **Transverse Plane**

- Forefoot Abduction
  - Rotatory/Coupled motions of LE-Subtalar/MidTarsal function
  - Proximal control and structural influence
  - Pronation status
Case 1
Patient Case  First Ray Dysfunction

MS  31 y/o female  walker/runner, physician.
PMH- Onset 05/2016, Rock climbing- Boot NWB 4wks, Boot WB 2 wks
  - Developed R PTTD 1 year ago, no incident
  - R CAI 3 yrs,  Dx with psuedogout
Began PT 1/5/2017, 9 visits to 3/15/2017
Pain sharp and achy with day along TP, inc with walk > 1 mile, stand> 1 hr
Present- no pain with stand or walk
Goal- Run TIW, Dance, Walk, Stand at work
First Metatarsal-Phalangeal MTP Joint

**Normal gait requires up to 75° of 1st MTP extension**
The last Level for propulsion: 3rd Rocker

Propulsion occurs as result of:
- heel lift
- STJ supination
- Midfoot stability
- normal sesamoid function
- FHL length
- Windlass mechanism

Vital Interface with Medial Cuneiform

Ligament /Capsular Laxity?
First Ray Function

- Pulley system activated at heel-off where 1\textsuperscript{st} MT head glides proximally on the sesamoid apparatus. Richardson 99 Anwar 05 Hockenberry 99

- Capsular ligamentous complex of the MTP withstands 40% to 60% of body weight during normal gait. McCormick 10

- Barefoot walking 0.8 × body weight through the MTP on toe-off

- Increases to 200% to 300% with athletic activity and 800% with running and jumping. Mason & Malloy 15

- FHB active midstance through the end of propulsion by stabilizing the proximal phalanx against the metatarsal head and ground.
**FHL: Flexor Hallucis Longus**

- FHL force production is 70% of that of the lateral gastrocnemius.
- Primary restraint to passive dorsiflexion at the first MTP joint.
- Dorsiflexion of the first MTP and ankle joints can increase the distal excursion of the FHL up to 25 mm.
- FHL EMG activity increased significantly with increasing speed [Peter et al 2017](#).
- FHL stays relatively same length at 3\textsuperscript{rd} Rocker.
- FHL hypertrophies with low resistance training [Macedo et al 2014](#).
Hallucal Sesamoids

- Medial larger and injured more.
- 2 sesamoids embedded in the tendons of FHB
- Lateral in tendon of Adductor Hallucis
  Richardson 99
- Bipartite tibial sesamoid is present in 10% of the population and 25% bilateral.
- Sesamoids rest near the joint line.
- Should be within 5-10 mm for the tibial sesamoid and 7.6-13 mm for the fibular sesamoid Richardson99 Boike et al 11
- Should be within 3 mm of the sesamoid position on the contralateral foot Maskill 06
First Ray/MTP Pathology or Dysfunction?? Forefoot Instability?

- Turf Toe
- Hallux Limitus
- Hyper-Pronation/Pes planus
- FHL Tendinopathy  Boruta 97 Richardson 87 Romash 94
- Metatarsal Stress fx  Korpelainen et al 2001
- HAV/Bunion
- Sesamoid Injury Richardson 87
Hallucal Sesamoid Injuries

- 9% of foot and ankle injuries - 12% of hallux injuries
- Stress fracture (40%),
- Chondromalacia/sesamoiditis/synovitis (30%)
- Acute fracture (10%)
- Osteochondritis/AVN (10%)
- Osteoarthritis (5%)
- Bursitis (5%)

Omey 99, Dedmond 06 Hockenberry 99, Glasoe99, Muneura07, Yildirim 05, Kindred 11 Richardson 99 Schein 15
Hallucal Sesamoid Injuries

- Overuse > Trauma (Sesamoiditis)
- Repetitive microtrauma to Sesamoid apparatus via:
  - Proximal Sesamoid Retraction
  - Metatarsus primus elevatus
  - Immobility
  - ↓ 1st MT plantar flexion
  - Rotation of Long axis of 1st MT
  - FHB spasm
  - Retrograde 1st MPJ compression

D'Amico 04, Barske 12 Richardson 99
Hallucal Sesamoid Injuries  

Interventions:

- Surgical excision has been the norm!? (one not both)
- Treatment-Directed-Test (taping)
- Foot Orthoses
- Shoe accommodations
- Stretching
- Muscle conditioning
- Functional Exercises: Foot lunge progression, Soleus, Eccentric FHL, Proximal imbalances
- Running re-training
- Manual Therapy
- Modalities?

*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*

Shamus, et al 04
Forefoot/Sesamoid Mobilizations

- Plantar flex 1st MT
- Dorsi Flex 1st MTP
- Orient 1st MT Longitudinal Rotation?
- Proximal- Distal Glides
  Shamus 04
- Medial and Lateral glides

- VIDEO
Sesamoid Taping
Foot Lunge series

Retro Heel Raise

Forward Heel Raise

Basic Foot Lunge
- Lift medial arch
- Plantar Flex 1st MTP/FHL
- Lunge forward over foot

Foot Lunge with Hip ER Stabilization

Pelvic Pivot with Foot Lunge
Case 2: Patient Cases  Midfoot Instability
PTTD

Plantar spring ligament
Case 2
Patient Case  Midfoot Instability

JL 27 y/o male golfer, runner, baseball, hockey.
PMH- Developed R PTTD 1 year ago, no incident
  - R CAI 3 yrs, Dx with pseudogout
Began PT 1/5/2017, 9 visits to 3/12/2017
Pain sharp and achy with day along TP, inc with walk > 1 mile, stand> 1 hr
Present- no pain with stand or walk , no ankle brace
Goal- Return to sports
Case 2: Midfoot Instability: Compromised Propulsion?

• PTTD Occurs in 15% of population Richie 07, Giederman et al 00

• Pes Planus??

• Metabolic/Systemic:
  • Diet - BW
  • disease
  • endocrine problems
  • vascularity
  • iatrogenic
  • aging

• Adult Aquired Flatfoot Deformity:
  o Hindfoot valgus, forefoot abduction, first ray elevation
  o First metatarsal movement at the end range of dorsiflexion and unable to have full hindfoot inversion at push-off following LCL. McCormick 12, Barske et al 12, Richie 07
Navicular:

- Keystone for the Medial longitudinal arch.
- Undergoes the greatest displacement of any of the tarsal bones (Navicular Drop)
- Major muscle attachment.
Tibialis Posterior Dysfunction (PTTD)

- Ranges from acute teno-synovitis to rigid flat foot deformity - 4 stages
- Lose pulley effect
- Instability of os navicularis, ligaments, PF (basically all passive stabilizers)
- Weakness (supinators) - TP, soleus
- Metabolic/Systemic
- Mechanical /Flexibility
- Transverse plane dysfunction from forefoot abduction to Sacro-Iliac joint problems

In Runners:
- Level of activity - correlated with age
- Inadequate footwear
- Overpronating foot
- Changes in training  
  Kindred et al 2011
PTTD Assessment

• First MT Rise Test
• Double Heel Rise
• Tenography
• *MRI
• *Single heel rise
• *Too Many Toes Sign
• Patla TP Length test push navic and Met heads
dorsal while in eversion/DF + pain

*Less Reliable
Landing Phase/Impact Midfoot Patterns

- Maximum foot deformation occurs at maximum ground reaction force. Dicharry et al 09, Eslami et al 07

- Elastic components of plantar arch function as a spring, returning ~17% of the energy generated during each stance phase Bramble 04

- Forefoot motion patterns affect collapse of the medial longitudinal arch via the talonavicular joint Eslami et al 07
Midfoot Interventions: PTTD

- Muscle conditioning- cycle-elliptical-swim
- Mobilizations- Navicular whip, STJ, Fibula, Talus
- Soft Tissue Mobilization
- Test with Tape- low and high dye Hyper-Pronation Taping
- Foot Orthoses
- Modalities: Phonophoresis- Indomethacin Ice
- Stretching- Hip flexors, Gastroc-soleus
- Gait Training: Running/Walking techniques

**Exercises:**
- Foot lunge
- Full lunge with trunk/calf bias/Pelvic pivots
- Stork with FHL active
- Eccentric Tibialis Posterior/FHL Kulig et al
- **Inward Pivots**
  - Slocum (Internal Tib rotation/supination)
- Single Leg balance with contra 90-90-add wobble/soft Johnson C, Medbridge 14
Evidence for Anti-Pronation Taping

• Changes foot and leg posture
  • Increase in navicular height
  • Reduced internal rotation
  • Reduction in calcaneal eversion
  • Alteration in plantar pressure (med to lat)

• Reduction in pain
  • 20% immediately following application in individuals with plantar fasciitis
  - 5-20% 1-7 days following application in individuals with heel pain
  - Reduction in peak tibialis posterior and tibialis anterior EMG activity, 45% and 24% respectively.


[29 articles were identified]
Functional Exercises

Sitting Soleus

Knee Press

Short Foot

Wall Nod Flex at Hip

Step Down
Conclusions

1. Gait propulsion is dependent on proper Forefoot function and Midfoot stability.
2. Midfoot stability is affected by TP and PL strength with ligamentous or boney morphological effects. Can we screen for potential AAFFD progression and manage it or prevent it?
3. Tendon function is compromised by weakness, ligamentous instability, mechanics, imbalances, proximal strategy, etc..
4. Sesamoid mobility effects First MTP motion and FHL function
5. Appropriate interventions may be useful in the management of these conditions.
6. Specific Criteria for return to activity must be established!
Thank You!

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