Biomechanical Problems in Native Youth

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2015 IHS National Combined Council Winter Meeting
Friday, January 30, 2015
“We are all athletes, the difference is that some of us are in training, and some are not.”

George Sheehan, MD
Heel Pain

- Overview of heel pain
- Functional errors
- Contributing factors to injuries
- Differential diagnosis of heel pain
- Evaluation & treatment
Functional Errors

- Inadequate shoe support or wrong type
- Sport surfaces stress different muscle groups
- Kinetic chain dysfunction: muscle weakness, alignment, excessive pronation
- Compulsion for activity
Contributing Factors to Injuries

- Training errors
- Muscle dysfunction: strength & flexibility
- Footwear
- Training surfaces
- Biomechanical factors
- Psychological factors
Windlass Effect of Hicks

- Dorsiflexion of hallux produces an arch raising effect on the standing foot
- Dorsiflexion of the hallux winds the plantar fascia distally and then superiorly around the first metatarsal head
- Produces raising of arch as it shortens the distance from the origin of plantar fascia and distal first metatarsal head
- Calcaneal dorsiflexion and first metatarsal plantarflexion raise the medial longitudinal arch
Windlass Effect (continued)

- Medial band of plantar fascia under a lot of tension with while standing
- Most tension on plantar fascia when body wt. is balanced forward on toes, with met heads everted to the ground by STJ pronation
Plantar Fascia: biomechanical functions

- Holds the medial longitudinal arch in a higher arched position (prevents arch collapse)
- Assists in resupination of STJ during propulsion phase
- Assists deep posterior compartment muscles by helping limit STJ pronation during gait
- Assists plantar intrinsic muscles to maintain arch height
Plantar Fascia: biomechanical functions (continued)

- Prevents excessive interosseous compression forces on dorsal joint surfaces of bones of medial and lateral longitudinal arch
- Helps maintain purchase of digits during standing and prevents floating toes
- Acts to store energy with its inherent elasticity within arch for activity

Kirby, K. Foot and Lower Extremity Biomechanics (1997)
Two-pronged treatment approach

1) Pain and inflammation: NSAIDs, cortisone injection, physical therapy, ice, modified activity/cross-training

2) Cause: overuse vs. biomechanical: taping, shoe recommendations/modifications, training/conditioning, stretching, and orthotics

**must address cause, especially when it becomes chronic**
Differential diagnosis of heel pain

- Plantar fasciitis
- Calcaneal apophysitis (Sever Disease)
- Achilles tendonitis/bursitis
- Stress fractures
- Retrocalcaneal exostosis
- Posterior tendonitis
- Bone cysts/tumors
- Neuritis
- Bursitis
- Rhematological
Differential diagnosis of heel pain in young athletes

- Overuse/trauma: calcaneal apophysitis, fracture, contusion/strain
- Developmental: coalition
- Inflammatory: tendonitis, bursitis, os trigonum
- Infectious
- Rheumatologic: rheumatoid arthritis, Reiter synd.
- Tumorous: benign–bone cyst, osteochondroma
- Neurologic: tarsal tunnel syndrome
Plantar Fasciitis
Etiology of plantar fasciitis

- Any motion of the foot that puts the fascia in excessive stretch (increased pronation) or a contracture (cavus or supinated foot)
- Traction enthesitis on calcaneus
- Commonly near the origin of the plantar fascia
- Ankle joint equinus that produces hypermobility and increased pull on fascia
Plantar Fascia: Physical Exam

- Pain at medial heel near origin of fascia
- May also be into longitudinal arch
- Hallux dorsiflexion can increase pain
- Rule out calcaneal stress fracture or nerve entrapment
- Pes cavus and pes planus foot types
- Muscle tightness of calf and fascia
Evaluation and Assessment of Plantar Fasciitis

- Post static dyskinesia: cycle
- Tenderness on palpation of band, commonly near the origin at the medial tubercle of calcaneus
- May have edema and erythema
- Increased pain with ankle dorsiflexion from stretch on fascia
- Antalgic gait/ toe walking
- History is very important
- Evaluate shoes and activity history
- X‐rays?
Evaluate training and shoes

- Evaluate training intensity, surfaces, terrain, and demands of sport or activity
- Biomechanical evaluation
- Shoe recommendations: stability, motion control, or cushion
- Cross training is critical for rehabilitation
- Incorporate stretching
X-rays for Heel Pain
Unicameral Bone Cyst
Plantar Fasciitis Treatment

- Control inflammation
- Stretching and massage
- Taping/functional orthotics
- Shoe recommendations: anti-pronation
- Night splint
- Cortisone injections
- Cross training
- ECSWT
- Surgery
Purpose of taping

- Allows functional movement
- Restricts excessive motion
- Provides proprioceptive feedback
- Remember improper taping can lead to skin problems, abnormal stress on the affected area, and increase injury risk
Appling anchor for arch strapping:
* alternate method arch cross anchors
* plantarflex first ray technique
Applying transverse straps with pressure lateral to medial to arch
Overlap transverse straps by one half for added strength and prevents gaps
Apply retention strap on top of foot to secure arch strapping
Side Stitch
by Dana Summers

“I couldn’t stand your running shoes, so I put them outside.”
Calcaneal Apophysitis
Calcaneal Apophysitis

- Repetitive micro trauma from pull of Achilles on unossified calcaneal apophysis
- Frequently occurs before or during growth spurt and beginning of new sport
- Most commonly in boys of 10–12 yrs of age and girls of 8–10 years of age
- Complain of pain in heels with running and jumping
**Calcaneal Apophysitis**

- Calcaneal apophysis develops as independent ossification center
- Appears around age 7-9
- Fusion of apophysis usually around 15-17 years
- Higher composition of fibrocartilage than epiphyses
- Subjected to strong shear stresses due vertical orientation and pull from Achilles tendon
Factors contributing to development of calcaneal apophysitis

- Biomechanical factors
- Tightness of Achilles tendon/plantar fascia
- Overuse
- High impact sport
- Improper footwear
- Sport surface
Treatment of calcaneal apophysitis

- Self-limiting, symptoms subside after fusion
- Focus on decreasing pain interfering with sport
- Ice pre- & post-activity
- Anti-inflammatory medication
- Stretching program: Achilles/ plantar fascia
- Taping/ orthotics
- Shoe recommendations
Achilles Tendonitis

- History: muscle imbalance/ tightness; biomechanical; recent increase in activity; change in shoe
- Most commonly at insertion or within 2–6 cm
- Control inflammation; correct training errors; stretching program; heel lifts; shoe recommendations; possible orthotics
Achilles Tendonitis
Achilles Tendon Rupture
Achilles Tendon Rupture
Achilles tendon taping/support
Achilles taping: applying anchors
Achilles taping: applying check reins
Achilles taping: split elasticon strips
Achilles taping: apply retention anchors to hold check reins
Achilles taping: fill in anchors with elasticon preferred for movement
Theraband Exercises
Retrocalcaneal Exostosis

- Repetitive rapid eversion of calcaneus at heel strike against the heel counter of the shoe
- Increased activity and stiffer heel counters can exacerbate the problem
- Treatment: orthotics, shoe modifications, possible surgery
Fatigue or insufficiency fractures

Fatigue fractures: occur in normal bone from application of abnormal stress or torque; repeated loads causes osteoclastic activity leading to bone weakening

Insufficiency fractures: diseased bone—osteoporosis, arthritic conditions, metabolic conditions, chronic diseases

Bilateral incidence is not uncommon
Calcaneal Stress Fracture
Symptoms of Calcaneal Stress Fracture

- Similar to plantar fasciitis
- Diffuse heel pain with wt. bearing, relieved by rest
- Increased pain with prolonged activity
- May have post–static dyskinesia
- Usually no history of trauma
- New activity or exercise routine started
- Positive squeeze test as well as on plantar heel
Biomechanical Etiology of Calcaneal Stress Fractures

- Pes cavus
- Calcaneal gait
- Limb length discrepancy
- Antagonistic pull of Achilles tendon with the plantar fascia, i.e. concentric and eccentric contraction of gastroc during activity
Calcaneal stress fractures best seen on lateral x-ray; also on axial or oblique
Usually not visualized until 2–3 weeks after onset of symptoms
Change of approximately 50% in bone density needed for delineation of trabecular lesions with visual sclerosis
Bone scintigraphy is gold standard, with three-phase technetium bone scan, typically in the posterior half of the calcaneus
MRI is highly sensitive and specific
Calcaneal Stress Fractures: Treatment

- Phase 1: Modified rest of about 6–8 weeks in first phase with protected weight bearing in walking boot
- Phase 2: Gradual increase to activity when pain free
- Modify activity and address biomechanical factors
Stretching

- Do not stretch an injured tendon; should be done during the rehabilitation phase
- Gradually increase stretching as tolerated once heel pain subsides
- Stretch both Gastroc–soleus and plantar fascia muscle groups
What is an orthotic?

- A device used to support or improve function of the foot and ankle
- Much debate as to the mechanism of achieving effects of treatment
- 70–80% patient satisfaction reported in surveys
Orthotic options

- Over the counter types: by shoe size, soft, accommodative
- Pre-fab/ pre-custom: more functional arch support, heel cup, more rigid, also by size
- Prescription functional orthotics: accommodative, semi-rigid, rigid.
- Custom orthotics offer the most functional control and modification options for specific sports.
types of custom orthotics

functional

accommodative
Prefabricated insoles

- Flat insoles
- Contoured insoles
- Biomechanical insoles
Orthotics in sports

- Biomechanical control
- Post injury
- Post operative
- Preventative
How to Determine Motion Control/Anti-Pronation with 3 Easy Tests

**Torsional Rigidity**

*Torsional Rigidity*

Visualize shoe in thirds. Front one-third should easily flex at the toe. The remaining two-thirds (middle and back) should not flex or twist to qualify as a moderate to excellent motion control/anti-pronation shoe.

**Heel Counter Rigidity**

*Heel Counter Rigidity*

**Flexion Stability**

*Flexion Stability*
Athletic shoe prescription

1. Shoe
   ◦ Cushion
   ◦ Stability
   ◦ Motion-control

2. Sock
   ◦ Cotton
   ◦ Synthetic/ acrylic
   ◦ Hybrid materials

3. Shoe insert
   ◦ OTC insert
   ◦ Semi-custom orthotic
   ◦ Custom orthotic
     • Flexible
     • Semi-rigid
     • Rigid

4. Lacing
   ◦ AAPSM bookmark
What is Equinus?

- Limitation of ankle joint dorsiflexion with STJ in neutral position (lack of 10 degrees)
- Ankle joint dorsiflexion should be greater than 15 degrees with the knee flexed
- Can be present while knee flexed, extended, or in both positions
Ankle joint ROM

- At birth, dorsiflexion unrestricted, about 75 degrees
- Dorsiflexion decreases to 20–25 degrees by age 3
- 15 degrees by age 10
- 10 degrees by age 15
- Ankle joint dorsiflexion should always be more than 15 degrees with knee flexed with normal development
Types of Congenital Equinus

- Congenital gastrocnemius equinus
- Congenital soleus equinus
- Congenital gastroc–soleus equinus
- Spastic equinus
Congenital gastroc equinus

- Most common type
- Limited ankle dorsiflexion with knee extended
- Flexion of knee demonstrates normal ROM
Congenital soleus equinus

- Limited ankle joint dorsiflexion when knee in flexed position
- May also have knee extended and limited ankle joint dorsiflexion
- Rare type
**Congenital gastroc–soleus equinus**

- Limitation of ankle joint dorsiflexion with knee in both the extended and flexed position
- Both gastroc and soleus units are tight
- Usually more dorsiflexion available with knee flexed but less than 10 degrees
- May see bony block of talotibial articulation in older child, has an abrupt feel at end point of ROM
- Radiographic changes with bony deformity
Spastic equinus

- Associated with spastic disorders like cerebral palsy
- Limited dorsiflexion of ankle in both knee positions
- May have increased Achilles reflexes and ankle clonus
Measuring ankle joint dorsiflexion

- Patient supine position
- Foot maximally dorsiflexed to leg with STJ maintained in neutral position
- If STJ pronated, MPJ unlocks and allows excessive dorsiflexion of FF to RF
- Slightly supinate the RF to reduce chance of pronating STJ
Compensated Equinus

- Normal heel off
- STJ and MTJ compensating
- STJ pronated at heel contact
- Midstance pronation with forefoot abducted on the rear foot
- Foot lifts off in two segments: rear foot lifts early, then forefoot lifts
- Toe off is apropulsive
- Characteristics: pronated foot with flattened medial arch, unlocked to subluxed STJ, forefoot supinatus, prone to HAV
Partially compensated Equinus

- Early heel off
- Inadequate compensation at STJ and MTJ
- Heel contacts and then comes off early in midstance
- Resupination occurs late in propulsion
- Characteristics: Mildly pronated foot with normal arch structure
Uncompensated Equinus

- No heel contact noted
- Forefoot contact only
- “Toe walking”
- Characteristics: Normal foot type, foot plantarflexed to leg
Etiology of Equinus

- Posterior muscle contracture: clonic spasm, tonic spasm, accommodative shortening
- Congenital short gastroc muscle or triceps surae
- Osseous ankle block
- Tight posterior ankle capsule
Mechanisms of Compensation

- Abducted gait
- Knee flexion
- STJ pronation, with unlocking of MTJ leading to dorsiflexion of forefoot and rear foot
- Genu recurvatum: subluxation of knee posteriorly
- Decreased stride