"Oh My Achin Feet"

Biomechanically Correct Foot Orthotics

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Objectives
- Define lower kinetic chain anatomy and the specific biomechanical input and relationships
- Explain the common pathologies associated with faulty mechanics in scientific and laymen terms
- Accurately classify common foot faults
- Understand and perform a clinical assessment
- Develop appropriate evidence based treatment plan
- Review, classify, and de-mystify foot orthotics (over the counter and custom)

Lower Chain Anatomy: Musculature
- gastrocnemius
- soleus
- tibialis posterior
- flexor digitorum longus
- flexor hallucis longus
- tibialis anterior
- extensor hallucis longus
- extensor digitorum longus
- peroneus Longus
- peroneus brevis
- additional intrinsic muscles of foot

Lower Chain Anatomy: Osteology
28 Bones
- tibia
- fibula
- talus
- calcaneus
- navicular
- cuboid
- 3 cuneiforms
- 5 metatarsals
- 14 phalanges

Lower Chain Anatomy: Joints
25 – 33 joints depending on reference and joints considered

- Proximal tibiofibular
- Distal tibiofibular
- talocrural
- talocalcaneal (subtalar)
- talonavicular
- calcaneoucuboid
- 5 TMT
- 5 MTP
- 9 IP

Talocrural Joint - Mortise joint formed with distal tibia and fibula
Arthrokinematics

- OKC: talus glides posteriorly with DF, anteriorly with PF
- CKC: tibia glides anteriorly with DF, posteriorly with PF

Osteokinematics

- DF: talus wider anteriorly creating slight separation of mortise, fibula glides superior and posterior, slight eversion
- PF: smaller portion of talus in mortise, fibula glides inferiorly and anteriorly, slight inversion

Subtalar Joint - Talus superiorly and calcaneus Inferiorly
Osteokinematics:

- Primarily responsible for tri-planar motions of pronation and supination
- Lies closest to the true tri-planar axis of the foot
- Joint discussed in original podiatric work of Root, Orien, and Weed in the 1970's when discussing gait mechanics

Midtarsal Joint - Consist of talonavicular joints and calcaneoucuboid joints

- Direct connection between midtarsal joint and subtalar joint
- With subtalar joint in supination the midtarsal joint becomes more restricted
- As subtalar joint is pronated then the midtarsal joint becomes more mobile
- Overall, the midtarsal joint plays an important role in foot adaptation to the ground

3 Primary Functional Areas
Forefoot

- Anterior to midtarsal joint, in weight bearing the forces are shared across the metatarsals.
- Forces vary depending of foot types

Midfoot

- Consist of cuneiforms, cuboid, and navicular

Rearfoot

- Talus, calcaneus, and lower 1/3 of leg
- Coupled motion present IR-ADD-EV, ER-ABD-INV
- Force dispersed between calcaneal tubercles

Lower Chain Anatomy: Arches and Ligaments
3 Primary Arches

- Medial Longitudinal
- Lateral Longitudinal
- Transverse Metatarsal

4 Main Ligaments of Talocrural joint

- Deltoid
- ATFL
- CFL
- PTF

Ligaments of Medial Arch/Foot

- Spring Ligament
- Short Plantar Ligament
- Long Plantar Ligament
- Plantar Aponeurosis

Transitioning Anatomy to Function
There are 3 planes of movement in the foot and ankle complex

- Sagittal: motion is PF and DF
- Frontal: motion is Inversion and Eversion
- Transverse: motion is abduction and adduction

In the ankle the 3 motions tend to work together in varying degrees in what is tri-planar motion (supination and pronation)

Pronation

- NWB: eversion, dorsiflexion, abduction
- WB: calcaneal eversion, PF/adduction of talus, IR of lower leg

Supination

- NWB: inversion, plantarflexion, adduction
- WB: calcaneal inversion, DF/abduction of the talus, ER of the lower leg

Windlass Effect

- Originally discussed by Hicks in 1954 Journal of Anatomy
- Formed by calcaneus, mid-tarsal, and metatarsals
- The medial longitudinal arch

Function of the Foot: Windlass Effect

- The plantar fascia assists in supporting this longitudinal arch based off its anatomy
- It acts as a cable running from the calcaneus to the metatarsalphalangeal joints
- Forces during the propulsive stage of gait create tension around the metatarsals

- This tension/winding assists in shortening the distance between the calcaneus and metatarsals

Transitioning Anatomy to Function: Gait Mechanics

- Understand that there are specific movements and muscles firing throughout the biomechanical chain
- Arms, lumbar spine, hips, and knees all play a critical role and can not be ignored
- There are specific biomechanics occurring with movements at all regions

Gait: Focusing in on the Foot

- Initial heel strike creates forces on lateral calcaneus with foot in supination
- Force then travels laterally as foot begins to pronate
- Translating forces primarily off of the 1st metatarsal
- With re-supination then occurring to allow rigid lever for propulsion

Gait: Subtalar Joint
Numerous ideas, research, and theories on role and positioning of subtalar joint during gait
Actual movement will vary based off intrinsic and extrinsic factors in lower extremity
i.e., tibial/femoral rotations, footwear, activity level, training program

Gait: Subtalar Joint
Supination

- Calcaneal inversion (varus)
- Talar abduction
- Talar dorsiflexion
- Tibiofibular lateral rotation

Pronation

- Calcaneal eversion (valgus)
- Talar adduction
- Talar plantarflexion
- Tibiofibular medial rotation

Common Pathologies in Lower Extremity

- Metatarsalgia (painful metatarsals)
- Morton’s Neuroma (inflamed digital nerves)
- Plantar Fasciitis (irritation to plantar fascia)
- Cuboid Dysfunction (subluxation of cuboid)
- Inversion Ankle Sprain (ankle rolls in)
- Eversion Ankle Sprain (ankle rolls out)
- Maisonneuve Fracture (proximal fibular fracture)
- Hallux Valgus (Bunion)
- Bunionette (Taylor’s Bunion)
- Hallux Rigidus (OA of 1st MTP)
- Hallux Limitus (turf toe)
- Tarsal Tunnel Syndrome (post tibial nerve compression)

- Syndesmosis Sprain (high ankle sprain)
- Post. Tibialis tendonitis (posteromedial shin splints)
- Ant. Tibialis tendonitis (anterolateral shin splints)

Biomechanical Foot Faults

Pes Cavus – High Arch

  - Medial longitudinal arch fails to flatten with WB
  - Metatarsals maintain a more plantar flexed position
  - Less adaptive to ground forces with overall increase in stress to heel and met heads

Pes Planus – Flat Feet

- Acquired or Congenital
- Thought to be due to posterior tibial dysfunction or disruption to medial longitudinal arch structures
- Foot maintains pronated position with decreased supination phases

Rearfoot Varus

  - Most common clinical presentation with 80-98% population
  - Rearfoot in inverted position creates forefoot hypermobility to allow to reach ground
  - Contact is made more laterally with a quick pronation phase from subtalar joint
  - Leads to a decrease in the rigid lever for push off
  - Plantar fasciitis, Hammer toes, knee pain, tailor's bunion, haglund's deformity

Forefoot Valgus

Flexible

  - High arch NWB, decreases with WB
  - Forefoot splay
  - Morton's neuroma, plantar fasciitis, lesser toe deformities

Rigid (less common)

  - High arch in NWB and WB
  - Heel inverted
  - Very poor shock absorption present
  - Inversion sprains, hammer toes, LBP, plantar fasciitis, tibial stress fractures

Forefoot Varus

  - Forefoot inverted relative to rearfoot
  - Compensation can occur in different ways
  - Increased subtalar pronation
  - Maintain more lateral foot contact
  - Hypermobility of 1st ray or forefoot
  - Prolonged subtalar pronation (delayed re-supination)
  - Shin splints, post. Tib. Tendonitis, plantar fasciitis, patella-femoral pain, hallux valgus, overlapping toes, sciatica

Equinus

  - Subtalar joint has less then 10 degrees of DF when in neutral
  - Lack of DF creates pronation and unlocking of the midfoot

- Becomes “rocker bottom” during gait
- Severe hallux subluxation, bouncing gait, hammer toes, severe postural deficits, talo-navicular pain

Additional Biomechanical Factors

- Genu Varus
- Genu Valgus
- Femoral Torsion

Clinical Assessment

- Systematic approach to evaluating lower extremity dysfunction with emphasis on foot mechanics

Initial Guidelines

- Ensure that appropriate subjective and history has been completed with clearance of red flags
- Initiate communication with patient as to what is going to be evaluated
- Make sure that all appropriate anatomy is exposed (no shoes, socks, or material covering the knee)

Posture -Static assessment

Front

- Knee, hip, shoulder alignment, position of tibia relative to femur

Lateral

- Cervical, thoracic, lumbar positioning, knee alignment

Posterior

- Spinal alignment, gluteal tone/positioning, scapular alignment

Gait Assessment - Complete visually on level ground and/or on treadmill (video equipment can be used to slow down mechanics)
Pick a method top to bottom or vice versa

- Assess from front, side, and back
- Pay attention to arm swing, thoracic/lumbar movements, hip mobility, positioning of knees, foot/ankle control and mechanics
- Dynamic Control
- Double leg squat
- Single leg squat
- Single leg balance

How is the patients overall movement pattern?
How is the lumbar spine being maintained?
What position do the knees fall into?
Do the patients ankle/arches collapse down further?
Is there a lack of control one side vs other?

More specific WB Assessment

- Foot placement angle (7-10 degrees toe out normal)
- Location of subtalar joint neutral
- Should have equal amount of pressure on 1st and 2nd digits from talus head when assessing
- Navicular height in neutral/relaxed stance
- 6-10 mm is typical
- Calcaneus position in neutral, relaxed, and squatting
- Feiss' line

NWB Assessment
Complete MMT and goniometric measurement of appropriate muscles and joints
** It is important to pay attention to differences side to side

MMT: hip abductors/extensors, quadriceps, ankle inverters/everters, 1st MTP control

ROM/Muscle length: IT band, 1-joint/2-joint hip flexors, 1st MTP flex/ext, DF, PF, gastroc/soleus length

NWB Assessment
- Locate subtalar neutral in NWB (typically in prone)
- Assess calcaneal position
- From subtalar neutral apply DF pressure to 4th and 5th metatarsals
- Assess forefoot position (varus/valgus)
- 1st ray mobility
- Midtarsal joint mobility
- Callus formation

Cont. if needed
- If patient is higher level athlete or participates is specific activities then assess further
- Watch runners run, cyclists bike, jumpers jump, and so on
- Pay attention to similar postures and positioning as before, just at a higher level

Evidence Based Treatment Plan
- Much controversy exist in regards to what is the best management of LE pathology's.

- There is numerous research being produced by PTs, Podiatrist, Athletic Trainers, and Chiropractors all of which vary in there reliability, validity, and bias to there particular field

- A 2006 study by Stuber and Kristmanson assessed use of numerous treatment methods and found no significant differences "It is difficult to determine which of these treatments is the most effective, as one study will conclude that one treatment outperforms another and the next study will assert the reverse".

So What Do We Do?

- Need to take evaluation data and treat each patient on a specific, individual basis
- All of the subjective and objective data need to be taken into considered
- The current symptoms need to be addressed as well as the biomechanical causes of the symptoms

Hip

- There is a correlation between proximal hip weakness and lack of deceleration of pronation
- Strengthening of specific muscles need to be addressed
- Gluteus medius
- Gluteus minimus
- Tensor fascia latae
- Flexibility limitation also need to be addressed, especially in hip flexors

Knee

- Tends to be stuck in the middle
- More research supporting treatment to the hip and foot then specifically at the knee
- Still need to be aware of quadriceps, hamstring imbalance
- Need to be sure proper tibial and fibular movement is obtained at joint level
- Knee control needs to be obtained in conjunction with the hip and foot
- Genu recurvatum, Genu varum, Genu valgus

Ankle/Foot

Pes Planus

- All musculature and flexibility deficits need to be addressed

Strengthen

- Posterior tibialis, ankle plantar flexors, and peroneus longus

Stretch

- Achilles (gastroc/soleus)

Orthotics/postings may also be utilized to control level of pronation

Ankle/Foot

Pes Cavus

- Still need to ensure proper strength and flexibility, however added focus on joint mobility and plantar fascia lengthening

Flexibility

- Achilles (gastroc/soleus) stretches, soft tissue techniques/US, night splints, Graston

Joint Mobility

- 1st ray and subtalar joint

Orthotics/postings can also be utilized to provide increased arch support and decrease tension on plantar fascia

Orthotics/Postings

Numerous philosophy's exist when in comes to orthotics whether custom or off the shelf, or in regards to postings

Another area where research is very inconclusive and also very biased as to who is producing the research.

Typical Use of Postings

Rearfoot Varus

- Medial Heel Wedge
- Decreases the prolong pronation during stance and helps allow for quicker resupination

Forefoot Varus

- Medial Forefoot Wedge
- Allows forefoot to reach ground sooner resulting in more stable foot for push-off

Forefoot Valgus

- Lateral Forefoot Wedge
- Allow more foot stability during pre-swing and push off

Orthotics

Numerous companies are producing orthotics in varying forms and off different theories

- MASS – Maximum Arch Subtalar Supination
- The Foot Alignment System orthotics
- Original Root casting of subtalar neutral
- Rothbart Proprioceptive Insoles
- Numerous others in varying forms

Sole Supports Custom Orthotics
Based of MASS casting system