Foot Biomechanics
Getting Back to the Base

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Objectives

• Understand basic foot biomechanics during walking and running

• Understand common sports injuries caused by abnormal foot biomechanics

• Discuss barefoot running as it applies to foot biomechanics and injuries
Socrates (471-401BC)

• “To him whose feet hurt everything hurts”

• To understand nature we must first try to understand ourselves.

Leonardo DaVinci (1452-1519)

• “The foot is the most marvellous of machines – and a work of art”

Basic Biomechanics

• During walking or running the foot serves 2 main functions

  1. The foot acts as a mobile adaptor to adjust to varying terrain and dissipate ground forces

  2. The foot acts as a rigid lever for forward propulsion
Anatomy

- 26 bones
- 19 muscles
- 33 joints
- 107 ligaments

Pronation

- Pronation = ankle **dorsiflexion** + subtalar (calcaneal) **eversion** + forefoot **abduction** (external rotation)

Supination

- Supination = ankle **plantarflexion** + subtalar (calcaneal) **inversion** + forefoot **adduction** (internal rotation)
Foot Biomechanics

At foot strike the calcaneus is supinated \(2^\circ\)
The foot passes through neutral to \(4^\circ\) of pronation by the start of mid-stance.
The foot then goes through neutral to \(2^\circ\) of supination through the propulsive phase to toe off.
Main Differences Between Walking and Running Gait Cycle

- Transition from double stance to double float
- 80% of runners still have heel strike
- Stance phase is less than 50% of the cycle (gets smaller as speed increases)
- Cadence and step length increase
- As speed increases the base of support narrows
- All lower limb joints require more motion
- There is a greater amount of eccentric muscle work
Abnormal Biomechanics as a Risk for Injury

- **Medial Tibial Stress Syndrome**
- **Ankle Sprains**
- **Fractures**
- **Patellofemoral Pain Syndrome**

Barefoot Running

- **Pubmed search barefoot running**
  - 1975 – 2008
    - 13 citations
  - 2009 – present
    - 80+ citations

- Descriptive Measures
  - *BORN TO RUN*
    - A Hidden Tribe, Super Athletes, and the Greatest Race the World Has Never Seen
    - Christopher McDougall

Barefoot Running to Reduce Running Related Injuries

- There has been tremendous growth in the bare foot or minimalist running shoe industry
- There have been claims in the medical literature that barefoot running will reduce injuries.

- Lieberman DE. What has been learnt about running since barefoot running - an evolutionary medical perspective. *Cen Sports Sci Rev.* 2012;38(3):49-72
In barefoot runners the slope of the ground reaction force curve is much more gradual.

**What We Know**

- More likely to have a midfoot or forefoot landing
- Shorter stride length
- High cadence (170 vs 150 in nonelite shod)
- Lower extremity is more compliant to absorb ground reaction force (also affected by knee flexion)
- Strengthens intrinsic muscles
Does Barefoot running Reduce Injury Rates?

- We lack randomized prospective studies that show lower injury rates
- There are retrospective studies showing lower injury rates in runners
  - Daoud AI, et al. Foot strike and injury rates in endurance runners: A retrospective study

There are Studies Showing Injuries in Barefoot Runners

  - 10 runners average experience of 18.9 years running
  - Avg 25.9 miles/week
  - 9 stress fractures, 1 plantar fascia rupture at an average of 2.6 months after switching to minimalist footwear

Practical Recommendations for Your Patients

- Adopting a barefoot running style (with shoes) might benefit runners with certain stress fractures and those with PFPS
- Do not recommend for patients with metatarsal stress fractures or achilles issues
- Not sure what to do with patients with plantar fascitis
Do Not Forget About…

• Core, hip and quad strength
• Menstrual issues
• Nutritional issues (caloric intake, Ca, Vit D)
• Pulmonary issues
• Training intensity
• Observations of watching my children run and race

There are Sports that Require Shoes

• We are left with the knowledge of foot biomechanics to manipulate the foot to reduce injuries in other sports
• In other sports a static foot can still affect performance

Thank You