Running Biomechanics:
The Good, the Bad, and … well you know!

Joseph Chorley, MD
Sports Medicine, Texas Children’s Hospital
Associate Professor, Baylor College of Medicine

Goals and Objectives

- Be able to assess biomechanical factors in a runner that may lead to injury
  - Discuss how to analyze running mechanics with and without technology
- Be able to recognize the signs and symptoms of exertional compartment syndrome
- Be able to develop a differential diagnosis for foot pain in the runner
Runners, Yeah, We’re Different

- 1,520,000 high school students are involved in track and CC in the U.S. in 2014/5
- Young runners will often have higher GPA, very goal oriented … but may have some mental health issues

Basics of the Running Gait

**Stance Phase**

- **Initial contact:** foot first touches the ground
- **Braking (shock absorption):** controlled landing with elastic energy storage
- **Midstance:** foot is directly under the hips
- **Propulsion:** when the ankle, knee and hip all extend to push the body up and forward
- **Toe off**
Swing Phase

Early → Mid → Terminal Swing

What’s Happening During the Gait Cycle?

**Early Stance Phase**
- store the energy, control motion
  - Flexion, Internal Rotation, Pronation

**Later Stance Phase**
- spend the energy moving forward
  - Extension, External Rotation, Supination
What Else Is Happening?

• Upper torso and arms – moving equal and opposite of the legs (maintain momentum)
• Hip stability to prevent excessive motion and stress

The Elegant Foot

**Function**

- Shock absorption
- Rigid lever for propulsion
- Balance

**Form**

- Pronation – open packed
- Supination – closed packed
What Are We Looking For?

**Feet**
- Foot strike
- Degree of pronation/supination

**Hips**
- Trendelenburg
- Other signs of the victims
Pronation Is the Cause of All Problems!

**Pronation**: combined motion that allows shock absorption
- Excessive pronation can put stress on medial structures but can come from lack of hip stability

It’s Cool to be Hip!
### How Can You Help These Runners Who Always Hurt?

<table>
<thead>
<tr>
<th>Form</th>
<th>Fatigability</th>
</tr>
</thead>
</table>
| • Shorter step length  
• Midfoot/Forefoot strike | • Coaching plans  
(in and out of season)  
• Strengthen weakest link  
(hip abductors)  
• Adequate calories |

### If Your Shin Hurts, It Must be MTSS

<table>
<thead>
<tr>
<th>Chronic Exertional Compartment Syndromes</th>
<th>Physical Exam</th>
</tr>
</thead>
</table>
| • Underlying pressure is the etiology that  
  – Decreases blood flow  
  – Presses on the nerve  
• Clinical symptoms  
  – Cramping pain and tightness that occur at the same point in a workout and improve quickly with rest (15-20 min) | • Tight hard muscles with exertion  
• Neurological findings  
  – Peroneal nerve  
    • Deep and superficial  
  – Tibial nerve  
  – Sural nerve |

NOT SO FAST
## Compartment Syndrome

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Percentage of CECS</th>
<th>Nerve</th>
<th>Motor/Sensory findings/Provocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior (AT, EHL, EDL)</td>
<td>45%</td>
<td>Deep Peroneal</td>
<td>Weak AT 1st web space PF ankle</td>
</tr>
<tr>
<td>Lateral (PB, PL)</td>
<td>10%</td>
<td>Superficial Peroneal</td>
<td>Weak PB Dorsum foot Ankle inversion</td>
</tr>
<tr>
<td>Deep Posterior (PT, FDL, FHL)</td>
<td>40%</td>
<td>Tibial</td>
<td>Weak ankle I Medial arch Ankle DF toe E</td>
</tr>
<tr>
<td>Superficial Posterior (G/S)</td>
<td>5%</td>
<td>Sural</td>
<td>Weak G/S Lateral foot DF ankle</td>
</tr>
</tbody>
</table>
## Make the Clinical Diagnosis

<table>
<thead>
<tr>
<th>CECS</th>
<th>MTSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Less common</td>
<td>• More common</td>
</tr>
<tr>
<td>• Normal PE at rest, but changes with exertion</td>
<td>• Classic PE at rest</td>
</tr>
<tr>
<td>• May have neurovascular complaints</td>
<td>• No neurovascular complaints</td>
</tr>
<tr>
<td>• Resolves with rest</td>
<td>• Improves with days/weeks of rest</td>
</tr>
<tr>
<td>• Tight cramping sensation at a specific point in exercise</td>
<td>• Pain post → during → constant</td>
</tr>
</tbody>
</table>

## Diagnostic Evaluation

- Plain radiographs
- 3-phase bone scan
- CT
- MRI
- Compartment pressure measurement at rest and after exercise
My Foot Hurts

Location of foot and ankle pain

(A) Posteromedial ankle and heel pain.
(B) Posterior ankle and heel pain.
(C) Anterolateral ankle, midfoot, and forefoot pain.
(D) Plantar foot pain.

Graph: 63450 Version 1.0

What Are the Most Common?

Heel Pain

- Calcaneal apophysitis: 8-12 year old, heel squeeze, heavy heel landing when jumping needs physical therapy
  - Achilles tendonitis: hurts 1-1.5” above insertion, look for biomechanical issues
  - Plantar fasciitis: skeletally mature, first step in the morning
    Heel cups, PF stretch, ice, form
    - Stress fracture: amenorrheic runner, high mileage, rearfoot striker
    - Posterior ankle impingement: bounce home
What are the Most Common?

**Lateral Ankle**
- Peroneal tendonitis: weak hip stability, old ankle sprain without rehab

**Medial Ankle**
- Excessive pronation from knee valgus from hip Trendelenburg
  - Tarsal tunnel, posterior tibialis tendonitis, medial calcaneal branch of the tibial nerve

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**Midfoot**
- Tight gastroc soleus: using midfoot for dorsiflexion
  - Navicular stress fracture
  - Kohler’s disease

**Forefoot**
- Stress fracture: most common 2\textsuperscript{nd} MT, worry 4-5\textsuperscript{th} MT
  - Morton’s neuroma - better with shoes off