Foot Anatomy & Foot-Pedal Interface

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Medicine of Cycling

Lower Extremity Anatomy Review:
- Normal Anatomy
- Abnormal Anatomy
- Orthotic Devices

Shoe/Pedal Interface:
- 5 Cleat Adjustments

Normal Anatomy

Bones of the foot
- 26 normally occurring
- 40 accessory ossicles of the foot
- 33 joints
- 106 ligaments

Anterior Tendons of the Leg
- Tibialis Anterior
- Extensor Hallucis Longus
- Extensor Digitorum Longus

Lateral Tendons of the Leg
- Peroneus Longus
- Peroneus Brevis
- Peroneus Tertius

Foot Anatomy

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Medial Leg Tendons
- Tibialis Posterior
- Flexor Hallucis Longus
- Flexor Digitorum Longus

Posterior Leg Tendons
- Achilles Tendon (medial and lateral heads of the gastrocnemius and the soleus)
- Plantaris

Nerves of the Foot

Abnormal Anatomy

Tendonopathies
- Tibialis Anterior Tendonitis
- Shoe gear irritation
- Direct trauma
- Compartment syndrome (rare)
- Saddle too high

Tendonopathies
- Posterior Tibial Tendonitis
- Flat foot
- Age
- Running/Triathletes
- Saddle too low
Tendonopathies
- Peroneal Tendonitis
- Rear foot varus
- Saddle too high
- Ankle sprain

Neuroma
- Inflammation of the insulation around a nerve.
  - Causes: biomechanical, trauma, improper shoegear and repeated stress.

Neuroma
- Typically between 3rd and 4th metatarsal heads (Morton’s Neuroma).
- Can be between any of the metatarsal heads.

Neuroma affects Webspace

Nerve Compression
- Deep Peroneal Nerve
- High Arched foot type
- Low volume shoes
- Overtightening shoes
- Spurring at the 2nd Metatarsal-Cuneiform joint (common).
**Varus Definition**
- Position of the rearfoot or the forefoot relative to the weight-bearing surface that is inverted.
- Towards the midline of the body.

**Valgus Definition**
- Position of the rearfoot or the forefoot relative to the weight-bearing surface that is everted.
- Away from the midline of the body.

**Rearfoot Varus vs. Valgus**

**Forefoot Varus & Valgus**

**Cycling orthotics**
- Must be thin (2mm suborthalon or carbon fiber)
- Allow for minimal correction due to depth of shoes.
- Minimal rearfoot control and forefoot correction.

**Is there a need for custom?**
The Question…
What is the BEST foot position for a cyclist?

The Answer…
The BEST foot position creates…
MAXIMAL biomechanical efficiency for lower extremity joints/tissue while MINIMIZING risk of injury… for that SPECIFIC CYCLIST

4%
- Less than 10% of people/cyclists have a neutral foot (Cornwell, 2000; Agosta 2001; Whitney, 2003)
- Break-down (Garbolosa et al., 1994)
  - 87% = FF varus
  - 9% = FF valgus
  - Plantar flexed first ray?
  - 4% = Neutral FF-RF relationship
  - Plantar flexed first ray?
- Pedals are made for flat-footed connection. (Millslagle et al., 2004)
- Therefore, conventional pedals only "fit" 4% of the cycling population. (Millslagle et al., 2004)

Leg Architecture: Everyone is UNIQUE!

What is “normal?” What is “efficient?”
Peak Force = Ball of Big Toe
(Sanderson & Cavanaugh, 1987)

Main peak pressure

Methods: Cleat Fore-Aft

- Primary Goal
  - Ball of big toe over or slightly in front of the pedal spindle for MAXIMAL FORCE TRANSFER
  - ↑ Stiffness = ↑ Fore-Aft Range

- Move cleat
  - Foot FORWARD (anterior) = Cleat BACK
  - Foot BACK (posterior) = Cleat FORWARD
Setting up front view

- Reference Points
  - Second toe (2nd ray)
  - Tibial tuberosity
- Lasers – self leveling
  - One for each leg

Medial-lateral cleat position

What would you change? WHY?

Methods: Cleat/Foot Medial-Lateral

- Primary Goal:
  - Bring foot under knee
- Move cleat
  - Foot OUT = Cleat IN
  - Foot IN = Cleat OUT

Side-to-Side

Cleat Medial = Foot Lateral
Cleat Lateral = Foot Medial

1mm Washer & 20mm Spacer &/Or Multiple Spindle Lengths

Pedal Brands
- Speedplay®
  - 5 widths
- Keypain®
  - 6 widths
- Shimano®
  - 2 widths

Lateral Knee: Before & After

Before
After

1/8” Longer Spindle
1/4” Longer
1/2” Longer Spindle
Valgus Forces & Cycling

Causes of Excessive Valgus Forces

- Morphological
  - Structure of the cyclist
- Neuromuscular
  - PMH
- Bike & Foot-Pedal Interface
  ***Genetics!***

Solutions: Excessive Valgus Forces

- External/Foot-Pedal Interface
  - OTC shoe inserts
  - Custom orthotics
  - Wedges
    - Cleat Wedges
    - ITS (In The Shoe) Fore Foot & Rear Foot
- Internal/Body
  - HEP
  - Manual RX
  - Etc…

Effects of Severe Valgus Forces

(Ruby, Holt, Kirby, Jenkins 1992; Sanner & O’Halloran, 2000; Powers, 2012)
Forefoot Varus: BikeFit Recommendations

Correcting for FF Varus**
- 0-2°
  - No Wedges
- 3-7°
  - 1 Wedge
- 6-12°
  - Up to 2 Wedges
- 12-20°
  - Up to 3 Wedges
** Static Measurements

Research demonstrates...
- Use of cleat wedges increases power output. (Moran & McGlinn, 1995, Dinsdale & Williams, 2010)
- Use of cleat wedges improves efficiency.
(Sinead FitzGibbon, doctoral candidate, RMUoHP Ph.D Orthopedics and Sports Physical Therapy).

MFPI vs. BikeFit® Recommendations

Modified Foot Posture Index
- MILD
  - 0-7 degrees
- MODERATE
  - 8-14 degrees
- STRONG
  - X > 15 degrees
- “WHOPPING”**
  - 20+ degrees

BikeFit® Recommendations
- 0-2°
  - No Wedges
- 3-7°
  - 1 Wedge
- 6-12°
  - Up to 2 Wedges
- 12-20°
  - Up to 3 Wedges

Pressure area with & without varus wedge

Posterior View

Tiberio, 1998

Valgus Forces: Before & After

Before

After
Cycling: Minimal Variation

- Rigid
- Neutral/Flat

Custom or Accommodative Inserts?

- Primary Goals:
  - Force redistribution
  - Capture the midtarsals
- Custom Orthotics:
  - CYCLING
  - Cycling orthotics
  - RUNNING
    - Running orthotics
- Accommodative:
  - MAJORITY of cyclists
  - Superfeet
  - Heat moldable
    - "semi-custom"

(Razeghi & Batt, 2000; Sanner & O’Halloran, 2000; Cobb 2006)

Rotation vs Float

(Ruby & Hull, 1993; Windshak, Hull, & Kern, 1996)

- Primary Goal: Reduce frictional torsion between tibia & femur
- Float = motion of the cleat in the pedal
- Rotation = position of the cleat

Cleat Rotation

Rotational Adjustment

- TOE-OUT
  - Rotate front of cleat IN
    - EX: Tibial External Torsion
- TOE-IN
  - Rotate front of cleat OUT
    - EX: Tibial Internal Torsion
Leg Length Differences

- Structural
  - Measurable difference between length of R & L femurs &/or tibias

- Functional
  - Lumbar spine/pelvic obliquity rotation
    - Asymmetry: COMMON
    - Symmetry: UNCOMMON

Leg Length Difference?

LLD or Pelvic Obliquity?

- How does this affect the legs?
LLD or Pelvic Obliquity?

- How does this affect the legs?
  - Right knee tracks MEDIALLY (BDS)
  - Left knee tracks LATERALLY (TUS)

Standing AP X-Ray

Gold Standard: Standing Scanogram

- Full-length x-ray
  - Feet → Lumbar Spine

Jackson & Porter 2012

Standing AP X-ray

“...& the MD cried...

Leg Length Difference

- Verify presence of a STRUCTURAL LLD
- Start correction at 25-50%
  - LLD: x > 12 mm...
  - Correction up to within 5 mm of total LLD
  - Sole lift, LL shim
  - cycling & daily shoes

When Do We Stop?

STOP WHEN...

- Your level of knowledge has been met.
- Noted improvement in efficiency of cyclist yet discomfort/pain still present.
- You’re little voice tells you to...
Clinical Differential Diagnosis (Two Classic Cycling “Pains”)

- Medial knee pain
- Numbness in ball of foot

Clinicians & Bike Fitters

- Advocacy creates allies.
- Referring out bolsters your credibility.
- There is always more to learn.

References


References cont.

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