Does Changing Footfall Patterns Benefit Runners?

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Footfall Patterns - RF
Footfall Patterns - FF
Footfall Patterns - MF
Rearfoot v. Forefoot Runners

- of 753 runners at the 10 and 20 km point of marathon races, 81% RF, 19% MF, 0% FF
  
  Ker et al., (1983)

- 283 elite runners analyzed at 9.3 mile mark of a half marathon: 75% RF, 24% MF, 1 %FF
  
  Hasegawa et al., (2007)

- 936 runners analyzed at 10 km point of marathon: 89% RF, 3% MF, 2% FF, 6% asymetrical
  
  Larsen et al., (2011)
Why are there so few forefoot runners?

- ancient homo (~500,000 years ago) may have been a runner (Liebermann et al., 2010)

- what footfall pattern did they use when running?

- Liebermann and others suggest that they used a FF pattern

- argument for using a FF pattern suggests that since ancient homo ran with a FF pattern so........
Why do we have so many footfall patterns?

- forward dynamics computer model
  - two-dimensional (sagittal)
  - 11 segments: trunk, two legs
  - vertical trunk force ≈ arm swing
  - soft constrains on joint ROM (ligaments, etc.)
  - foot-ground contact
  - wobbling masses (trunk, thighs, calfs)

- 12 Hill-based muscle models per leg
  - contractile and series elastic components
  - parameters: dynamometer experiments

Miller & Hamill, (2012)
Energetic Optimality for Computer Model

- RF strike pattern for minimal energy solution

- MF strike increased energy rate (15.9 → 16.9 W\cdot kg^{-1}, +1.2 kcal\cdot min^{-1})

- FF strike to maximize average speed
Rearfoot v. Forefoot

- there is little to no evidence that FF or MF running is a healthy alternative to RF running

- there is also little scientific evidence that RF is a healthy alternative to FF or MF running
What those who advocate change really say?

• changing to a FF or MF footfall pattern from an RF pattern:
  ✓ caused by modern footwear
  ✓ is metabolically more efficient
  ✓ decreases the impact forces in running
  ✓ reduces running-related injuries
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Are footwear the cause of few FF runners?

- one argument often mentioned is „modern footwear“
- the development of the modern running shoe (i.e. thick heel) allowed individuals to run with an RF pattern
- the thick heel cushioning thus decreased the number of runners who ran with a FF pattern
University of Oregon 1977
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Running Economy

- running with a FF pattern is not more economical than running with an RF pattern

Gruber et al., 2012
## Carbohydrate Oxidation

### Habitual RF Runners

<table>
<thead>
<tr>
<th>Speed</th>
<th>Group</th>
<th>CHO (g·hr⁻¹)</th>
<th>CHO (% of EE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>RF</td>
<td>88.89 ± 23.41</td>
<td>51.3 ± 12.7</td>
</tr>
<tr>
<td></td>
<td>FF</td>
<td>100.23 ± 21.76</td>
<td>58.5 ± 8.3</td>
</tr>
<tr>
<td>Medium</td>
<td>RF</td>
<td>131.17 ± 39.65</td>
<td>64.7 ± 15.5</td>
</tr>
<tr>
<td></td>
<td>FF</td>
<td>140.08 ± 33.00</td>
<td>71.3 ± 11.4</td>
</tr>
<tr>
<td>Fast</td>
<td>RF</td>
<td>187.87 ± 58.05</td>
<td>77.9 ± 16.8</td>
</tr>
<tr>
<td></td>
<td>FF</td>
<td>186.12 ± 39.82</td>
<td>80.9 ± 11.8</td>
</tr>
</tbody>
</table>

Gruber et al., 2012
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RF v. FF Running

Lieberman et al., 2010
Vertical Ground Reaction Force Component

VGRF Component (N)

Percent Support

RF
FF

Gruber et al., 2011
Spectral Decomposition of VGF Component
Vertical Ground Reaction Force Frequencies

- 4 – 8 Hz
- 10 – 20 Hz

Amplitude vs Frequency (Hz)

Impact peak
Active peak
**Frequency Content of VGRF**

Gruber et al., 2011
Why is there no impact peak in FF running?

- In RF running, the foot/ground collision occurs early in the support period.
- In FF running, the collision occurs later in the support period.
Wavelet Analysis of VGRF Component

Rearfoot Pattern

Forefoot Pattern
The Impact Peak in RF running?

Bobbert et al., 1992
The Impact Peak in FF running?
**Do Impacts Cause Injury?**

- running on hard surfaces did not increase injuries over running on soft surfaces
  
  *Van Mechelen, 1992*

- incidence of osteoarthritis found in equal frequency in runners and non-runners

  *Lane et al., 1986; Panush et al., 1986; Eichner, 1989*
Injury and Impacts?

- subjects with greater impact peaks had significantly fewer running-related injuries

Relative Injury Frequency (%)

Nigg, 1997
Do Impacts Really Cause Injury?
What those who advocate change really say?

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**Injury Epidemiological Studies**

- Few epidemiological studies

- Prospective study on 471 runners
  - No difference in injury rates between FF and RF
  - Suggested injury site affected by portion of the foot that makes initial contact

  *Kleindienst, 2003*

- Prospective study on 1203 runners
  - No differences in injury rates between FF and RF
  - Difference in location and kind of injury

  *Walther, 2005*
Possible Injuries If Changing to an FF Pattern

• Achilles tendinitis

• Plantar Fasciitis

• Patellofemoral Pain
Achilles Tendinitis

Gruber et al., 2011

Achilles Tendon Force (N)

Percent Support

Gruber et al., 2011
Plantar Fasciitis

Gruber et al., 2010
Foot Motion with Different Running Patterns

- foot acts like a rigid structure thus plantar fascia is always under tension.
Patellofemoral Pain

- increased knee abduction and external rotation moments related to PFPS (Stefanyshyn et al., 2001)

Kleindienst et al., 2005
What those who advocate change really say?

- changing to a FF or MF footfall pattern from an RF pattern:
  - caused by modern footwear NO
  - is metabolically more efficient NO
  - decreases the impact forces in running NO
  - reduces running-related injuries NO (and possibly causes running-related injuries)
Conclusions

• our research suggests that changing one’s footfall pattern is not beneficial to the runner

• the change in footfall pattern (i.e. rearfoot to forefoot) may result in stressing tissue not used in the RF pattern possibly resulting in a running-related injury
Take-home Message

Changing one’s footfall pattern is not good!

thus

Variety of one’s footfall pattern is not always the spice of life!
Thank you!

Questions?