BIOMEKANISK VINKEL PÅ BELASTNING AF KROPPEN UNDER LØB

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RUNNING-RELATED INJURIES

› High incidence of running-related injuries.

› To prevent injuries we need to understand the underlying causal mechanisms.

› Biomechanics may answer some of our questions.
RUNNING-RELATED INJURIES

Cumulative load > injury threshold = Injury!
STRESS-FREQUENCY CURVE

- Hreljac (2005)
- Structure-specific, individual-specific.

- Muscle
- Tendon
- Ligament
- Bone
- etc.

![Stress-Frequency Curve Diagram](image)
STRESS-FREQUENCY CURVE

- Cumulative load = Stress per stride · Number of strides
- Cumulative load > injury threshold = Injury!
STRESS-FREQUENCY CURVE

- Cumulative load = Stress per stride \cdot Number of strides
- Cumulative load > injury threshold = Injury!
STRESS-FREQUENCY CURVE

- Not static!
STRESS-FREQUENCY CURVE

› Positive remodeling → Higher Injury Threshold

› Previous training
  - Running
  - Strength training
STRESS-FREQUENCY CURVE

> Negative remodeling → Lower Injury Threshold

> Previous injury
  Disease
  Age
HOW TO PREVENT INJURIES?

Stay in the "No Injury Region"!
HOW TO PREVENT INJURIES?

› Stay in the "No Injury Region"!

› Modify:
  - Stress per stride
  - Number of strides
NUMBER OF STRIDES

› Easy to modify.

› Run a shorter distance!

› Also influenced by:
  - Stride length/stride frequency
  - (Running speed)
STRESS PER STRIDE

- Influenced by:
  - Running speed
  - Stride length / stride frequency
  - Footstrike pattern
  - (Anthropometry / Anatomy)
FOOTSTRIKE PATTERN

› Heelstrike → Forefoot strike:
  - Knee joint load (↓)
  - Ankle joint load (↑)

No difference in injury incidence.

Boyer et al. (2013), Kulmala et al. (2013), Rooney & Derrick (2013), Shih et al. (2013).
STRIDE LENGTH/STRIDE FREQUENCY

> Decreases in stride length (increases in stride frequency) reduces knee and ankle joint load per stride.

**Stride frequency:**

- Lenhart et al. (2014).

**Stride length:**

- Hobara et al. (2012), Lenhart et al. (2014), Schubert et al. (2014), Thompson et al. (2014).

Stress per stride (↓) · Number of strides (↑) = Cumulative load ??
RUNNING SPEED

- Running speed (↑) - Stress per stride (↑)

- Petersen et al. (2014)

- Heel strikers.

- Ankle joint load per stride increases more than knee joint load per stride, when running speed increases.
RUNNING SPEED

› From a biomechanical perspective:
  - High running speed ➔ Greater risk of sustaining an injury at the posterior part of the lower leg or underneath the foot as compared to the anterior part of the knee.

› Theoretical framework – Nielsen et al. (2013) "Pacing injuries" ”Volume injuries"
RUNNING SPEED

- Running speed (↑) - Knee joint load per stride (↑)
- Running speed (↑) - Stride length (↑)

TABLE 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>8.02 ± 0.17 km/h*</th>
<th>11.79 ± 0.21 km/h*</th>
<th>15.78 ± 0.22 km/h*</th>
<th>P Value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stride characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stride length, m</td>
<td>1.68 ± 0.09</td>
<td>2.43 ± 0.11</td>
<td>3.00 ± 0.12</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Strides per 1000 m, n</td>
<td>596 ± 31</td>
<td>413 ± 18</td>
<td>334 ± 13</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Peak moment per stride, Nm/kg</td>
<td>2.18 (2.03, 2.33)</td>
<td>2.61 (2.46, 2.76)</td>
<td>2.62 (2.46, 2.77)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Impulse per stride, Nm-s/kg</td>
<td>0.26 (0.24, 0.29)</td>
<td>0.27 (0.25, 0.30)</td>
<td>0.26 (0.23, 0.28)</td>
<td>0.20</td>
</tr>
<tr>
<td>Impulse cumulative, Nm-s/kg/1000 m</td>
<td>155 (143, 166)</td>
<td>113 (102, 125)</td>
<td>86 (74, 97)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Peak power (absorption) per stride, W/kg</td>
<td>-6.29 (-7.11, -5.47)</td>
<td>-9.07 (-8.98, -8.25)</td>
<td>-9.39 (-10.24, -8.54)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Peak power (generation) per stride, W/kg</td>
<td>3.24 (2.74, 3.72)</td>
<td>4.90 (4.41, 5.39)</td>
<td>5.99 (5.50, 6.49)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Work (negative) per stride, J/kg</td>
<td>-0.38 (-0.44, -0.33)</td>
<td>-0.50 (-0.56, -0.45)</td>
<td>-0.47 (-0.53, -0.42)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Work (positive) per stride, J/kg</td>
<td>0.21 (0.17, 0.25)</td>
<td>0.30 (0.26, 0.34)</td>
<td>0.33 (0.29, 0.37)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

*Values in parentheses are 95% confidence interval.

Petersen et al. (2014)
RUNNING SPEED

- Running speed (↑) - Stride length (↑) - Number of strides (↓)

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<th>TABLE 2</th>
<th>LOAD PER STRIDE (PEAK MOMENT, IMPULSE, PEAK POWER, AND WORK) AND CUMULATIVE LOAD (CUMULATIVE IMPULSE) AT THE KNEE JOINT AT DIFFERENT RUNNING SPEEDS</th>
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<tr>
<td>Impulse cumulative, Nm-s/kg/1000 m³</td>
<td>1.55 (43.166)</td>
</tr>
<tr>
<td>Peak power (absorption) per stride, W/kg</td>
<td>-5.23 (-71.5, -5.47)</td>
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The P value is derived from the test result that the development of the loads within 1 parameter across the 3 speeds was significantly different from zero (a low P value corresponds to a significant increase or a significant decrease).

Values are ± SD.

Decreased significantly as speed increased.

Cumulative impulse at the knee is calculated by multiplying the individual impulse per stride by the individual number of strides per 1000 m³.
RUNNING SPEED

› Slow speed:
  Stress per stride (↓) · Number of strides (↑↑) = Cumulative load (↑)

› The cumulative load at the knee joint is greater at slow-speed running than at fast-speed running!

› Runners may be advised to increase their running speed to reduce the cumulative knee joint load.

Petersen et al. (2014)
RUNNING SPEED

Cumulative load knee joint load.
ANTHROPOMETRY / ANATOMY

› Not well documented.

› Malalignment, instability → Stress per stride (↑) in some structures.

› Correct dysfunctions → redistribute load.
TAKE-HOME MESSAGE

› Cumulative load is important!
  Cumulative load > injury threshold = Injury!

› Modify ”Number of strides” and ”Stress per stride”.

› Based on biomechanical studies
  – need for high-quality epidemiological studies.

› Knee joint pain ~ distance
  ➔ Run shorter distance, faster. (Change to forefoot strike)

› Ankle joint pain ~ speed
  ➔ Run slower and shorter distance. (Change to heelstrike)
REFERENCES


THANK YOU FOR YOUR ATTENTION!