Jarek Mäestu, PhD

Monitoring athlete’s training loads

Sports Injury Prevention Conference,
27 February 2016
Tartu
Just some thoughts…. 

❖ Is physiotherapist the “bad” wanting to keep the athlete from training.
❖ How can we help coaches to max performance with minimizing the risk?
❖ Why the team rather measures external loads compared to internal load?
❖ Are the injuries preventable?
There is no theory that would describe the type, amount and intensity of different training methodology to compile an individualized training program for everyone.

- Empirical evidence
- Consensus?
  - Higher workload - higher performance.
Training load

- Volume X intensity
  - Useless
  - Recovery
  - Improving
  - Overloading

Optimal load

Low  | Training load | High
--- |---------------|---

Overload
The set of different tools or methods to increase the likelihood of the positive outcome of athletic performance

- Why?
- What?
- How often?
- How?

Minimal testing - maximal reliable feedback

Feeling of involvement
How big should be the change?

Is it also meaningful???

- For individual athlete: half of the variability of competitive performance, or 0.5-1 % in terms of power.

- One standard deviation difference from the average

- For team performance 1/5 of the standard deviation for average result of the team.

- Run up to 1500m 0,8%
- Run 1500 - 10000 1,1%
- Marathon 3,0%
- High jump 1,7%
- Mountain bike 2,4%
- Swimming 0,8%

(Hopkins, 2004)
What can we measure in terms of training load?

❖ EXTERNAL TRAINING LOAD

• Physical work
  • Lifted weight
  • Covered distance
  • Number of jumps, throws
  • Intensity of the exercise
  • ……

❖ INTERNAL TRAINING LOAD

 • Physiological response
   • Heart rate
   • Perceived exertion
   • Psychological response
   • Hormonal/biochemical response
   • ……
Training load response

External training load      Absolute vs Relative

TRAINING LOAD

Physical capacity
Stress tolerance
Recovery potential

Athlete

Internal Training outcome

Subjective
Psychological
Physiological

Immunological
Biochemical

Chronological age
Training background
History of injuries
Internal load
What is monitored?

Australian and New Zealand high performance athletes
Overall 91% coaches indicated some kind of monitoring

<table>
<thead>
<tr>
<th>What?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury prevention</td>
<td>29% Self-reporting tests 84%</td>
</tr>
<tr>
<td>Effectiveness of training program</td>
<td>27% Performance test 61%</td>
</tr>
<tr>
<td>Maintaining performance</td>
<td>22% Performance during competition 43%</td>
</tr>
<tr>
<td>Preventing overtraining</td>
<td>22% Biochemical parameters 8%</td>
</tr>
</tbody>
</table>
### Continuous overview

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
<th>Date</th>
<th>Time</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morily Ruusta</td>
<td></td>
<td>25.02.2016</td>
<td>5:12:16</td>
<td></td>
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<tr>
<td>Mikk Tooming</td>
<td></td>
<td>26.02.2016</td>
<td>2:50:00</td>
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<tr>
<td>Minna Mati Evi</td>
<td></td>
<td>25.02.2016</td>
<td>3:33:00</td>
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<td>Misa Sindi</td>
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<td>25.02.2016</td>
<td>0:54:39</td>
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<td>Misa Joll</td>
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<td>4:30:00</td>
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<tr>
<td>Elga Soothe</td>
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<td>26.02.2016</td>
<td>5:17:00</td>
<td></td>
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<tr>
<td>Elina Risti</td>
<td></td>
<td>26.02.2016</td>
<td>3:20:00</td>
<td></td>
</tr>
</tbody>
</table>
Internal training load. Borg scale

- “How was your workout?”
- RPE x duration of the session
- In soccer:
  - 300-500 AU easy session
  - 700-1000 AU hard session
- In endurance:
  - 200-400 AU easy session
  - 600-900 AU hard session
Session RPE at different intensities

- 12 competitive swimmers
- 20 training sessions at different intensities

Wallace et al, 2008
Session RPE
Comparison between perception of coach and athlete

<table>
<thead>
<tr>
<th>Training type</th>
<th>n</th>
<th>Coach</th>
<th>Athlete</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery</td>
<td>100</td>
<td>1.87±0.8</td>
<td>2.17±0.8</td>
<td>0.35; p=0.002</td>
</tr>
<tr>
<td>Base training</td>
<td>121</td>
<td>3.61±0.63</td>
<td>3.50±1.0</td>
<td>0.25; p=0.006</td>
</tr>
<tr>
<td>Speed+Interval</td>
<td>61</td>
<td>6.64±2.0</td>
<td>5.57±1.81</td>
<td>0.718; p=0.000</td>
</tr>
<tr>
<td>Total</td>
<td>282</td>
<td>3.65±2.0</td>
<td>3.48±1.7</td>
<td>0.798; p=0.000</td>
</tr>
</tbody>
</table>

Heinsoo, 2015
RPE and internal training load
Training load - performance-injury

MONITORING INDIVIDUAL ATHLETE WELL-BEING

Athletes can report their subjective perceptions of training intensity, for example, using the rating of perceived exertion (RPE). The RPE can be used to quantify the internal training loads of athletes. At the completion of each training session, athletes provide a 10-point Likert scale rating of how intense they perceived their training to be. A rating of 1 indicates that the training was very easy, and a rating of 10 indicates that the training was very hard. The units refer to the intensity of the session. The intensity of the session is multiplied by the session duration to provide training load. The units typically no larger than a mobile phone, are worn by athletes and provide information on non-locomotor sport-specific activities (eg, jumps in volleyball, collisions in rugby and strokes in swimming). These devices, which are a game-changer in previous work. A more accurate term might be referred to them as accelerometers, gyroscopes) embedded in the devices also provide information on speed and distances covered, while inertial sensors (ie, engineering) can be used to directly measure the joint of interest (eg, knee, ankle) and provide data on joint movement and loading.

Figure 1

Hypothetical relationship between training loads, fitness, injuries and performance. Redrawn from Orchard.

Table 1

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Relative risk (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury history in the previous season (no vs yes)</td>
<td>1.4 (0.6 to 2.8)</td>
</tr>
<tr>
<td></td>
<td>0.7 (0.4 to 1.4)</td>
</tr>
<tr>
<td></td>
<td>0.9 (0.2 to 4.1)</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1.6 (0.8 to 3.3)</td>
</tr>
<tr>
<td>High intensity</td>
<td>1.0 (0.2 to 4.4)</td>
</tr>
<tr>
<td>Very high intensity</td>
<td>1.5 (0.3 to 8.6)</td>
</tr>
<tr>
<td>Very low intensity</td>
<td>0.9 (0.4 to 2.0)</td>
</tr>
<tr>
<td>Low intensity</td>
<td>1.6 (0.8 to 3.3)</td>
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<tr>
<td>Low intensity</td>
<td>1.0 (0.2 to 4.4)</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>1.4 (0.3 to 7.5)</td>
</tr>
<tr>
<td>High intensity</td>
<td>0.5 (0.2 to 1.1)</td>
</tr>
<tr>
<td>Very high intensity</td>
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Importantly, most of this data can be obtained in real-time, accompanied by an exuberant athlete. A more accurate term might be referred to them as accelerometers, gyroscopes) embedded in the devices also provide information on speed and distances covered, while inertial sensors (ie, engineering) can be used to directly measure the joint of interest (eg, knee, ankle) and provide data on joint movement and loading.
How to monitor data?

High absolute training loads are associated with greater injury risk.
Can we predict injury?

2-year study period
Session RPE-likelihood of injury

Additional 2 years to determine if non-contact soft tissue injuries could be predicted

True positive - predicted injury - injured 67%
False positive - predicted injury - not injured 13%
False negative - no predicted injury - injured 11%
Positive predictive value 85%
Negative predictive value 98.9%

Gabbet, 2010
Temporal changes in training load

Test 1  Test 2  Test 3

Total distance (m)

Intensity

Volume

Lactate 4 mmol/l

Lehmann et al. 1997
Temporal changes in training load - Injury risk

- 40% of injuries were associated with rapid changes in training load (>10%) compared to preceding week in football players (Piggott et al 2009);

- If the change is higher than than 1100 to 1200 AU in absolute values (Cross et al 2015; Rogalski et al 2013).

To minimize the risk of injury do not exceed weekly load increases greater than 10%

Gabbet, 2016
Acute vs Chronic Load

- Acute load - average weekly load  
  FATIGUE
- Chronic load - average of previous 28-40 days  
  FITNESS

Emphasises the load that the athlete has performed relative to what he/she has prepared for
Acute:Chronic Load

blue line = CTL Chronic Training Load
pink line = ATL Acute Training Load
yellow bar = TSB Training Stress Balance

see the CTL (your fitness) step up gradually during a build or decline during a rest

redrawn from Hunter
The “Sweet Spot”

Likelihood of subsequent injury (%)

Acute:Chronic load ratio

Sweet Spot

Danger zone

Injury risk

Blanche & Gabbet, 2015
Active Straight Leg Raise

Vasaku jala ASLR testi tulemused

Parema jala ASLR testi tulemused

Kalev, 2015
## Internal workload and injury risk

<table>
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<tr>
<th>Risk factors</th>
<th>Transient</th>
</tr>
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<tbody>
<tr>
<td>Injury history in the previous season (no vs yes)</td>
<td>1.4 (0.6 to 2.8)</td>
</tr>
<tr>
<td>Total distance (≤3910 vs &gt;3910 m)</td>
<td>0.6 (0.3 to 1.4)</td>
</tr>
<tr>
<td>Very low intensity (≤542 vs &gt;542 m)</td>
<td>0.6 (0.2 to 1.3)</td>
</tr>
<tr>
<td>Low intensity (≤2342 vs &gt;2342 m)</td>
<td>0.5 (0.2 to 1.1)</td>
</tr>
<tr>
<td>Moderate intensity (≤782 vs &gt;782 m)</td>
<td>0.4 (0.2 to 1.1)</td>
</tr>
<tr>
<td>High intensity (≤175 vs &gt;175 m)</td>
<td>0.8 (0.2 to 3.1)</td>
</tr>
<tr>
<td>Very high intensity (≤9 vs &gt;9 m)</td>
<td>2.7 (1.2 to 6.5)*</td>
</tr>
<tr>
<td>Total high intensity (≤190 vs &gt;190 m)</td>
<td>0.5 (0.1 to 2.1)</td>
</tr>
<tr>
<td>Mild acceleration (≤186 vs &gt;186 m)</td>
<td>0.2 (0.1 to 0.4)†</td>
</tr>
<tr>
<td>Moderate acceleration (≤217 vs &gt;217 m)</td>
<td>0.3 (0.1 to 0.6)†</td>
</tr>
<tr>
<td>Maximum acceleration (≤143 vs &gt;143 m)</td>
<td>0.4 (0.2 to 0.8)*</td>
</tr>
<tr>
<td>Repeated high-intensity effort bouts (≤3 vs &gt;3 bouts)</td>
<td>0.9 (0.4 to 2.0)</td>
</tr>
</tbody>
</table>

Gabbet & Ullah, 2012
Training load distribution

Basic periodization - Champion Skier

Annual intensity distribution of 12 Olympic/World champions - XC skiing

Seiler, 2013
Conclusion

- Training has both positive and negative effects;
- There is a relationship between high training loads and injuries;
- The ratio of acute to chronic training load is better predictor of injury than acute or chronic loads in isolation;
- This is an ongoing process with lot’s of adaptations.
“Can we win the championships if we have the best knowledge from sport science, best coaches available and best equipment? NO. But if we do not have it, we can lose the title”

Chris Carmichael

THANK YOU FOR YOUR ATTENTION!