OVERTRAINING IN EXTREME ENDURANCE SPORTS

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OVERTRAINING-THE GREAT UNKNOWN!!!

The assumption that a specific training plan will work is WRONG.
There are MANY recreational and elite athletes suffering from overtraining and most of them don’t even know it!
Why?
Most of them NEVER find out!. So most overtrained athletes are not diagnosed.
Factors involved in Overtraining

- Excessive training
- Poor recovery and assimilation
- Improper Nutrition
- Psychological Stress
PRINCIPLES OF TRAINING

- Overload
- Frequency
- Intensity
- Specificity
- Recovery
- Supercompensation
General Workout/Recovery Cycle

- Training Stimulus
- Fatigue
- Recovery
- Supercompensation
- Involution

Zatsiorsky & Kraemer, 2006
Supercompensation

- Biological state
- Before stimulus
- Fatigue
- Compensation (recovery)

- Training too easy
- Training adequate
- Training too hard

New stimulus applied:
- A - too early
- B - on time
- C - too late
Supercompensation Models

Supercompensation positive

Supercompensation positive

Supercompensation negative

Supercompensation positive accumulated

Supercompensation null

Zatsiorsky & Kraemer, 2006
Overtraining

- Many Athletes train more than what they can assimilate
- In many cases coaches and trainers don’t know how much training an athlete can assimilate
- It is essential to perform Physiological Testing throughout the season!
Physiological Testing - Coaching 101

Main Parameters

• Lactate Metabolism
• Fat metabolism
• Carbohydrate Metabolism
• VO2max
• Metabolic Efficiency

- Only with the evaluation of these parameters it is possible to establish an appropriate and individual training program for an athlete.

- Otherwise, without testing.....We are guessing!
Central Adaptations

Local Adaptations

- Lungs
- Heart
- Veins
- Arteries

- Hemoglobin
- Glucose
- Oxygen
- Carbon dioxide
- Mitochondria
- Adenosine triphosphate
- Adenosine monophosphate
- High energy bonds
- Synthesis of ATP
- Energy
Monitoring throughout the season
Monitoring of Overtraining

- Essential to prevent Overtraining before it happens
- Diagnose Overtraining in time
- One of the most important tools for an elite athlete and Coach
- Essential to have a scientific and clinical approach
- The answer is in the blood
- There are many parameters in the blood indicators of many different physiological conditions
Hematological Monitorization Throughout the Season

- **Important Biomarkers**

  - Hematological
  - Biochemical
  - Hormonal
  - Serological
About 200 Billion RBC’s are destroyed daily. So 200 Billion have to be replaced daily.
Hematological Monitorization Throughout the Season
Bollood Profiling

Hgb Evolution during the season

- Optimum Performance Frame
Hematological Monitorization Throughout the Season Bolood Profiling

Hgb Evolution during the season

- DETECTION, INTERVENTION AND CORRECTION
- Optimum Performance Frame
**Hematological Monitorization Throughout the Season**

**Bolood Profiling**

- 15g/dl Hgb x 1.34 mL O2 = 20.1g/dl O2
- 14.0g/dl Hgb x 1.34 mL O2 = 18.76 g/dl O2

**Optimum Performance Frame**

- Hgb Evolution during the season
Hematological Monitorization Throughout the Season
Blood Profiling

- NO Detection, Intervention, correction = OVERTRAINING!!
- Optimum Performance Frame
Hematological Monitorization Throughout the Season
Blood Profiling

- 15g/dl Hgb x 1.34 mL O2 = 20.1g/dl O2
- 12.8g/dl Hgb x 1.34 mL O2 = 17.15 g/dl O2
  -15% !
Hematological Monitorization Throughout the Season
Blood Profiling

Muscle Damage
- Healthy muscle
- Muscle Injury

- Sarcomere
- Z-Lines

Figure 4.11 (a) An electron micrograph showing the normal arrangement of the actin and myosin filaments and Z disk configuration in the muscle of a runner before a marathon race. (b) A muscle sample taken immediately after a marathon race shows Z disk streaming caused by the eccentric actions of running. Reprinted from Hageman et al. (1984).
Hematological Monitorization Throughout the Season

Blood Profiling

- Muscle Injury
Hematological Monitorization Throughout the Season

Blood Flow

Muscle Damage

Muscle Enzymes

Figure 4.11: (a) An electron micrograph showing the normal arrangement of the actin and myosin filaments and Z disk configuration in the muscle of a runner before a marathon race. (b) A muscle sample taken immediately after a marathon race showed Z disk streaming caused by the eccentric actions of running. Reprinted from Hagerman et al. (1984).
Ultra-marathon-induced changes in serum markers of skeletal or cardiac muscle damage and inflammation

<table>
<thead>
<tr>
<th>Variable</th>
<th>URL</th>
<th>Pre-race</th>
<th>12 h running</th>
<th>24 h running</th>
<th>48 h running</th>
<th>24 h post-race</th>
<th>48 h post-race</th>
<th>ANOVA results</th>
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<tr>
<td>CK [U/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>174</td>
<td>193 ± 79</td>
<td>5056 ± 46</td>
<td>18010 ± 1</td>
<td>20605 ± 2</td>
<td>6277 ± 60</td>
<td>1582 ± 13</td>
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<td>AST [U/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42</td>
<td>33 ± 6</td>
<td>138 ± 95*</td>
<td>541 ± 517</td>
<td>813 ± 896</td>
<td>401 ± 428</td>
<td>228 ± 251</td>
<td><strong>F&lt;sub&gt;5,30&lt;/sub&gt; = 4.54, p &lt; 10&lt;sup&gt;-3&lt;/sup&gt;</strong></td>
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<td>ALT [U/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40</td>
<td>30 ± 8</td>
<td>48 ± 20**</td>
<td>124 ± 95*</td>
<td>226 ± 220</td>
<td>172 ± 150</td>
<td>140 ± 121</td>
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<td>LDH [U/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>180</td>
<td>193 ± 38</td>
<td>377 ± 136**</td>
<td>700 ± 498</td>
<td>1014 ± 916*</td>
<td>696 ± 569</td>
<td>582 ± 487*</td>
<td><strong>F&lt;sub&gt;5,30&lt;/sub&gt; = 2.36, p &lt; 10&lt;sup&gt;-3&lt;/sup&gt;</strong></td>
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<td>GGT [U/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37</td>
<td>24 ± 8</td>
<td>ND</td>
<td>22 ± 8</td>
<td>21 ± 6*</td>
<td>20 ± 5**</td>
<td>21 ± 4</td>
<td><strong>F&lt;sub&gt;4,24&lt;/sub&gt; = 4.09, p = 0.012</strong></td>
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<td>NTproBNP [pg/ml]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>125</td>
<td>54 ± 50</td>
<td>299 ± 194**</td>
<td>508 ± 458**</td>
<td>329 ± 412**</td>
<td>ND</td>
<td>108 ± 86*</td>
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<td>hs-cTnT [ng/ml]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.016</td>
<td>0.004 ± 0.002</td>
<td>0.014 ± 0.012*</td>
<td>0.008 ± 0.006</td>
<td>0.008 ± 0.008</td>
<td>ND</td>
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<td>4.72</td>
<td>0.64 ± 0.34</td>
<td>35.86 ± 1</td>
<td>33.25 ± 1</td>
<td>23.20 ± 1</td>
<td>7.39 ± 13</td>
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<td>CRP [mg/l]&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.0</td>
<td>0.8 ± 0.8</td>
<td>3.4 ± 1.7*</td>
<td>30.0 ± 8.9***</td>
<td>63.5 ± 31.5***</td>
<td>45.5 ± 37.8***</td>
<td>28.0 ± 31.2**</td>
<td><strong>F&lt;sub&gt;5,30&lt;/sub&gt; = 5.93, p &lt; 10&lt;sup&gt;-3&lt;/sup&gt;</strong></td>
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</tbody>
</table>

Kłapcińska et al, 2013
Monitoring throughout the season

Free Radicals and Antioxidant Capacity

Average Free Radicals Accumulation*

Intervention Increased Antioxidants

Intervention Increased more Antioxidants

3 hard Mountain Stages

Inigo San Millan, PhD, 2013
Monitoring throughout the season

Free Radicals and Antioxidant Capacity
Training Monitoring and Quantification
In many cases, poor nutrition triggers overtraining.

Elements to watch out:

- CARBOHYDRATES (CHO)
- Vitamines (B-Complex, Folic Acid, Vit-D, A, E, C)
- Iron
- Antioxidants
Nutrition

- Muscle Glycogen Concentration (mMol/kg)

- Gollnick et. al. 1974
- Hermansen et. al. 1967
The relationship of muscle glycogen content, work time and dietary carbohydrate intake

Scientific Study – Glycogen and Performance

Time to Exhaustion

Graph showing the relationship between muscle glycogen content (grams/kg muscle) and work time (minutes) with different dietary carbohydrate intakes:
- Low Carbo Diet
- Mixed Diet
- High Carbo Diet

The graph indicates that higher muscle glycogen content is associated with longer work time and better performance.
Scientific Study – Glycogen and Performance
Scientific Study – Glycogen and Performance


Time to exhaustion, min

Initial muscle glycogen, g - 100 g muscle⁻¹

High carbohydrate

Normal diet

Low carbohydrate

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Kenyan runners have dominated for decades and are the skinniest athletes in the world.
Kenyan runners have dominated for decades and are the skinniest athletes in the world.

Kenyan’s diets
Energy Intake: 2987Kcal
- Carbohydrates: 76.5%!!
  - 10.7g/kg/day!!
- Fat: 13.4%
- Protein: 10.1%
- 20% Simple sugars!!
HIGH CHO and LOW FAT diet!!

Carbohydrates during the Tour de France

Garmin Riders at TdF
Total Energy Intake: 6000-9000 Kcal/day
- Carbohydrates: 75-80%
- About 1,000 g/day of CHO
  - 400g simple sugars!!
- 4000 kcal/day of CHO
  - 1600 Kcal/day Simple Sugars!
- 13-14g/kg/day!!

TOUR de FRANCE PROVEN!!!
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES

Glucose

FAT (FFA)

Muscle
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES
The Importance of CHO and Gycogen Storages

Before exercise

After Exercise
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES

During High Exercise intensities (Competition, hard training)

Muscle Protein (Alanine, Glutamine, BCAA’s)

Muscle Glycogen depleted

FAT

glycogen
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES

Catabolism

Muscle Glycogen depleted
The Importance of CHO and Gycogen Storages

Muscle Damage

- Healthy muscle
- Muscle Injury

- Glycogenin disruption??
- Increased glucose uptake damaged cell??

Z-Lines

Sarcomere

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INDIRECT ASSESSMENT OF GLYCOGEN STATUS IN COMPETITIVE ATHLETES

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1SCHOOL OF MEDICINE, UNIVERSITY OF COLORADO DENVER, DENVER, CO.; 2DEPARTMENT OF PHARMACOLOGY AND PHYSIOLOGY, SCHOOL OF MEDICINE, UNIVERSITY OF ZARAGOZA, SPAIN

INTRODUCTION: Proper glycogen storage is of great importance for athletic performance. Multiple studies show the positive correlation between glycogen storage and performance. Nevertheless, glycogen assessment is difficult to determine due to the invasive and impractical nature of muscle biopsies. Therefore, it is difficult to identify suboptimal glycogen levels in athletes. Throughout the measurements of maximal blood lactate levels ([La]b max) and maximal carbohydrate oxidation rates (CHOox max) it could be possible to indirectly estimate muscle glycogen status in competitive athletes and identify suboptimal glycogen levels. The purpose of this study was to assess indirectly muscle glycogen status through measurement of [La]b max and CHOox max.

METHODS: 82 competitive men (28 professionals and 54 non-professionals) and 17 competitive carried out a bicycle ergometer test, starting at 2 W·kg⁻¹ with increments of 0.5 W·kg⁻¹ until exhaustion, the duration of three first steps was 5 min, and then 10 min. Oxygen uptake (VO₂) and carbon dioxide (VCO₂) were measured (ParvoMedics TrueOne 2400, Sandy, UT) throughout the test and blood lactate concentration ([La]b) (YSI 1500, Yellow Springs Instruments, Ohio) at the end of each step. [La]b max was considered the value at the end of last step of exercise. Fat and carbohydrate oxidation rates (FATox and CHOox) were estimated by means of Fainl’s equations. A cutoff of 1 SD respect to the ([La]b) max was suggested in order to classify the subjects in two groups: GO (Optimal [La]b max) and GS (Suboptimal maximal [La]b max) with [La]b max of <5.27 mM in men and <4.00 mM in women respectively as the cutoff. A Student t-test for independent data was used to compare groups, the determination of the Pearson correlation coefficient was used to verify the existence of relationships between variables, level of statistical significance was set at p<0.05.

RESULTS: The results of the present study sowed that 30% for men and 24% for women showed suboptimal [La]b max (GS). The correlation between [La]b max and CHOox max was high in men (r=0.771, p<0.05) and low in women (r=0.373). In men, [La]b max, CHOox max, and RER max were significantly higher in GO vs. GS, whereas FATox max was significantly lower in GO vs. GS. In women, there were not found significant differences neither in CHOox max nor in FATox max. Nevertheless [La]b max, and RER max were significantly higher in GO.
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Novel Methodology for Muscle Glycogen Content Assessment through Imagery Diagnosis
PRO CYCLIST BEFORE AND AFTER MAXIMAL EXERTION (V02MAX TEST)

Pre-exercise cross section
Quad

Post-exercise same muscle

Vein
Vein
Glycogen depletion pattern

Rider 3

Glycogen content in the muscle

0 25 45 60

RFLA
RFSA

Right RF / Thu Sep 5th, 12:17 PM
Novel Methodology for Muscle Glycogen Content Assessment through High Frequency Ultrasound
LOW CHO DIETS + COMPETITIVE TRAINING + COMPETITION = OVERTRAINING
Summary

Overtraining is a big Unknown affecting many athletes.
It is important to perform scientific and clinical monitoring to detect overtraining before it happens.
Physiological testing and monitoring is important to quantify correct and individual workloads.
Improper nutrition leads many times to overtraining.
THANK YOU!

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