THE SCIENTIFIC PREPARATION AND MONITORING OF THE ATHLETE

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Peter Drucker

- The man who invented Management
- Father of Business Analytics
- Father of Modern Business Corporation

What Gets Measured, Gets Managed” – Peter Drucker
Determinants of Performance

- Physiology
- Genetics
- Training
- Nutrition
- Health Injuries
- Monitoring
- Psychology
- Lifestyle
HOW MANY ELEMENTS DO WE CONTROL???
HOW MANY ELEMENTS DO WE CONTROL???
Physiological Testing

➢ The foundation of any scientific-based training program - Coaching 101

➢ It is crucial to establish the physiological and metabolical parameters of each athlete in order to prescribe the most accurate and scientific-based training program.
➢ Evaluation of the “engine” of an athlete.
➢ Evaluation of the weak and strong points.
➢ Evaluation of quantity and quality of training
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!
Each Body is DIFFERENT!. We have DIFFERENT Metabolic parameters and training zones!!
 INDIVIDUALIZATION is KEY

Each Body is DIFFERENT!. We have DIFFERENT Metabolic parameters and training zones!!
INDIVIDUALIZATION is KEY

### Training Intensity Zones

<table>
<thead>
<tr>
<th>Heart Rate Zones (cycling and running)</th>
<th>Swim Pace (time per 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZONE 1 Recovery pace</td>
<td>T-pace + 10 sec</td>
</tr>
<tr>
<td>ZONE 2 Aerobic base pace</td>
<td>T-Pace + 5 sec</td>
</tr>
<tr>
<td>ZONE 3 Aerobic tempo pace</td>
<td>T-Pace</td>
</tr>
<tr>
<td>ZONE 4 Sub-LT “race” pace</td>
<td>T-Pace</td>
</tr>
<tr>
<td>ZONE 5A Super-LT pace</td>
<td>T-Pace</td>
</tr>
<tr>
<td>ZONE 5B Anaerobic effort</td>
<td>T-Pace – 5 sec</td>
</tr>
<tr>
<td>ZONE 5C All out sprinting effort</td>
<td></td>
</tr>
</tbody>
</table>

### Heart Rate Training Zones

<table>
<thead>
<tr>
<th>Zone/Level</th>
<th>Name</th>
<th>Range</th>
<th>Edwards</th>
<th>Coggan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Active Recovery</td>
<td>Low 50%</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Endurance</td>
<td>High 60%</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tempo</td>
<td>Low 70%</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Threshold</td>
<td>Mid 80%</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>VO2max</td>
<td>High 100%</td>
<td>134</td>
<td></td>
</tr>
</tbody>
</table>

### Intensity Levels

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Zone</th>
<th>Accomplishment</th>
<th>Borg</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>1</td>
<td>Low Endurance</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Basic Endurance</td>
<td>3</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>3</td>
<td>Tempo</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Road Race</td>
<td>6</td>
</tr>
<tr>
<td>HIGH</td>
<td>5</td>
<td>Speed training above</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>VO2 max training</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anaerobic sprint</td>
<td></td>
</tr>
</tbody>
</table>
IMPROVEMENT IN PERFORMANCE BUT NOT NECESSARILY IN VO2MAX

Professional 32 y.o. male cyclist

No Improvement in VO2max

Very important Improvement in Lactate Clearance Capacity
Physiological/Metabolic Testing

In the Laboratory:

Kara Goucher
Physiological/Metabolic Testing

In the Field:

Ryder Hesjedal
2012 Tour of Italy (Giro) Winner

Tom Danielson
1st Stage 4 of US Pro Cycling Challenge 2012

Rory Sutherland
Winner of Queen Stage of US Pro Cycling Challenge 2012
Physiological/Metabolic Testing

In the Field:

CU Football

Colorado Rapids
Local Adaptations

Cellular Level

- The events happening at the cellular level ultimately make the difference.
- A mediocre cyclist can have the highest VO2max but not the best cellular adaptations to exercise.
Muscle Lactate Metabolism

- Lactate Metabolism crucial in performance
- Of all physiological and metabolic parameters it is the one that discriminates the most
Muscle Lactate Metabolism

Glycogenolysis

Glucose → Lactate accumulation

Decreased pH (Acidosis)

[H+]

Skeletal Muscle Cell/Fiber

Endomysium

Perimysium

Muscle fasciculus

Epimysium

Blood vessels

Myofibril

Nucleus

Sarcomplasm

Muscle fibers

Body of muscle

Tendon

Bone
Muscle Lactate Metabolism

- **Glycogenolysis**
  - Glucose → Lactate
  - Decreased pH (Acidosis)
  - Interference and inhibition of muscle excitation-contraction coupling

- **Lactate accumulation**

- **Hydrogen Ions \([H^+]\)**

- **Skeletal Muscle Cell/Fiber**

- **GLYCOLYSIS**
  - Input: 2 ATP, 2 ADP, \(C_6H_{12}O_6\)
  - Output: 2 NADH, 2 pyruvate
  - Net: 2 ATP

- **LACTATE FORMATION**
  - Electrons, hydrogen from NADH → 2 lactate

- \([H^+]\) arrows indicate increased acidity.
Muscle Lactate Metabolism

GLYCOLYSIS:

C\textsubscript{6}H\textsubscript{12}O\textsubscript{6} → 2 pyruvate

2 ATP energy input → 2 ADP
4 ATP energy output → 2 pyruvate

2 ATP net

LACTATE FORMATION:

2 lactate

electrons, hydrogen from NADH

Blood Glucose

Glucose → Lactate → Pyruvate

Krebs Cycle

Lactate, Piruvate

Liver, Heart, Skin, Kidneys...

Blood Lactate

Oxidation in Adjacent Cell/Fiber
## Muscle Lactate Metabolism

### World Class Runner vs College Level Athlete

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>World Class</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>7.5</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>8</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>8.5</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>9</td>
<td>0.7</td>
<td>1.3</td>
</tr>
<tr>
<td>9.5</td>
<td>0.8</td>
<td>1.9</td>
</tr>
<tr>
<td>10</td>
<td>0.95</td>
<td>2.05</td>
</tr>
<tr>
<td>10.5</td>
<td>1.12</td>
<td>3.5</td>
</tr>
<tr>
<td>11</td>
<td>1.3</td>
<td>4.7</td>
</tr>
<tr>
<td>11.5</td>
<td>1.6</td>
<td>6.8</td>
</tr>
<tr>
<td>12</td>
<td>2.2</td>
<td>8.7</td>
</tr>
<tr>
<td>12.5</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>13.5</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>8.2</td>
<td></td>
</tr>
</tbody>
</table>
Muscle Lactate Metabolism

<table>
<thead>
<tr>
<th></th>
<th>JC</th>
<th>AC</th>
<th>PC</th>
<th>WPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>( W_{\text{peak}} )</td>
<td>317 ± 23(^{1,2} )</td>
<td>338 ± 26(^{3,4} )</td>
<td>370 ± 32(^{1,3} )</td>
<td>401 ± 29(^{2,4} )</td>
</tr>
<tr>
<td>( W_{\text{peak}} \cdot \text{kg}^{-1} )</td>
<td>4.91 ± 0.28(^{5,6} )</td>
<td>5.09 ± 0.21(^{7} )</td>
<td>5.27 ± 0.39(^{5,8} )</td>
<td>6.10 ± 0.31(^{6,7,8} )</td>
</tr>
<tr>
<td>3.5 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td>1.8 ± 0.2(^{d,e,f,g} )</td>
<td>1.3 ± 0.2(^{d} )</td>
<td>1.3 ± 0.1(^{e,h} )</td>
<td>1.0 ± 0.4(^{f,g,h} )</td>
</tr>
<tr>
<td>4.0 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td>3.0 ± 0.9(^{i,j,k} )</td>
<td>2.1 ± 0.7(^{i,l} )</td>
<td>1.8 ± 0.6(^{j,m} )</td>
<td>1.3 ± 0.2(^{k,l,m} )</td>
</tr>
<tr>
<td>4.5 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td>6.6 ± 2.0(^{n,\tilde{n},o} )</td>
<td>4.6 ± 1.3(^{n,p,q} )</td>
<td>3.2 ± 1.0(^{n,h,p,r} )</td>
<td>1.88 ± 0.4(^{o,q,r} )</td>
</tr>
<tr>
<td>5.0 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td>10.1 ± 2.1(^{s,t} )</td>
<td>8.7 ± 2.0(^{u,v} )</td>
<td>5.8 ± 1.5(^{s,u,w} )</td>
<td>3.1 ± 0.9(^{t,v,w} )</td>
</tr>
<tr>
<td>5.5 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td></td>
<td>9.35 ± 3.26</td>
<td>7.86 ± 2.16</td>
<td>5.64 ± 1.29</td>
</tr>
<tr>
<td>6.0 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td></td>
<td></td>
<td></td>
<td>8.63 ± 0.50</td>
</tr>
<tr>
<td>6.5 ( \text{W} \cdot \text{kg}^{-1} )</td>
<td></td>
<td></td>
<td></td>
<td>11.4 ± 1.21</td>
</tr>
</tbody>
</table>

\( W_{\text{peak}} \) are peak powers measured during the Tour de France, World Championship, or UCI Pro Tour stage races.

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- **WPC Criteria:**
  - Tour de France, Italy and Spain winners or podium finishers.
  - World Champions.
  - UCI Pro Tour stage races or “classics” winners.
Substrate Utilization

- Fat and Carbohydrates Oxidation
- Fatty Acids can only be oxidized in the mitochondria, therefore Fat oxidation measurement is a good indicator of mitochondrial and oxidative capacity
Substrate Utilization

- **FATmax**
- **Crossover Point**

**FAT and CHO Oxidation rates vs HR**

Fat Oxidation Rate (g/min)
CHO Oxidation Rate (g/min)

Fat and CHO Oxidation rates vs HR T

San Millan Lab
Recreational Athlete

World Class Athlete
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
PREVENTING OVERTRAINING IS KEY

It is important to measure and monitor different important parameters throughout the season.

We need to apply a scientific approach.
Factors involved in Overtraining

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

Overload
Frequency
Intensity
Specificity
Recovery
Supercompensation
Supercompensation

Biological state
Before stimulus

Fatigue

Super-compensation

Compensation (recovery)

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

- training too easy
- training adequate
- training too hard
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!
Monitoring throughout the season
Training Monitoring and Quantification
Training Monitoring and Quantification

### Laps & Splits Column Chart

<table>
<thead>
<tr>
<th>Lap</th>
<th>Start</th>
<th>End</th>
<th>Duration</th>
<th>Moving Duration</th>
<th>Miles</th>
<th>rTSS</th>
<th>IF</th>
<th>NGP</th>
<th>Avg Pace</th>
<th>Max Pace</th>
<th>Elev Gain</th>
<th>Elev Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap 1</td>
<td>0:00:00</td>
<td>0:36:54</td>
<td>0:36:54</td>
<td>0:30:01</td>
<td>4.08</td>
<td>30.1</td>
<td>0.74</td>
<td>07:43</td>
<td>07:21</td>
<td>06:26</td>
<td>128</td>
<td>74</td>
</tr>
<tr>
<td>Lap 2</td>
<td>0:36:54</td>
<td>0:41:56</td>
<td>0:05:02</td>
<td>0:05:02</td>
<td>0.77</td>
<td>7.2</td>
<td>0.91</td>
<td>06:18</td>
<td>06:30</td>
<td>06:05</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Lap 3</td>
<td>0:41:56</td>
<td>0:43:58</td>
<td>0:02:02</td>
<td>0:02:02</td>
<td>0.35</td>
<td>3.2</td>
<td>0.96</td>
<td>06:57</td>
<td>06:40</td>
<td>05:34</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lap 4</td>
<td>0:43:58</td>
<td>0:48:01</td>
<td>0:05:02</td>
<td>0:05:02</td>
<td>0.72</td>
<td>6.4</td>
<td>0.85</td>
<td>06:42</td>
<td>07:00</td>
<td>05:50</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lap 5</td>
<td>0:49:00</td>
<td>0:54:01</td>
<td>0:05:01</td>
<td>0:05:01</td>
<td>0.77</td>
<td>7.2</td>
<td>0.91</td>
<td>06:12</td>
<td>06:28</td>
<td>06:01</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lap 6</td>
<td>0:54:01</td>
<td>0:56:04</td>
<td>0:02:02</td>
<td>0:02:02</td>
<td>0.33</td>
<td>3.2</td>
<td>0.97</td>
<td>06:56</td>
<td>06:03</td>
<td>05:38</td>
<td>0</td>
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<td>Lap 7</td>
<td>0:56:04</td>
<td>1:01:04</td>
<td>0:05:01</td>
<td>0:05:01</td>
<td>0.70</td>
<td>4.5</td>
<td>0.72</td>
<td>08:01</td>
<td>07:11</td>
<td>06:42</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Lap 8</td>
<td>1:01:04</td>
<td>1:06:08</td>
<td>0:05:01</td>
<td>0:05:01</td>
<td>0.78</td>
<td>7.0</td>
<td>0.90</td>
<td>06:24</td>
<td>06:22</td>
<td>05:45</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

**Duration:** 0:02:02
**Avg Pace:** 06:03 min/mi
Training Monitoring and Quantification
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
Hematological Monitorization Throughout the Season

➢ About 200 Billion RBC’s are destroyed daily. So 200 Billion have to be replaced daily.

Red blood cells contain several hundred hemoglobin molecules which transport oxygen. Oxygen binds to heme on the hemoglobin molecule.
Hematological Monitorization Throughout the Season Bolood 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
Bolood Profiling

- Muscle Injury
Hematological Monitorization Throughout the Season
Blood Profiling

Muscle Damage

- Blood Flow

Biomarkers
Monitoring throughout the season

Free Radicals and Antioxidant Capacity

Average Free Radicals Accumulation*

Day 1  Day 5  Day 10  Day 15  Day 20
267  284  278  319  284

Intervention Increased Antioxidants

3 hard Mountain Stages

Intervention Increased more Antioxidants
Monitoring throughout the season

Free Radicals and Antioxidant Capacity
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

[Graph showing muscle glycogen concentration over time with data points from Gollnick et al. 1974 and Hermansen et al. 1967]

[Image of a person running in the mountains]
The relationship of muscle glycogen content, work time and dietary carbohydrate intake (adapted from Borgström et al. 1967).
Scientific Study – Glycogen and Performance
Scientific Study – Glycogen and Performance
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

Muscle

Glucose

FAT (FFA)
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES

Liver

Glucose

Muscle

Glycogen
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

glycogen

FAT
THE IMPORTANCE OF CHO AND GYCOGEN STORAGES

Catabolism

Muscle Glycogen depleted

glycogen
The Importance of CHO and Glycogen Storages
Muscle Damage

- Healthy muscle
- Muscle Injury

- Z-Lines
- Sarcomere

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

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).
INDIRECT ASSESSMENT OF GLYCOGEN STATUS IN COMPETITIVE ATHLETES

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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]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]ₘₐₓ max and CHOox max.

METHODS: 82 competitive men (28 professionals and 54 non-professionals) and 17 competitive women 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 the 10 min. Oxygen uptake (VO₂) and carbon dioxide (VCO₂) were measured (ParvoMedics TrueOne 2400, Sandy, UT) throughout the test and blood lactate concentration ([La]ₘₐₓ) (YSI 1500, Yellow Springs Instruments, Ohio) at the end of each step. [La]ₘₐₓ 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 Frayn’s equations. A cutoff of 1 SD respect to the ([La]ₘₐₓ) max was suggested in order to classify the subjects in two groups: GO (Optimal [La]ₘₐₓ max and GS (Suboptimal maximal [La]ₘₐₓ) max) with [La]ₘₐₓ 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 showed that 30% for men and 24% for women showed suboptimal [La]ₘₐₓ max (GS). The correlation between [La]ₘₐₓ max and CHOox max was high in men (r=0.771, p<0.05) and low in women (r=0.373). In men, [La]ₘₐₓ 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]ₘₐₓ max, and RER max were significantly higher in GO.

Figure 1. [La]ₘₐₓ max, CHOox max, FATox max and RER max comparisons between both groups of men. *p<0.05, ***p<0.001.

Figure 2. [La]ₘₐₓ max, CHOox max, FATox max and RER max comparisons between both groups of women. *p<0.05, **p<0.01.
INDIRECT ASSESSMENT OF GLYCOGEN STATUS IN COMPETITIVE ATHLETES

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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 (\([\text{La}]_\text{b, max}\) 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 \([\text{La}]_\text{b, max}\) and CHOox max.

METHODS: 82 competitive men (28 professionals and 54 non-professionals) and 17 competitive women 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 (\(\dot{V}O_2\)) and carbon dioxide (\(\dot{V}CO_2\)) were measured (ParvoMedics TrueOne 2400, Sandy, UT) throughout the test and blood lactate concentration (\([\text{La}]_\text{b}\) (YSI 1500, Yellow Springs Instruments, Ohio)) at the end of each step. \([\text{La}]_\text{b, max}\) 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 Frayn’s equations. A cutoff of 1 SD respect to the \([\text{La}]_\text{b, max}\) was suggested in order to classify the subjects in two groups: GO (Optimal \([\text{La}]_\text{b, max}\) and GS (Suboptimal maximal \([\text{La}]_\text{b, max}\) with \([\text{La}]_\text{b, max}\) 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 showed that 30% for men and 24% for women showed suboptimal \([\text{La}]_\text{b, max}\) (GS). The correlation between \([\text{La}]_\text{b, max}\) and CHOox max was high in men \((r=0.771, \ p<0.05)\) and low in women \((r=0.373)\). In men, \([\text{La}]_\text{b, max}\), 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 \([\text{La}]_\text{b, max}\) and RER max were significantly higher in GO vs.
Glycogen Monitoring
Muscle Biopsy

Very invasive and aggressive

Impractical and not possible to apply
Novel Methodology for Muscle Glycogen Content Assessment through Imagery Diagnosis

PRO CYCLIST BEFORE AND AFTER MAXIMAL EXERTION (V02MAX TEST)

Pre-exercise cross section

Quad

Glycogen depletion pattern

Rider 3

Glycogen content in the muscle

RFLA
RFSA

0 25 45 60

30 35 40 45 50 55 60
Novel Methodology for Muscle Glycogen Content Assessment through High Frequency Ultrasound

Glycogen Content Regulates Muscle Contraction

- A 25% decrease in Glycogen in the legs will decrease Ca++ release from SR by a 10% !!
Glycogen Evolution Throughout the season

Glycogen Content Pre-PostGame

<table>
<thead>
<tr>
<th>Team</th>
<th>PRE Game</th>
<th>Post Game</th>
<th>% Change</th>
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<tbody>
<tr>
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<tr>
<td>Jose M Team</td>
<td>14.3</td>
<td>14.3</td>
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</tr>
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LOW CHO DIETS + COMPETITIVE TRAINING + COMPETITION = OVERTRAINING
MARGINAL GAINS. HOW IMPORTANT ARE THEY?
HOW MANY ELEMENTS DO WE CONTROL???

PERFORMANCE

- Physiology
- Genetics
- Training
- Monitoring
- Nutrition
- Health
- Injuries
- Psychology
- Lifestyle
MARGINAL GAINS. HOW IMPORTANT ARE THEY?
Summary

- Scientific Training maximizes and utilizes all possible resources

- The Goal is to utilize 100% of genetic potential (“engine”)

- No Scientific Training = minimization and under-utilization of potential

- Overtraining is a great unknown affecting many cyclists and it should be assessed properly by a professional

- A true Scientific Training Necessary to make it to the next level
THANK YOU!

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