The effect of intensified training on performance and health

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• Head of section of Integrative Physiology
• Head of Copenhagen Centre for Team Sport and Health
• Former professional and national team player
• Assistant coach for the Danish national football team
• Former assistant coach at Juventus F.C.
Speed endurance training of endurance trained athletes
Aim of the study

To study the effect of 8 weeks with a 25% reduction in training volume with sessions of speed endurance training:

12 x 30 s at 90-95% of max running speed/
3 min of rest
Study design

17 male runners
VO2-max: 59 ml/kg/min

30-s speed endurance training and aerobic high-intensity training (25% reduction in volume)

Sessions per week:
2-3 x AnT, 1 x AH, 1 x AL, 1 x AM
Performance – repeated intense runs to exhaustion

![Graph showing performance comparison between PRE and POST for 1st and 2nd runs.](chart.png)
10-K performance

10-K performance (min)

Pre | Post
--- | ---

Intensified training

***

Graph showing changes in 10-K performance before and after intensified training.
Conclusion

Speed endurance training, and reduced training volume, leads to performance improvements in endurance trained athletes.
What caused the improved performance?
Potassium and fatigue
Potassium induced fatigue

K\textsuperscript{+}

0 20 40 60 80 100
K\textsuperscript{+} (mM)
Kraft (%)
-80 -75 -70 -65 -60 -55 -50
Em (mV)
Kraft
Em

K\textsuperscript{+} (mM)
0 20 40 60 80 100
Kraft (%)
-80 -75 -70 -65 -60 -55 -50
Em (mV)
Potassium induced fatigue

![Diagram showing potassium ions and their effect on muscle fibers.](image)

**Graph:**
- Kraft (%)
- $E_m$ (mV)
- $K^+$ (mM)

- Kraft (%)
- $E_m$ (mV)
- $K^+$ (mM)

- Kraft (%)
- $E_m$ (mV)
- $K^+$ (mM)
One-legged kicking model
Microdialysis
Microdialysis
Muscle interstitial potassium with (filled symbols) and without (open symbols) previous exercise

![Graph showing the change in interstitial potassium concentration over time with and without previous exercise. The graph includes error bars and asterisks indicating significant differences.](image-url)
Potassium – fatigue
Conclusion

• Accumulation of potassium in muscle interstitium may play an important role in the development of fatigue during intense exercise
Effect of training on accumulation of potassium in muscle interstitium

Accumulation of potassium in muscle interstitium may play an important role in the development of fatigue during intense exercise.

By training the rate of potassium accumulation in muscle interstitium is reduced and performance is elevated.
Na\textsuperscript{+}/K\textsuperscript{+} pump location and subunits

\begin{itemize}
  \item \textbf{a1} \quad \textbf{a2} \quad \textbf{Na/K pump} \quad \textbf{β1}
\end{itemize}

Fitts. 1994
Na⁺/K⁺ pump

Capillary
Na\textsuperscript{+}/K\textsuperscript{+} pump subunit expression after speed endurance training

Mohr et al. 2007 8 wks
Iaia et al. 2008 4 wks
Bangsbo et al. 2009 6-9 wks
Thomassen et al. 2010 2 wks
Summary

SET in trained runners

Short-term and long-term performance

Na-K pump subunits (a1 + a2)

H⁺ transport capacity

Running economy

Maximal oxygen uptake

Enzyme activity (PFK, CS, HAD)

Iaia et al. 2008
Iaia et al. 2009
Bangsbo et al. 2009
Summary

SET in trained runners

- Short-term and long-term performance
- Na-K pump subunits ($\alpha_1 + \alpha_2$) → $K^+$ handling?
- $H^+$ transport capacity
- Running economy
- Maximal oxygen uptake
- Enzyme activity (PFK, CS, HAD)

Iaia et al. 2008
Iaia et al. 2009
Bangsbo et al. 2009
Does intensified training lead to better K⁺ handling in trained individuals?
**Design**

8 trained cyclists; 
**VO$_2$ max**: 60 ml/kg/min

7 weeks with SET and AH  
~70% reduction in volume

**SET**: 12x~40s:4min@>90% max. intensity

**AH**: 5x3-4min:1.5-2min@>90% HRmax

2.5 SET + 1.5 AH /WK

1  2  3  4  5  6  7 weeks

Gunnarsson et al. 2013
Performance

- effect of 7 weeks of intensified training

Repeated sprint test

Gunnarsson et al. 2013
Performance

- effect of 7 weeks of intensified training

Repeated sprint test

Time trial

Gunnarsson et al. 2013
Femoral venous plasma $k^+$

Gunnarsson et al. 2013
Femoral venous plasma $\text{K}^+$

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
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<tbody>
<tr>
<td>EX1 (mmol)</td>
<td>2.7±0.8</td>
<td>2.3±1.0</td>
</tr>
<tr>
<td>Rec 1 (mmol)</td>
<td>-1.0±0.7</td>
<td>-2.0±0.9</td>
</tr>
<tr>
<td>EX2 (mmol)</td>
<td>4.5±1.0</td>
<td>1.7±1.6</td>
</tr>
<tr>
<td>Rec 2 (mmol)</td>
<td>-0.6±0.4</td>
<td>-1.6±0.6</td>
</tr>
</tbody>
</table>

**Net plasma $\text{K}^+$ release**

- $\text{K}^+$ uptake in recovery
- $\text{K}^+$ release during intense exercise
- $\text{K}^+$ uptake in recovery

Gunnarsson et al. 2013
Microdialysis
K⁺ handling during intense exercise

Interstitial K⁺

Before
After

Gunnarsson et al. 2013
Effect of Additional Speed Endurance Training on Performance and Muscle Adaptations

THOMAS PETURSSON GUNNARSSON, PETER MØLLER CHRISTENSEN, KRIS HOLSE, DANNY CHRISTIANSEN, and JENS BANGSBO

Department of Exercise and Sport Sciences, Section of Human Physiology, University of Copenhagen, DENMARK

18 male Danish sub-elite soccer players

7 players (VO₂max ~61 ml/kg/min):
- Performance testing
- Muscle biopsies
- VO₂ (sub- and maximal)
Effect of Additional Speed Endurance Training on Performance and Muscle Adaptations

5-wk intensified training during the season

One speed endurance production training/wk:
5-9 x 30-s sprint // 180-s recovery

January    February    March    April    May    June

(P)    (P)    (P)    (P+B)    (P+B)

Pre-season    Season (4 wks)    Season (5 wks)

Gunnarsson et al., 2012
Effect of Additional Speed Endurance Training on Performance and Muscle Adaptations

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yo-Yo IR2 (m)</td>
<td>782±54</td>
<td>778±65</td>
<td>862±63*</td>
</tr>
</tbody>
</table>

↑ ~10%

Gunnarsson et al., 2012
Intense training and health?

The 10-20-30 training concept

- 30s Jogging
- 20s running
- 10s sprint

2-3 min rest

2-4x
What is the 10-20-30 concept?

3x/wk
3x5 min for 4 wks
4x5 min for 3 wks

HR distribution

Time spent in heart rate category during training (min per session)

Heart rate (% of HR max)

Before
After

0-70 % 70-80 % 80-85 % 85-90 % 90-95 % 95-100 %

Gunnarsson & Bangsbo 2012
# Training overview

## Distance

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>During</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance 10-20-30</td>
<td>30.4</td>
<td>14.0</td>
</tr>
<tr>
<td>Change</td>
<td>-54.0%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

## Training time

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>During</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training time 10-20-30</td>
<td>155.9</td>
<td>95.1</td>
</tr>
<tr>
<td>Change</td>
<td>-39.0%</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

## CON

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>During</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance 10-20-30</td>
<td>24.1</td>
<td>24.8</td>
</tr>
<tr>
<td>Change</td>
<td>2.8%</td>
<td>-4.4%</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>During</th>
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</thead>
<tbody>
<tr>
<td>Training time 10-20-30</td>
<td>119.2</td>
<td>132.4</td>
</tr>
<tr>
<td>Change</td>
<td>11.1%</td>
<td>-7.7%</td>
</tr>
</tbody>
</table>
Performance

5-K run

1500-m run

Dias 41

Gunnarsson & Bangsbo 2012
Health measurements

Fasting blood samples

Blood pressure and heart rate at rest
Health measurements

- Blood lipid profile
  - Total cholesterol
  - LDL
  - HDL
- Blood pressure
  - Systolic
  - Diastolic
- Resting heart rate

Gunnarsson & Bangsbo 2012
Mean arterial pressure (MAP) and resting heart rate (HR)

Effect of 10-20-30 cycle training in hypertensive males

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>Diff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-h MAP (mmHg)</td>
<td>123±4</td>
<td>116±4*</td>
<td>-5.4±1.1</td>
</tr>
<tr>
<td>24-h HRrest (bpm)</td>
<td>62.4±3.9</td>
<td>54.1±2.1*</td>
<td>-13.3±2.5</td>
</tr>
</tbody>
</table>
Summary - 10-20-30 training

↑ Short & long-term performance

↑ VO2max

↑ Health profile
Summary

Intensified and reduced volume training in trained individuals leads to:

- Improved performance
- Better running economy
- Better $K^+$ handling
- Better health variables
What is the optimal combination of various types of training?
Key questions

- What is the optimal way of conducting intensified training? – how to combine it with other types of training and nutritional strategies?

To be addressed - examples:
- How can performance in the heat be improved?
- What is the optimal supplementation strategy?
Thank you!
Questions?

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5-10-15 training

Maximum oxygen uptake
Further information

www.bangsbosport.com