Influence of Increased Duration or Intensity on Training Load as evaluated by EPOC and TRIMPS

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Training Effect - Disturbance of Homeostasis

$\text{VO}_{2\text{max}}$ of beginner exercisers increases 10-20% during the first 10-20 weeks and thereafter levels off.

$\text{VO}_{2\text{max}}$ of endurance athletes increases for ~1-3 years and thereafter only small changes occur.

Why? Because disturbance of homeostasis induced by training is necessary to obtain training effect for both athletes and beginners.

Do we know when our homeostasis is disturbed and is longer duration at lower intensity better than shorter duration at higher intensity?
How to measure Disturbance of Homeostasis - Training Load?

- Heart rate: time at diff. intensities, not enough?
- Blood lactate: invasive, time consuming, momentary?
- Stress hormones: invasive, expensive, time consuming, requires laboratory analysis?
- RPE: feelings of fatigue, need for recovery
- TRIMP: Training Impulse (Bannister 1991):
  - Time x relative intensity x multiplying factor (blood lactate vs. relative exercise intensity)
  - Accumulates also during low intensity recovery exercise
  - Not totally physiological index
EPOC: Excess Postexercise Oxygen Consumption

E.g. Brooks & Fahey, EXERCISE PHYSIOLOGY, John Wiley & Sons Inc 1984:

- "In reality, the cause of Excessive Postexercise Oxygen Consumption (EPOC) is the general disturbance to homeostasis brought on by exercise"
- "EPOC integrates the effects of increase in body temperature, changes in stress hormone and metabolite levels, changes in intracellular ion concentrations, etc... after exercise"
- EPOC could be a physiological measure for
  - disturbance of homeostasis,
  - exercise induced fatigue accumulation and
  - recovery time needed after exercise
To evaluate the effect of increased duration or intensity of exercise on training load as evaluated by $EPOC_{\text{meas}}$, $EPOC_{\text{pred}}$ and TRIMP

To evaluate the differences between $EPOC_{\text{meas}}$, $EPOC_{\text{pred}}$ and TRIMP
Subjects
- 8 males
- Age $28 \pm 4$ years (mean $\pm$ SD)
- Weight $81 \pm 15$ kg
- Height $180 \pm 4$ cm
- BMI $25 \pm 4$ (%Fat $17 \pm 5$)
- $\text{VO}_2\text{max}$ $52 \pm 8$ ml/kg•min$^{-1}$
  - $v\text{VO}_2\text{max}$ $13,6 \pm 2,1$ km/h
  - $v\text{RCT}$ $10,8 \pm 2,2$ km/h
  - $v\text{LT}$ $8,1 \pm 1,5$ km/h
  - (3% slope)

Three treadmill running exercises (3% slope)
- Normal: CV21/68%
  - 21 min at 9,3 km/h, 68% $v\text{VO}_2\text{max}$
- Increased Intensity: CV21/79%
  - 21 min at 10,8 km/h, 79% $v\text{VO}_2\text{max}$
- Increased Duration: CV40/68%
  - 40 min at 9,3 km/h, 68% $v\text{VO}_2\text{max}$

Measurements: $\text{VO}_2$ (Sensor Medics), RR-Intervals (Polar RR-recorder), blood lactate concentration (EBIO 6666), RPE
EPOC_{meas} and TRIMP

- **EPOC_{meas}:** 15-min recovery VO\textsubscript{2} – resting VO\textsubscript{2} (sitting)

- **TRIMP:** 
  \[ t \times \%\text{HRR} \times 0.64e^{1.92(\%\text{HRR})} \]
  
  - = duration x relative intensity x multiplying factor
**EPOC**\textsubscript{pred}:

\[ EPOC_{t} = EPOC_{t-1} + f(EPOC_{t}, \%HR_{t}, \Delta t) \]

- Neural Network computational model based on the relations between EPOC vs. intensity of exercise as the \%VO\textsubscript{2}\textsubscript{max} (%HR\textsubscript{max}), duration of exercise and On-Off information

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**Description of exercises**

**VO₂** as expected: higher with increased intensity

Heart rate as expected: continued to increase with increased duration
Which one induced a greater disturbance of homeostasis?

Blood lactate as expected: higher with increased intensity

RPE as expected: continued to increase with increased duration
Accumulation of TRIMP and $\text{EPOC}_{\text{pred}}$

**TRIMP**
greater change with increased duration

**$\text{EPOC}_{\text{pred}}$**
greater change with increased duration
And decreased during recovery
Comparison of exercises

Intensity induced a greater change: RPE, bLa, peakHR, EPOC\_meas

Duration induced a greater change: EPOC\_pred, TRIMP
High Correlation between $EPOC_{\text{pred}}$ and TRIMP

$R^2 = 0.75$
Why difference between $EPOC_{\text{meas}}$ vs. $EPOC_{\text{pred}}$ and TRIMP?

$EPOC_{\text{pred}}$ and TRIMP start to accumulate with time at $\sim$50-60% HRR (over LT).

Present subjects had higher $VO_2\text{max}$, LT and RCT than "average persons": e.g. LT 63%HRR (78%HRmax)
Conclusions

- Increase in training intensity from 68% to 79% \( v\text{VO}_2\text{max} \) for 21 min exercise induced a greater disturbance of homeostasis (increase in training load) than increase in training duration from 21 to 40 min at 68% \( v\text{VO}_2\text{max} \) based on:
  - Heart rate
  - Blood lactate
  - RPE
  - Measured EPOC

- TRIMP and \( \text{EPOC}_{\text{pred}} \) were more sensitive to increase in training duration than intensity at the present training intensities
Conclusions

- TRIMP and $\text{EPOC}_{\text{pred}}$ integrated similarly the intensity and duration of exercise.

- $\text{EPOC}_{\text{pred}}$ and TRIMP depend very much on the % HR and %HRR level which may differ between subjects having different training background.

- Calculation of $\text{EPOC}_{\text{pred}}$ and TRIMP should take into account the differences in individual "threshold" –values.

- $\text{EPOC}_{\text{pred}}$ can give dynamic information on the accumulation of training load and allows calculation of time needed for recovery (decrease of $\text{EPOC}_{\text{pred}}$ to resting level).
Thank you for your attention