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

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Training Effect - Disturbance of Homeostasis

VO_{2max} of beginner exercisers increases 10-20% during the first 10-20 weeks and thereafter levels off.

VO_{2max} 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

Purpose

To evaluate the effect of increased duration or intensity of exercise on training load as evaluated by $EPOC_{meas}$, $EPOC_{pred}$ and TRIMP

To evaluate the differences between $EPOC_{meas}$, $EPOC_{pred}$ and TRIMP

Methods

Subjects

- 8 males
- Age 28 ± 4 years (mean ± SD)
- Weight 81 ± 15 kg
- Height 180 ± 4 cm
- BMI 25 ± 4 (%Fat 17 ± 5)
- VO_{2max} 52 ± 8 ml/kg•min^{-1}
  - vVO_{2max} 13,6 ± 2,1 km/h
  - vRCT 10,8 ± 2,2 km/h
  - vLT 8,1 ± 1,5 km/h
  - (3% slope)

Three treadmill running exercises (3% slope)

- **Normal: CV21/68%**
  - 21 min at 9,3 km/h, 68% vVO_{2max}
- **Increased Intensity: CV21/79%**
  - 21 min at 10,8 km/h, 79% vVO_{2max}
- **Increased Duration: CV40/68%**
  - 40 min at 9,3 km/h, 68% vVO_{2max}

Measurements: VO_2 (Sensor Medics), RR-Intervals (Polar RR-recorder), blood lactate concentration (EBIO 6666), RPE

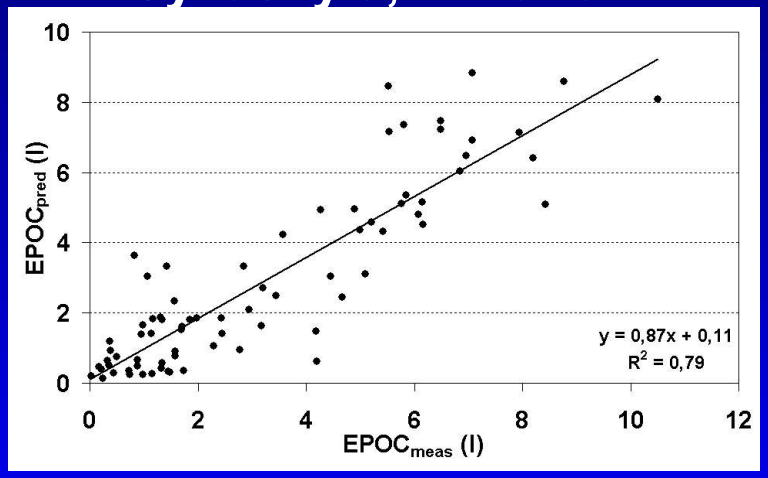
$EPOC_{meas}$ and TRIMP

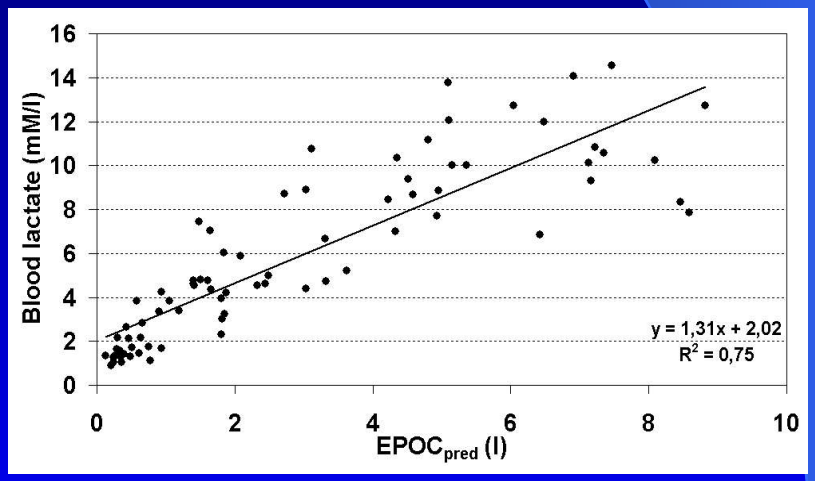
- $EPOC_{meas}$: 15-min recovery VO_2 – resting VO_2 (sitting)

- TRIMP: = t x %HRR x $0.64e^{1,92(\%HRR)}$
  - = duration x relative intensity x multiplying factor
  - Bannister E.W. 1991: Modelling Elite Athletic Performance. In: MacDougall, J.D., Wenger, H.A. & Green, H.J. (Eds.) Physiological Testing of High-Performance Athlete 2nd ed. Human Kinetics, Champaign, Illinois.

$EPOC_{pred}$

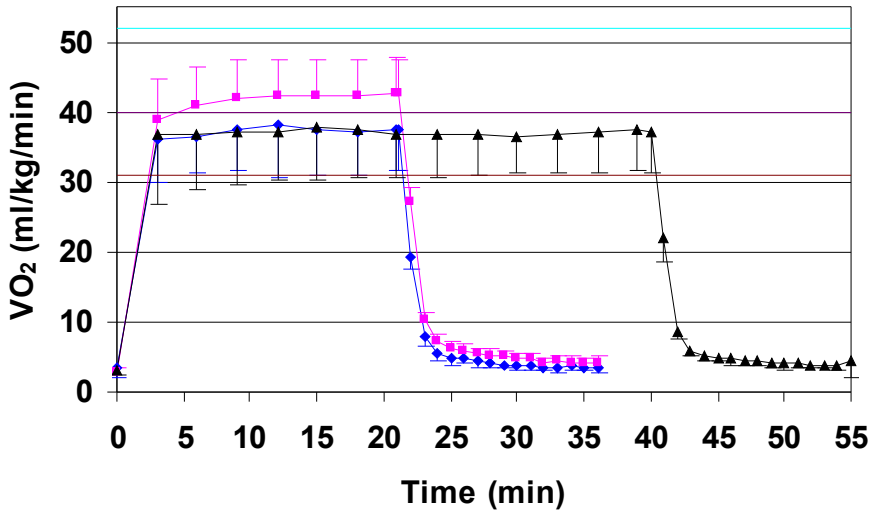
- $EPOC_{pred}$: $EPOC_t = EPOC_{t-1} + f(EPOC_t, \%HR_t, \Delta t)$
  - Neural Network computational model based on the relations between EPOC vs. intensity of exercise as the $\%VO_{2max}$ ($\%HR_{max}$), duration of exercise and On-Off information
  - Saalasti S. 2003: Neural networks for heart rate time series analysis. Ph.D. Dissertation. Department of Mathematical Information Technology, University of Jyväskylä, Finland

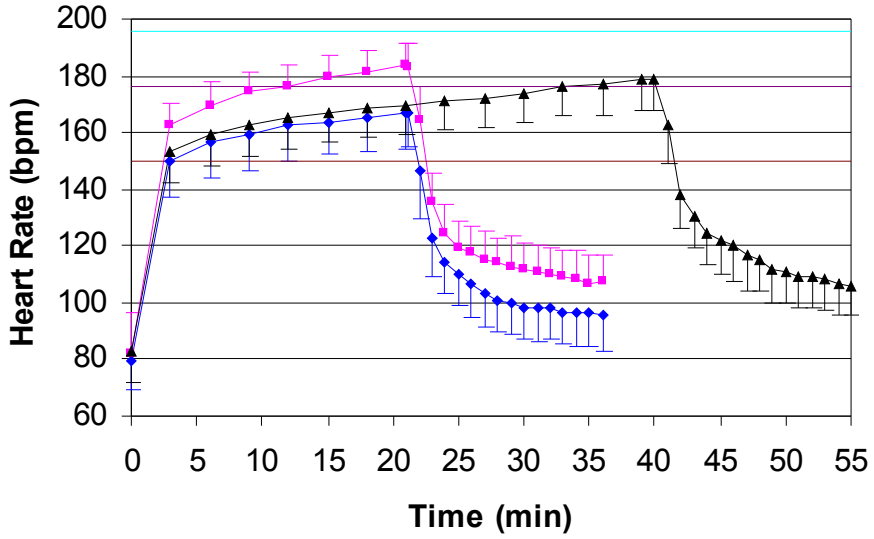




Rusko, H.K., Pulkkinen, A., Saalasti, S., Hynynen, E., & Kettunen, J. Pre-prediction of EPOC: A tool for monitoring fatigue accumulation during exercise? Medicine and Science in Sports and Exercise, 35: S183, 2003.

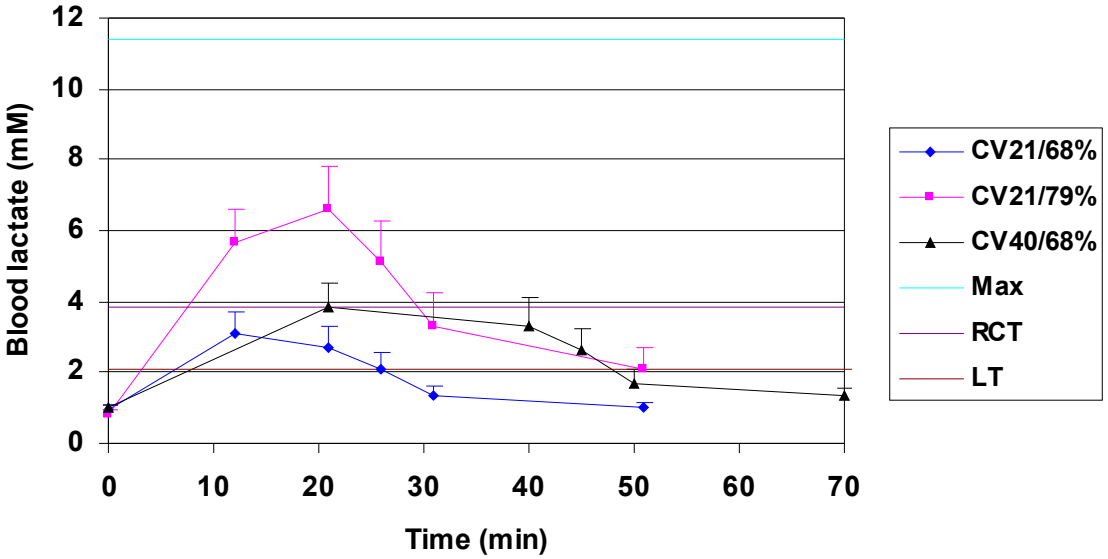
Description of exercises

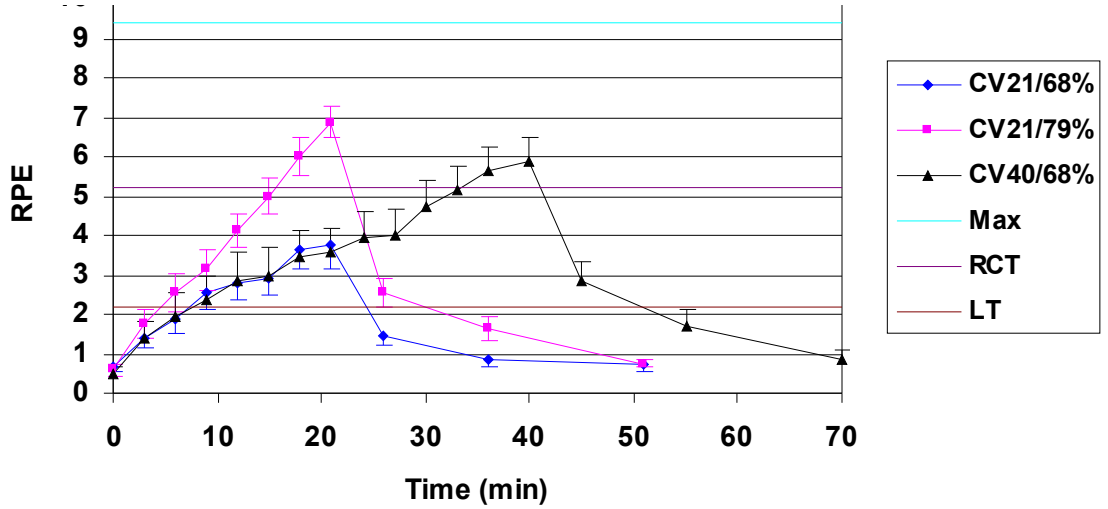




$\underline{VO_2}$ as expected: higher with increased intensity

Heart rate as expected: continued to increase with increased duration





Blood lactate

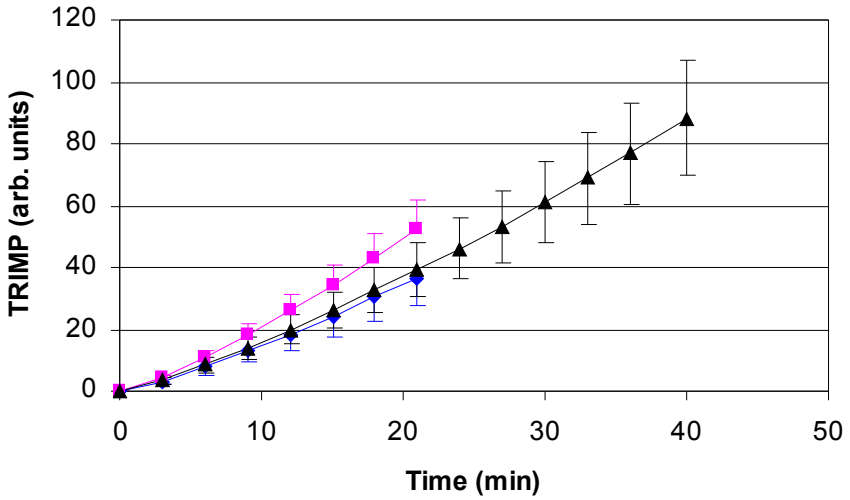
as expected: higher with increased intensity

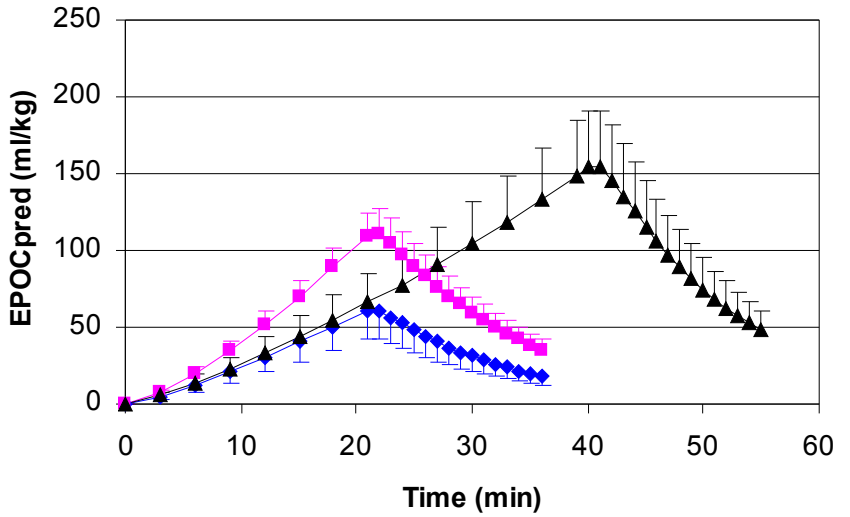
RPE

as expected: continued to increase with increased duration

Which one induced a greater disturbance of homeostasis?

Accumulation of TRIMP and $EPOC_{pred}$





TRIMP

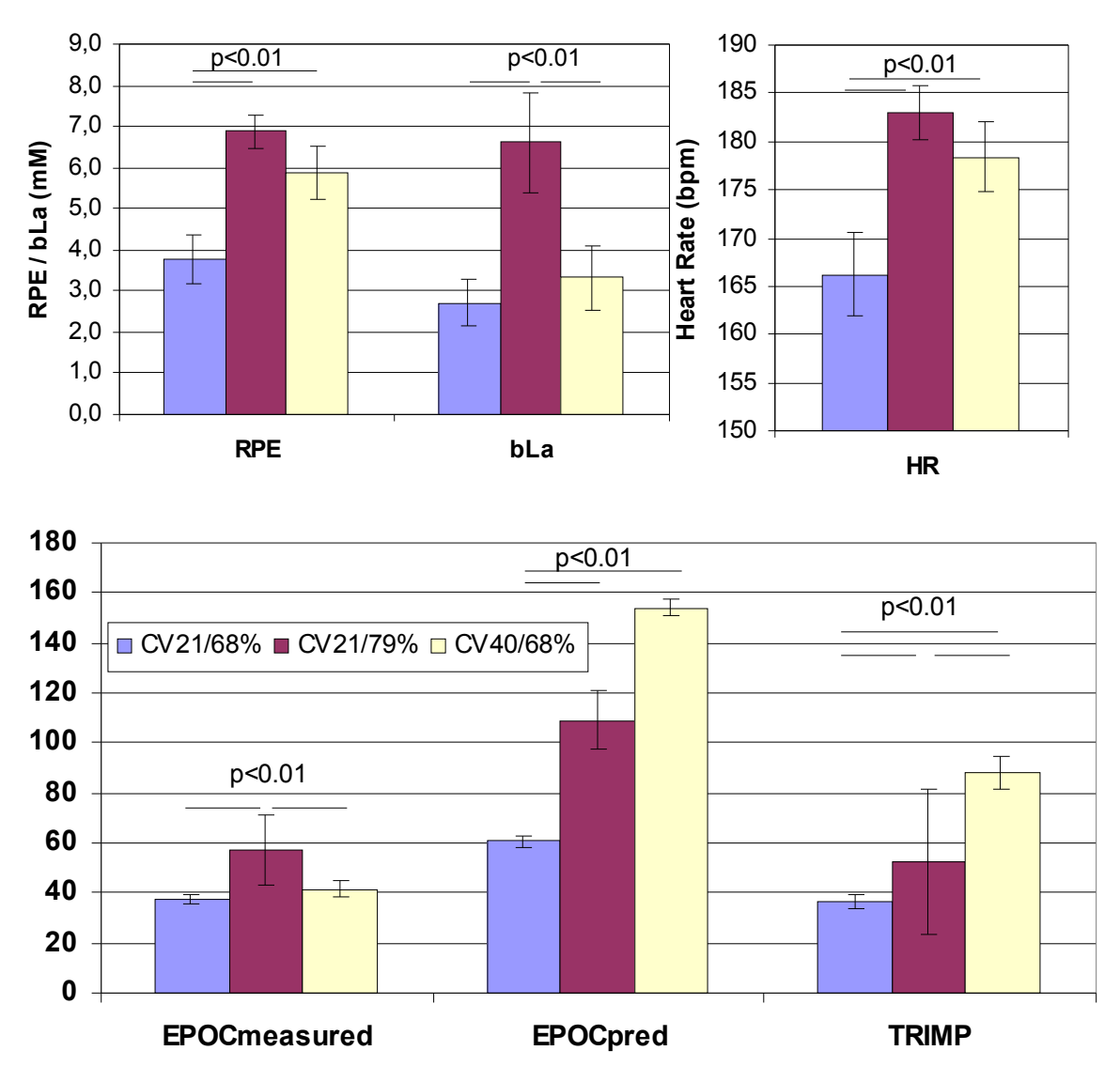
greater change with increased duration

$EPOC_{pred}$

greater change with increased duration

And decreased during recovery

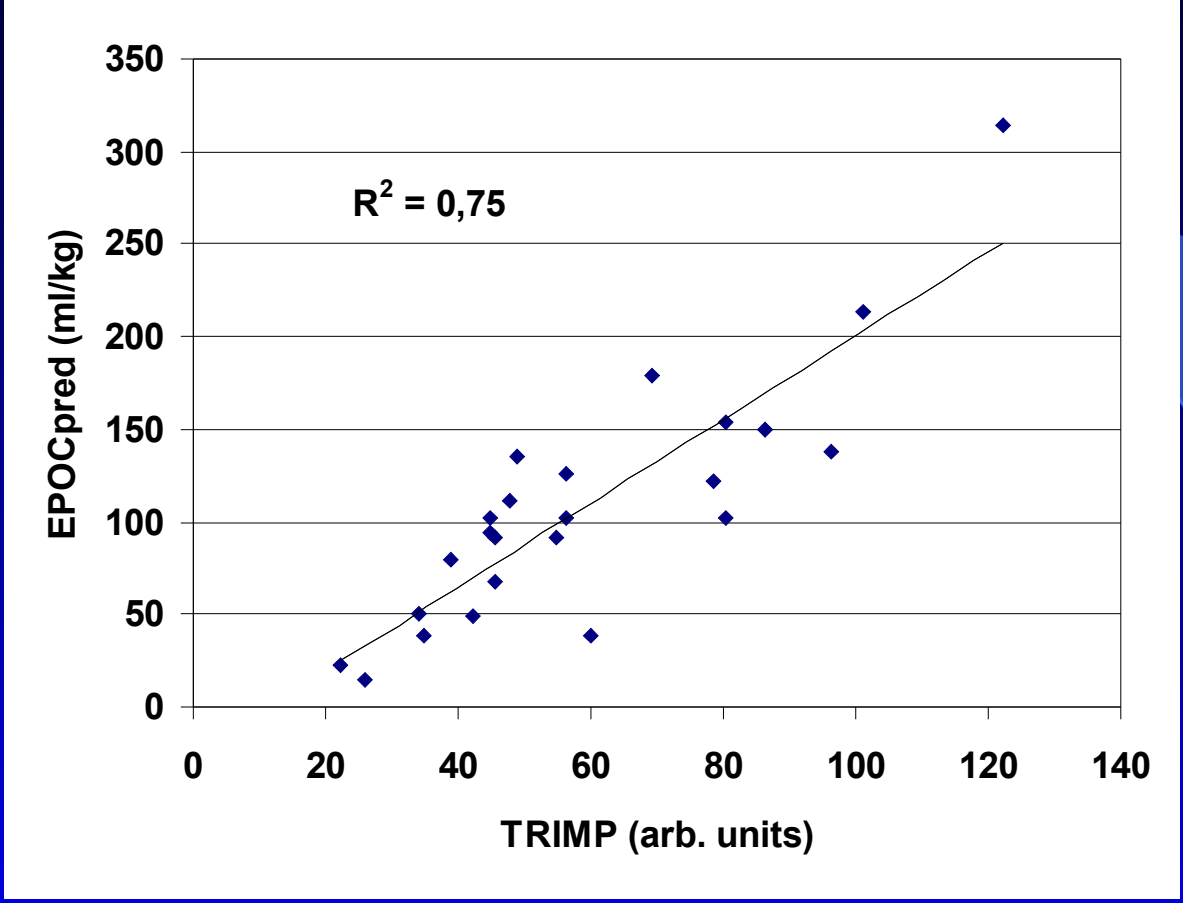
Comparison of exercises



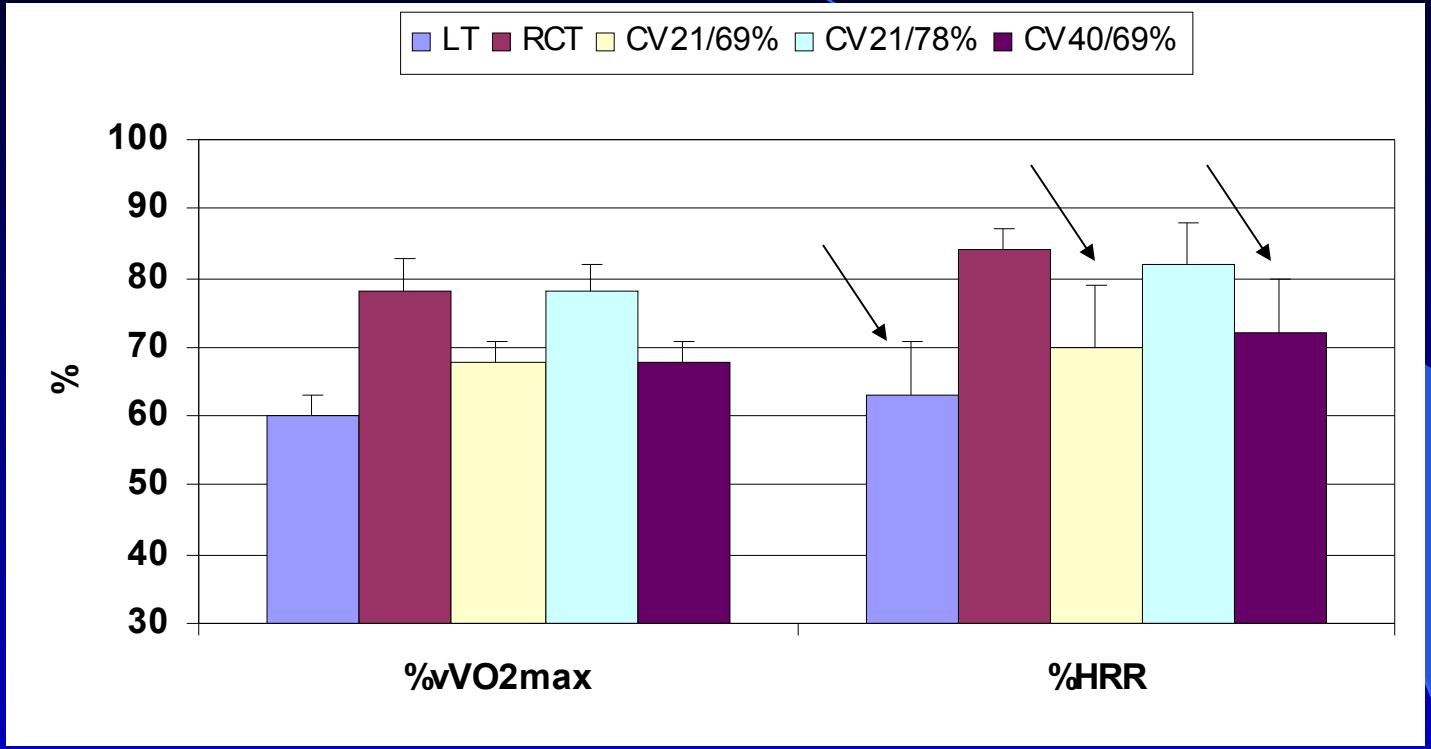
<u>Intensity</u> **induced a greater change: RPE, bLa, peakHR, $EPOC_{meas}$**

<u>Duration</u> **induced a greater change: $EPOC_{pred}$, TRIMP**

High Correlation between $EPOC_{pred}$ and TRIMP



Why difference between $EPOC_{meas}$ vs. $EPOC_{pred}$ and TRIMP?



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

Present subjects had higher VO_{2max}, LT and RCT than "average persons": e.g. LT 63%HRR (78%HRmax)

Conclusions

- Increase in training intensity from 68% to 79% vVO_{2max} 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%vVO_{2max} based on
  - Heart rate
  - Blood lactate
  - RPE
  - Measured EPOC
- TRIMP and $EPOC_{pred}$ were more sensitive to increase in training duration than intensity at the present training intensities

Conclusions

- TRIMP and $EPOC_{pred}$ integrated similarly the intensity and duration of exercise
- $EPOC_{pred}$ and TRIMP depend very much on the % HR and %HRR level which may differ between subjects having different training background
- Calculation of $EPOC_{pred}$ and TRIMP should take into account the differences in individual ”threshold” –values
- $EPOC_{pred}$ can give dynamic information on the accumulation of training load and allows calculation of time needed for recovery (decrease of $EPOC_{pred}$ to resting level)

Thank you for your attention