PROGRAMA NACIONAL DE MARCHA E CORRIDA

ENDURANCE: *Physiological Demands & Limitations*

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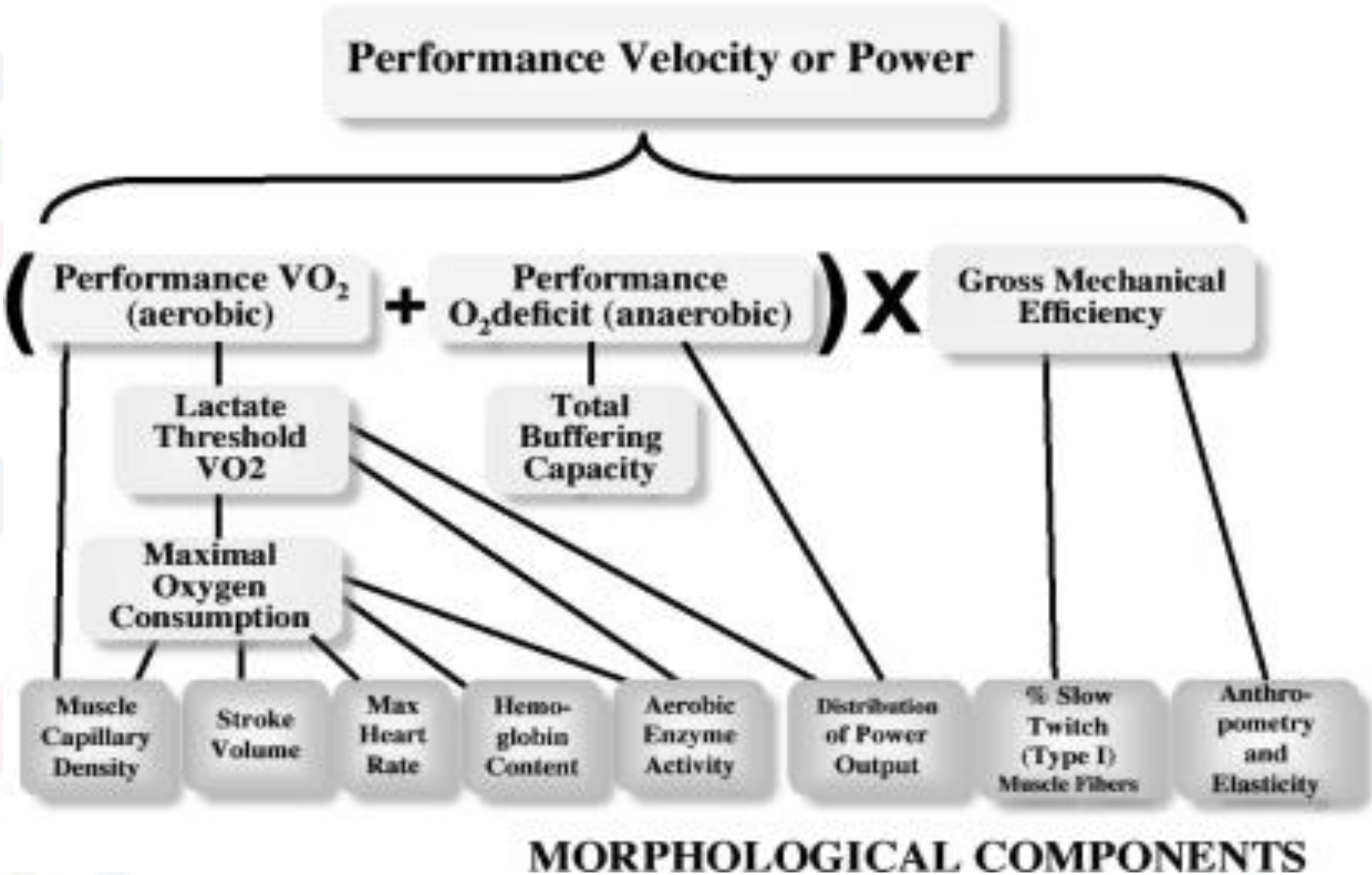
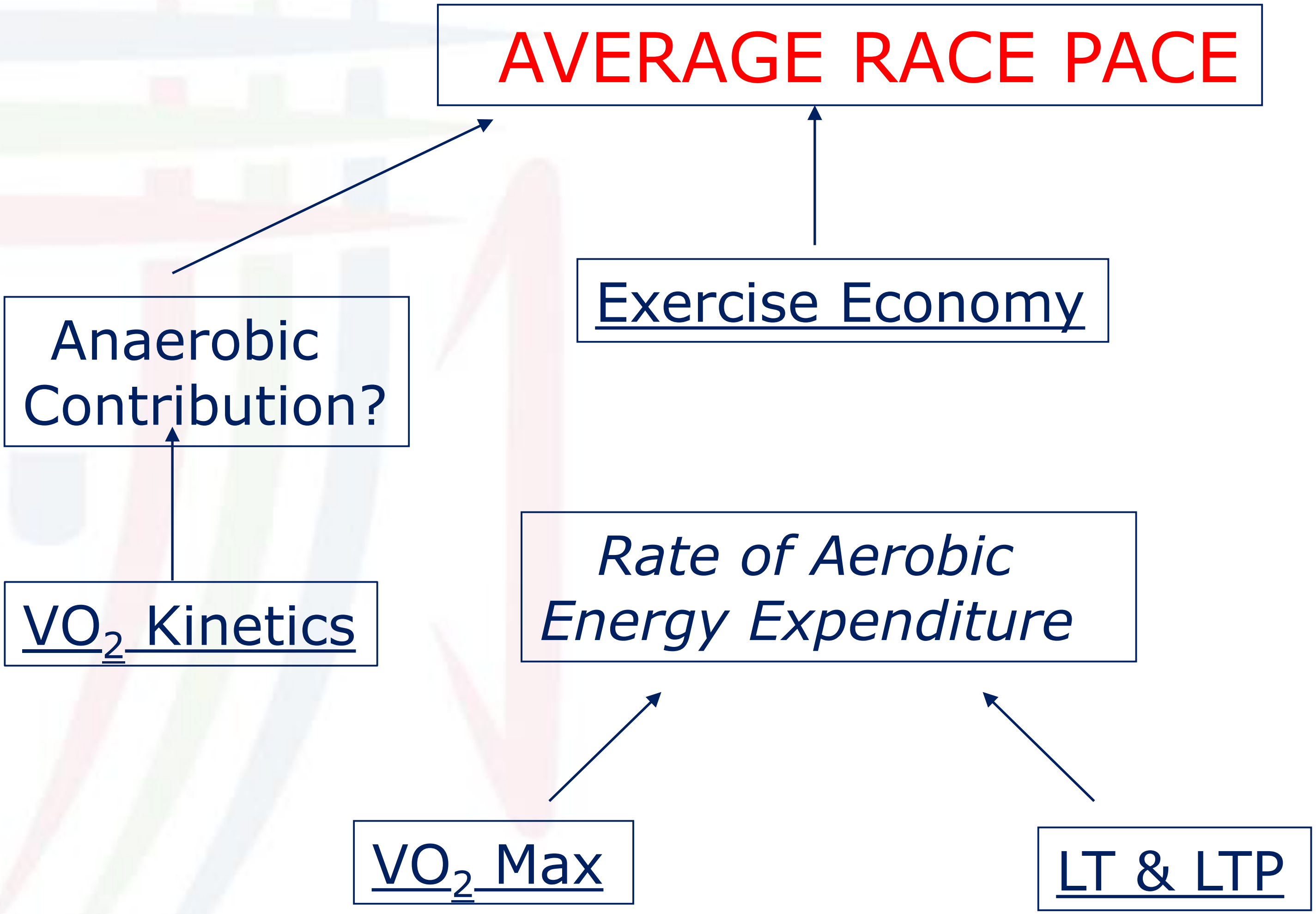
FEDERAÇÃO PORTUGUESA ATLETISMO

Physiological Determinants of Endurance Performance



Joyner and Coyle, 2008

Physiological Determinants of Endurance Performance



Energetics of Running

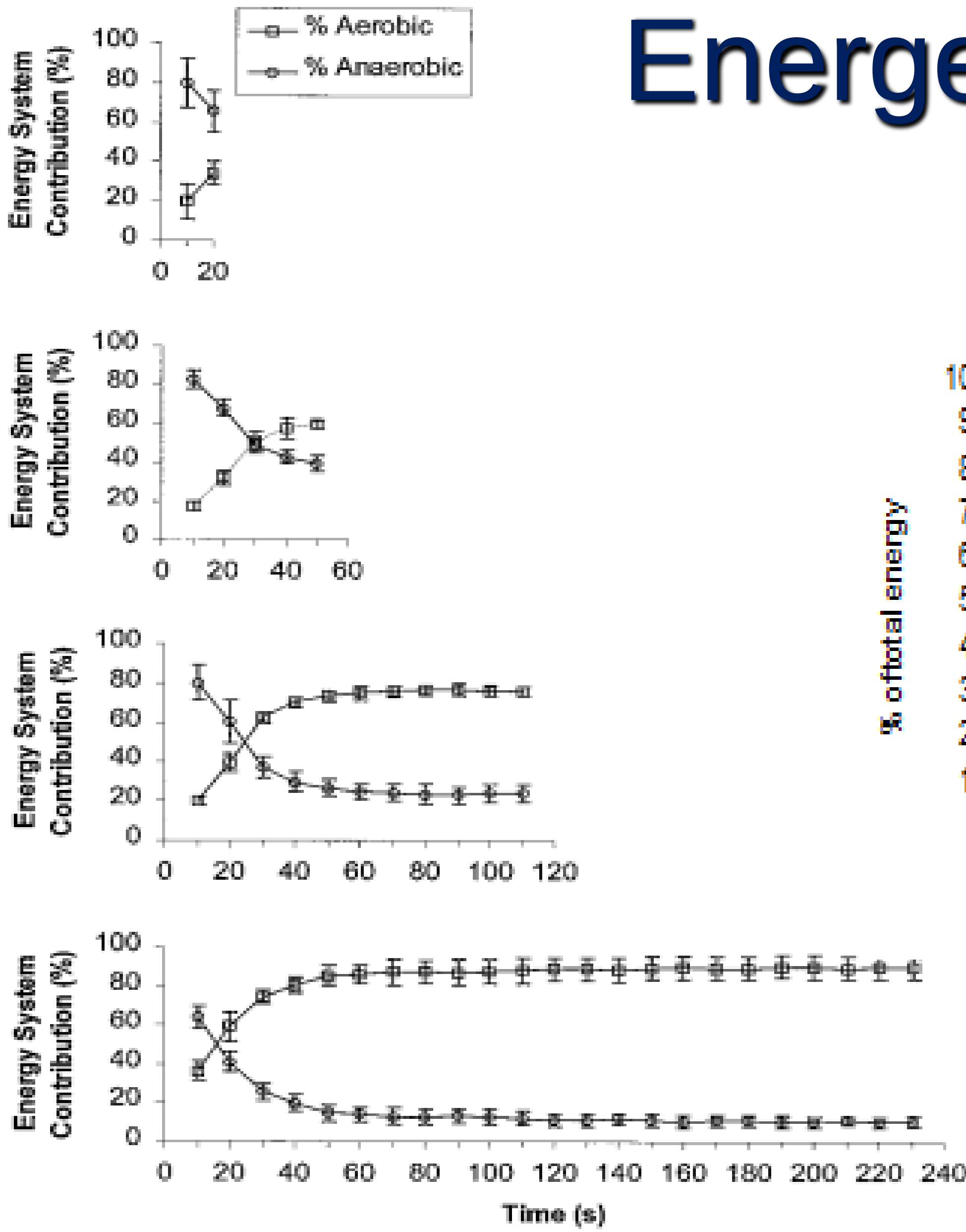
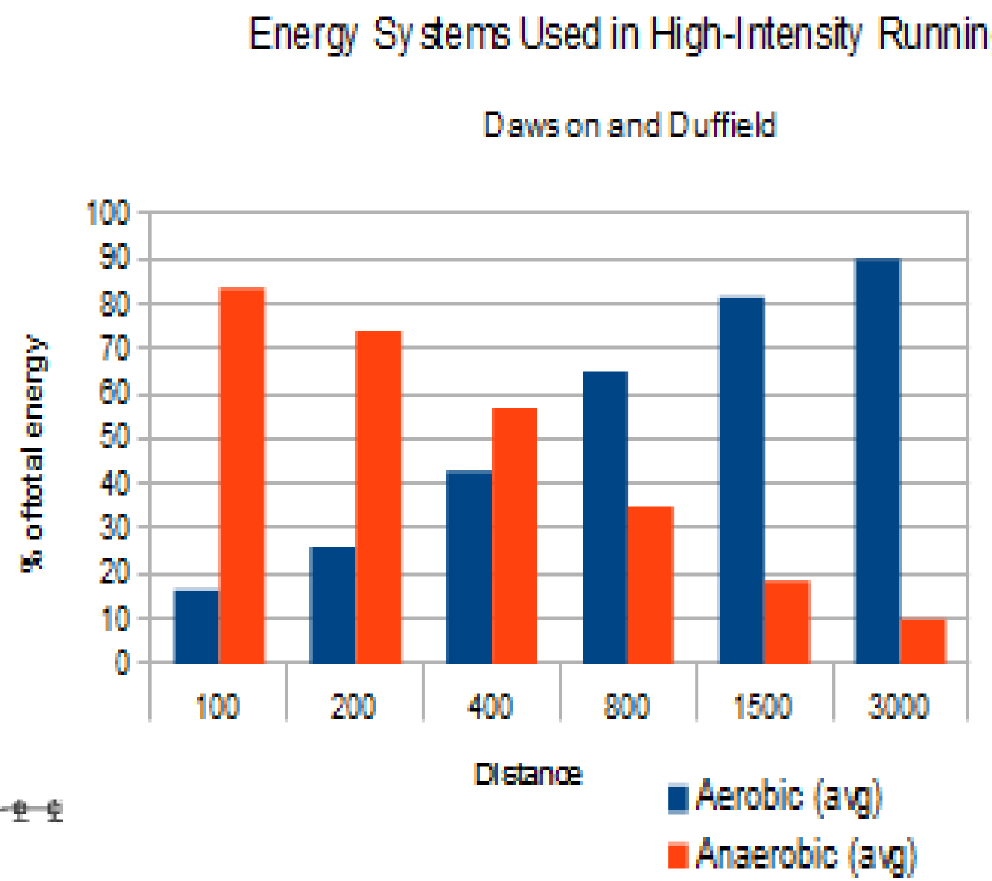
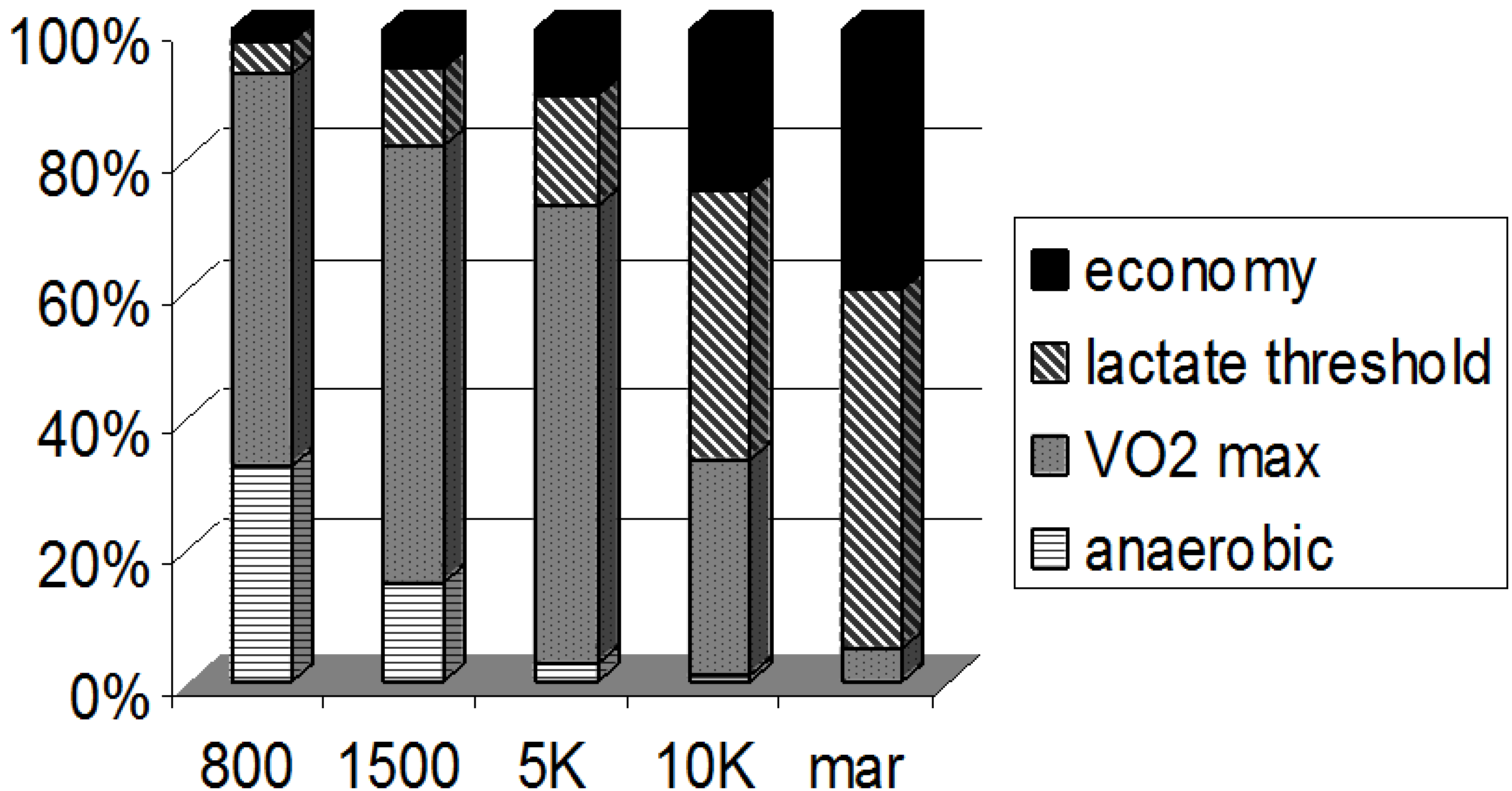


FIGURE 1—Energy system contribution in 10-s time intervals for the 200, 400, 800, and 1500 m. Data are mean values ± SD.



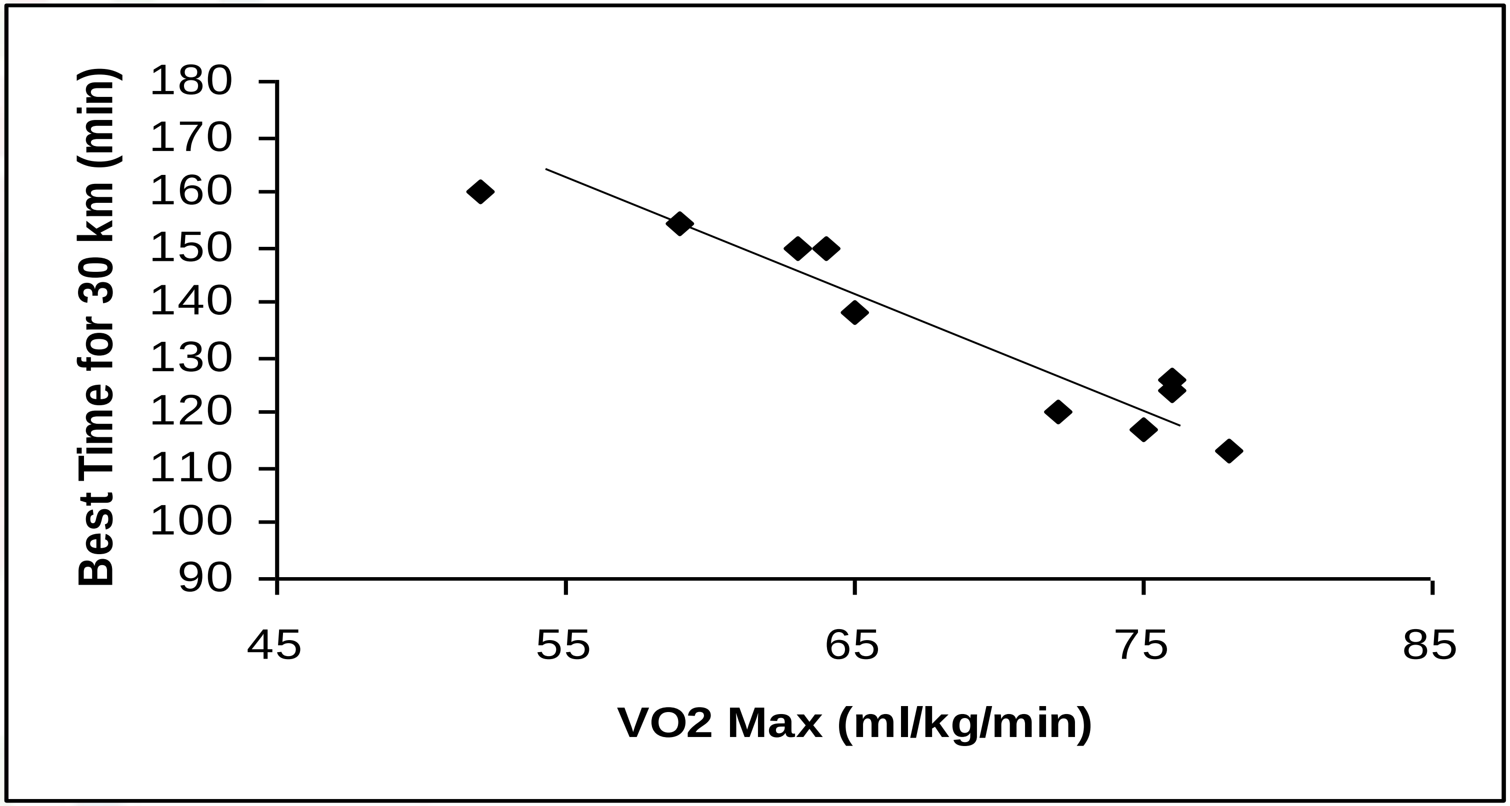
Physiology of Running



Maximal Oxygen Uptake

- The maximal rate at which ATP can be re-synthesised aerobically
- Strong correlations between VO_2 max and endurance performance in heterogeneous groups
- Elite runners tend to have high VO_2 max values (70-85 ml/kg/min in men, 60-75 ml/kg/min in women)

VO_2 Max and Performance



(From: Karlsson & Saltin, 1971)

How to Improve VO_2 Max?

The Fick Equation: $VO_2 = (HR \times SV) \times a\text{-}vO_2$ difference

VO_2 max limited by the maximal cardiac output

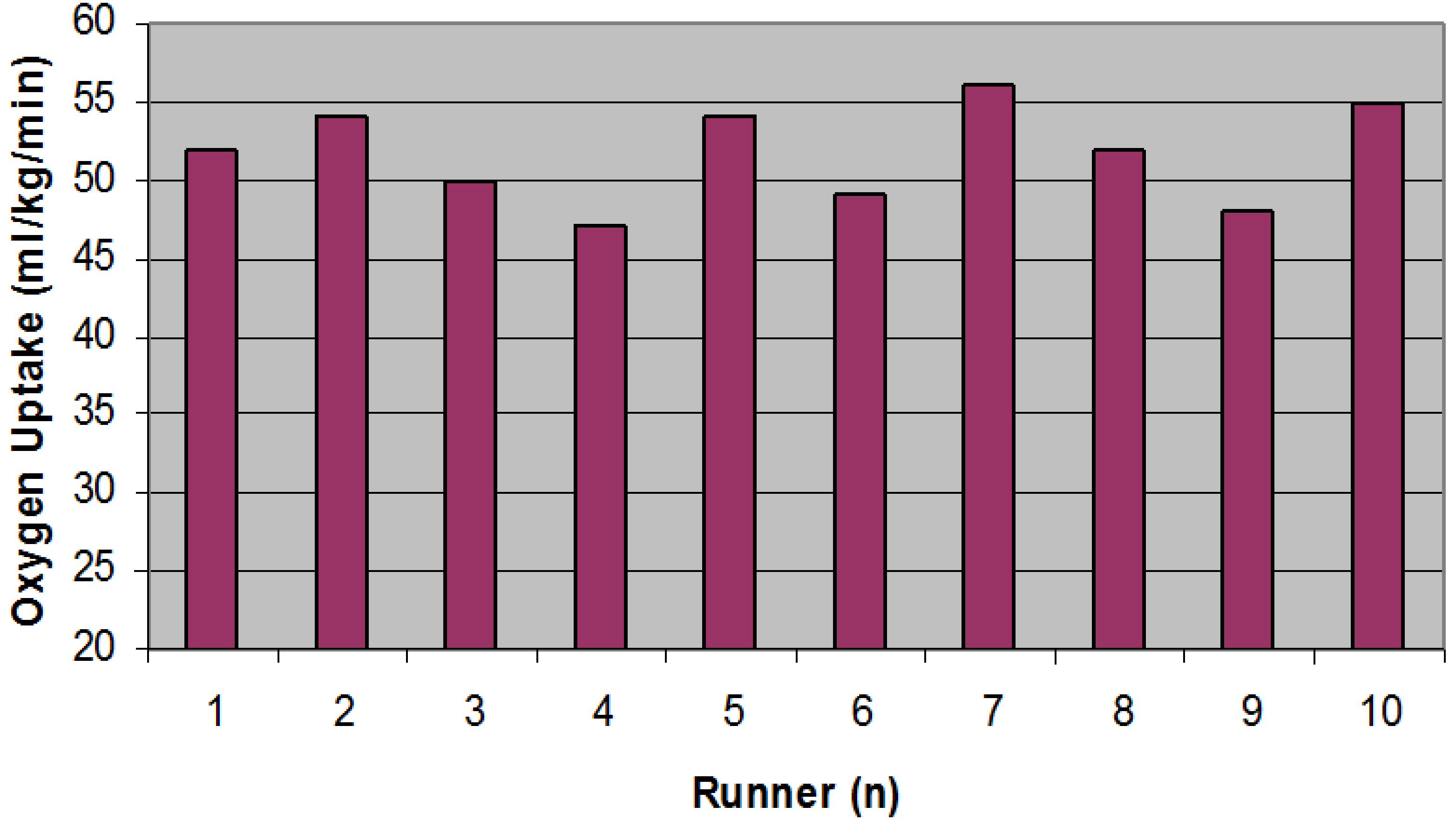
Therefore, training at near-maximal HR is considered to be an effective way to enhance VO_2 max

An example session is 5 x 3 min hard effort with 2-3 min recovery

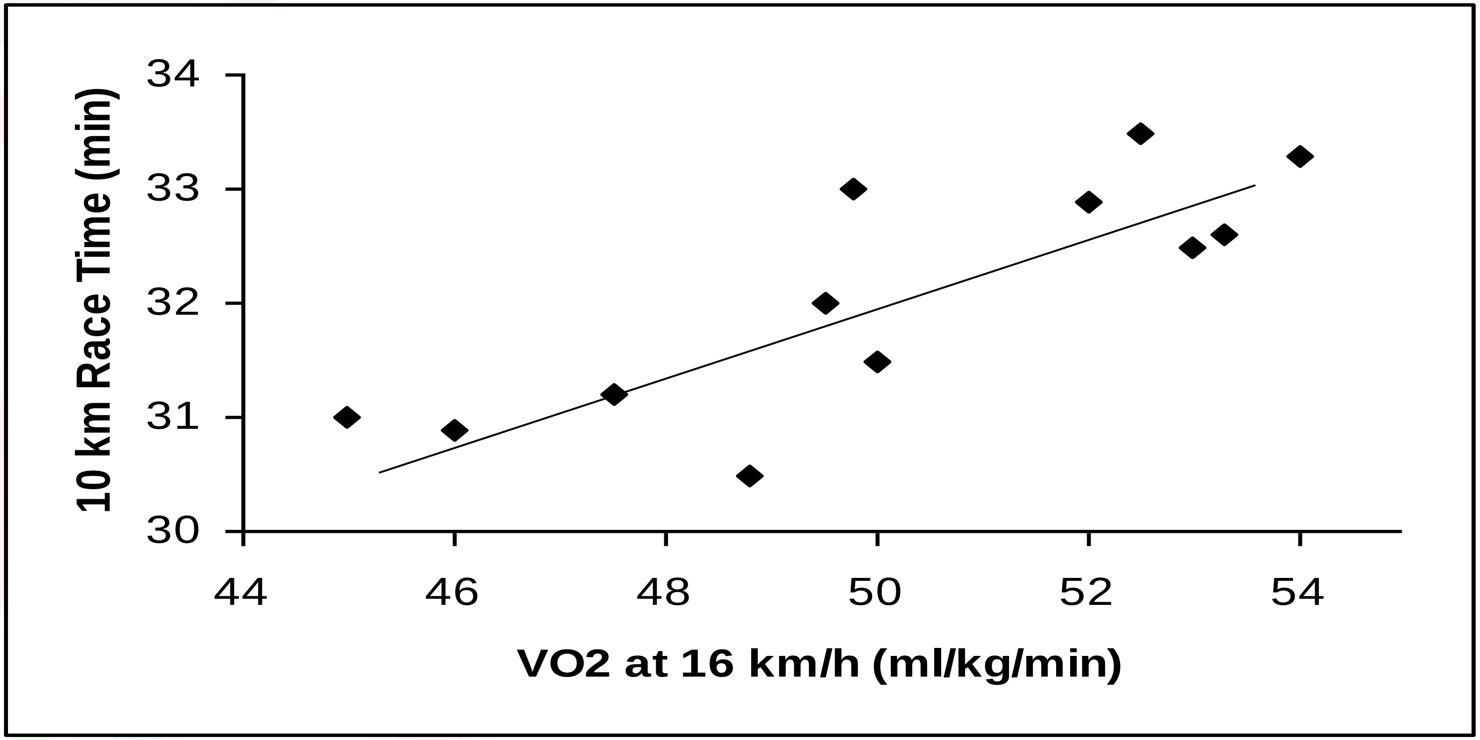
Running Economy

- The oxygen cost of running at sub-maximal speeds (ml/kg/min or ml/kg/km)
- Significant inter-individual variability
- Influenced by anthropometric, physiological, biomechanical, and technical factors
- Generally better in longer distance specialists

Running Economy at 16 km/h

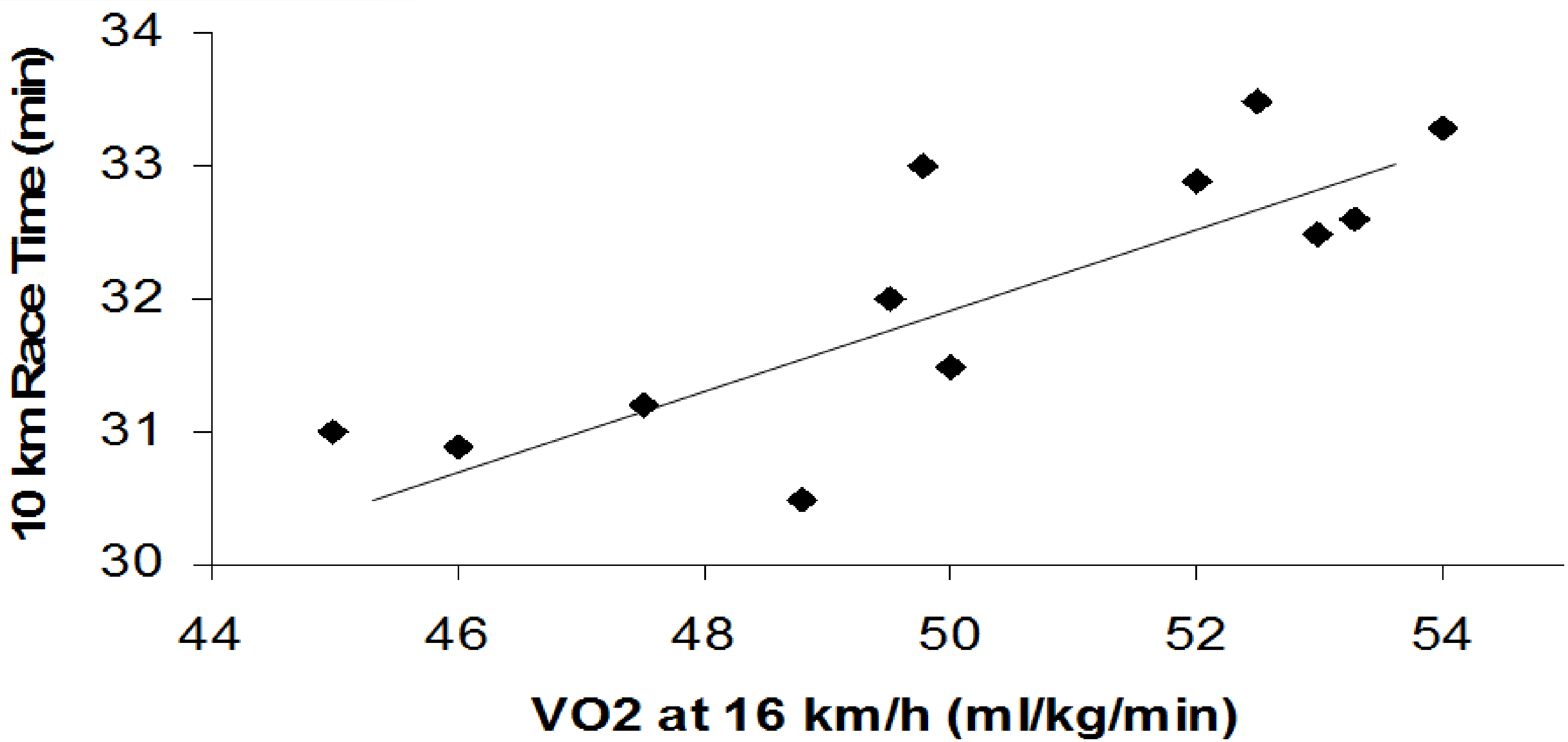


Running Economy and Performance



(From: Conley and Krahenbuhl, 1980)

Running Economy and Performance

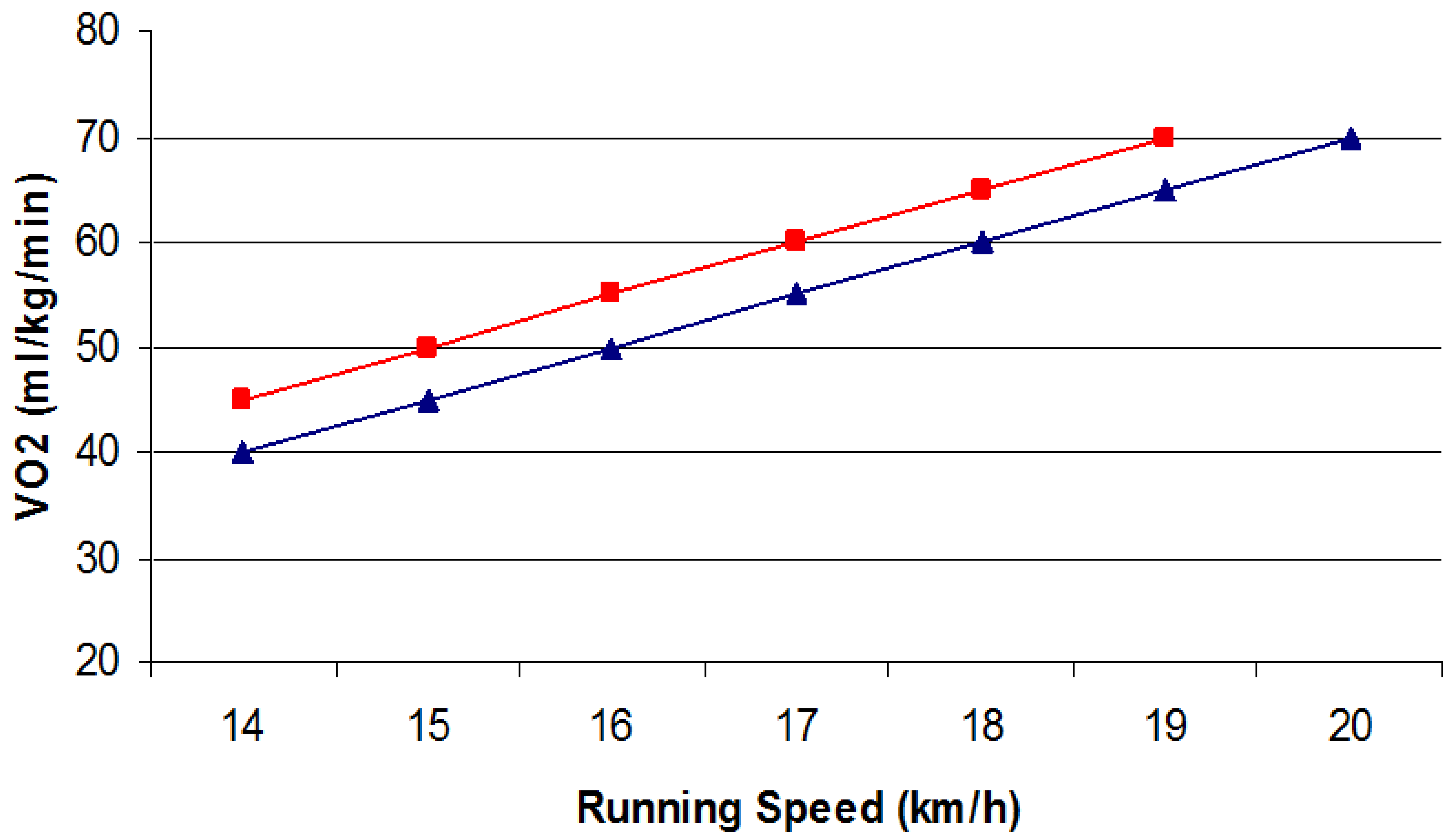


(From: Conley and Krahenbuhl, 1980)

Running Velocity at VO_2 Max

- The interaction of VO_2 max and running economy
- Provides 'functional expression' of VO_2 max in units of km/h
- Helps explain difference in performance in athletes with similar VO_2 max
- Enables accurate prediction of race performance

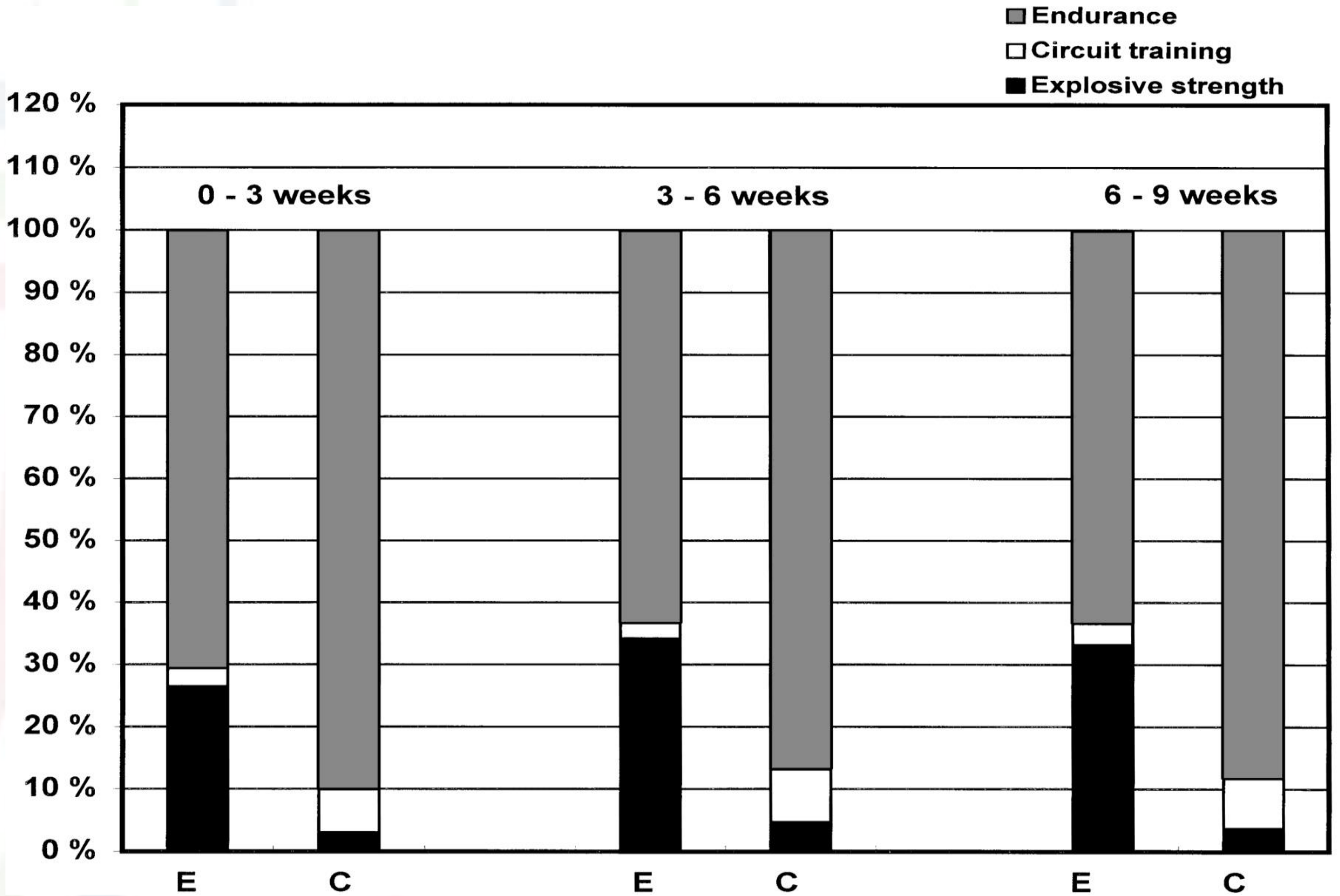
Running Velocity at VO_2 Max



How to Improve Economy?

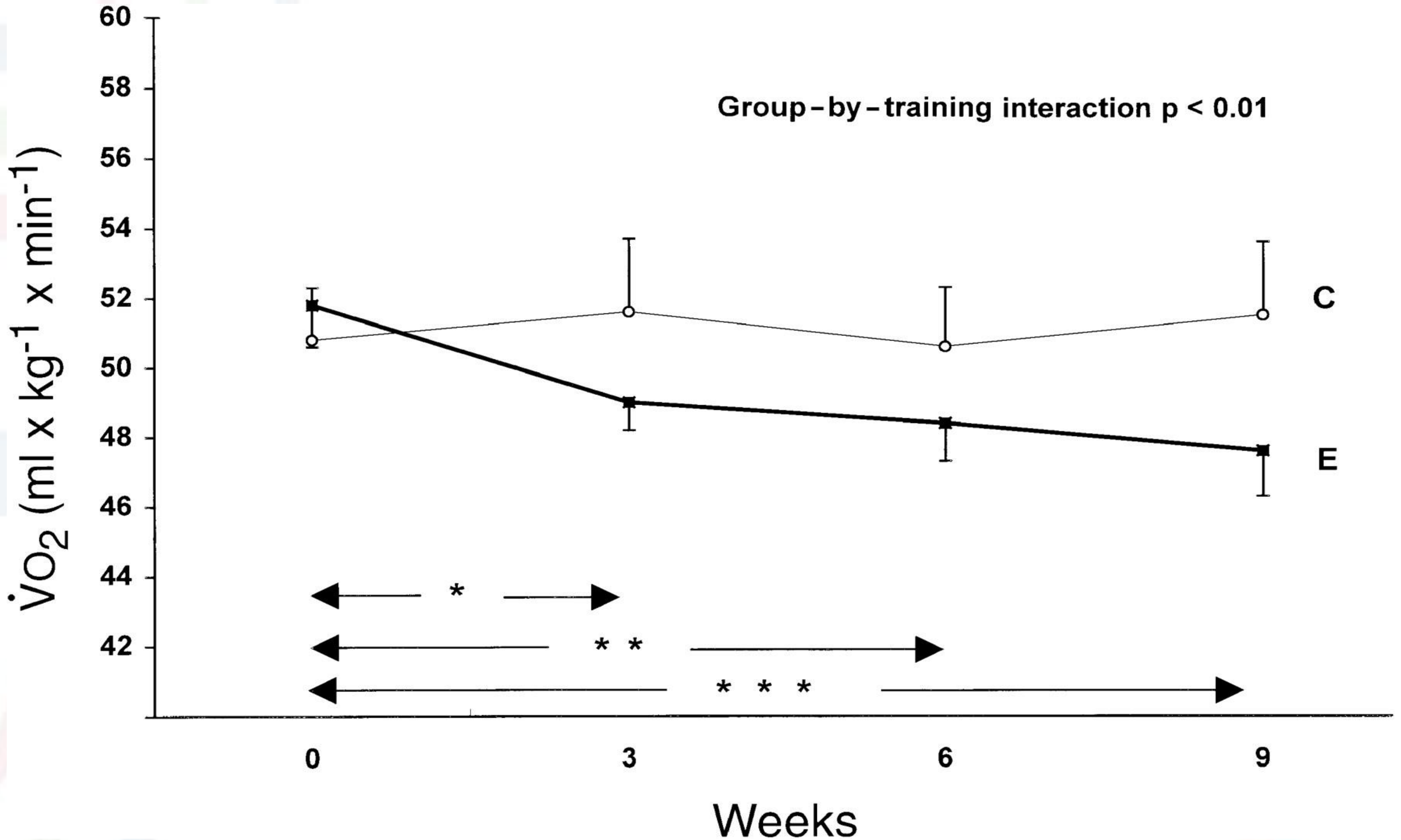
- Economy is related to anthropometrical, physiological and biomechanical factors
- Optimal training is unclear but economy is known to improve over many years
- It is possible that accumulating a high volume of endurance training over many years is necessary to 'hone' economy
- Consistent (high-volume?) training over many years seems to be key
- There is some evidence that altitude training and certain types of strength training might also benefit economy

Relative volumes of different training in experimental (E) and control (C) groups during 9-wk explosive-type strength and endurance training

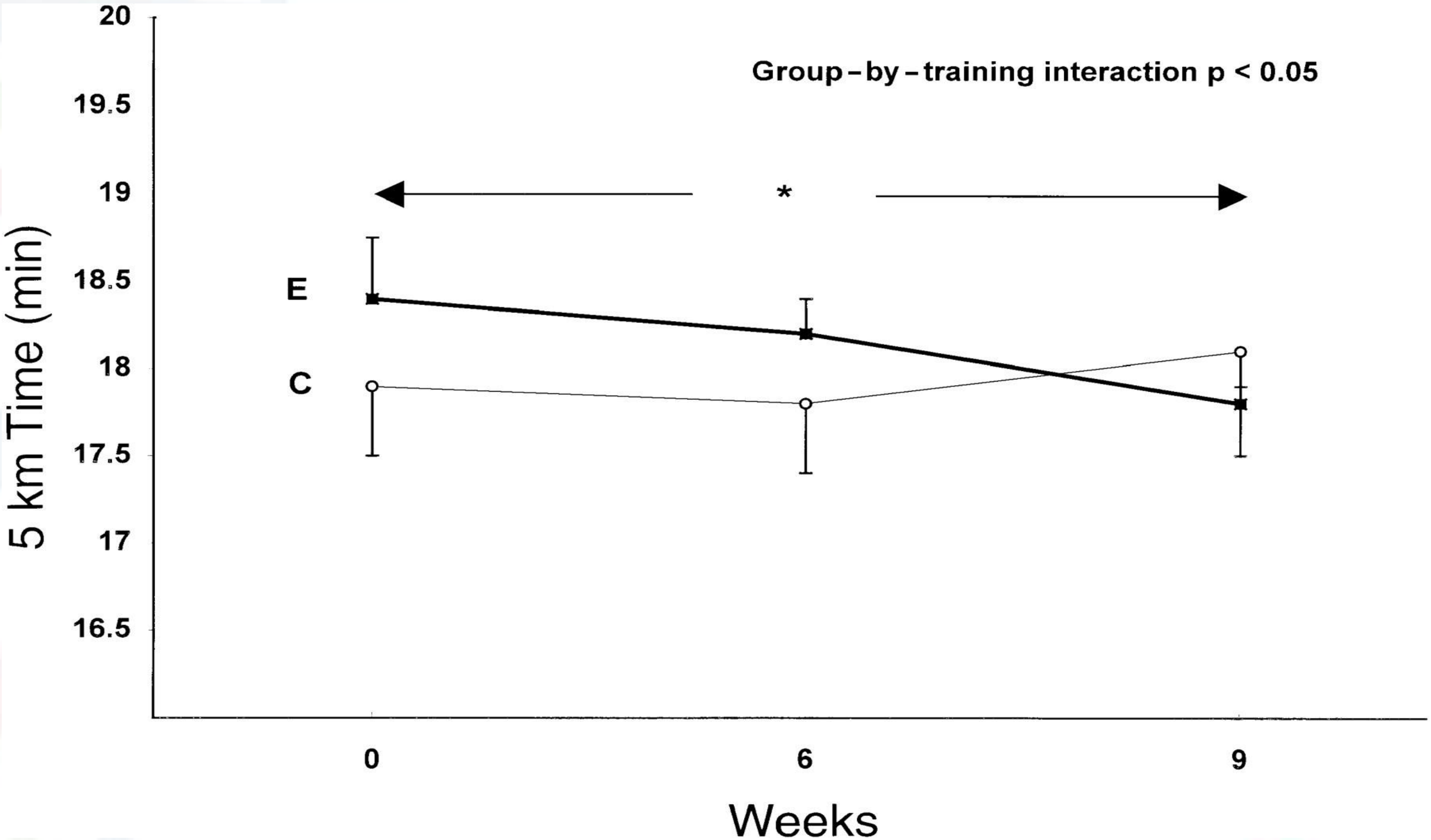


Paavolainen, L. et al. J Appl Physiol 86: 1527-1533 1999

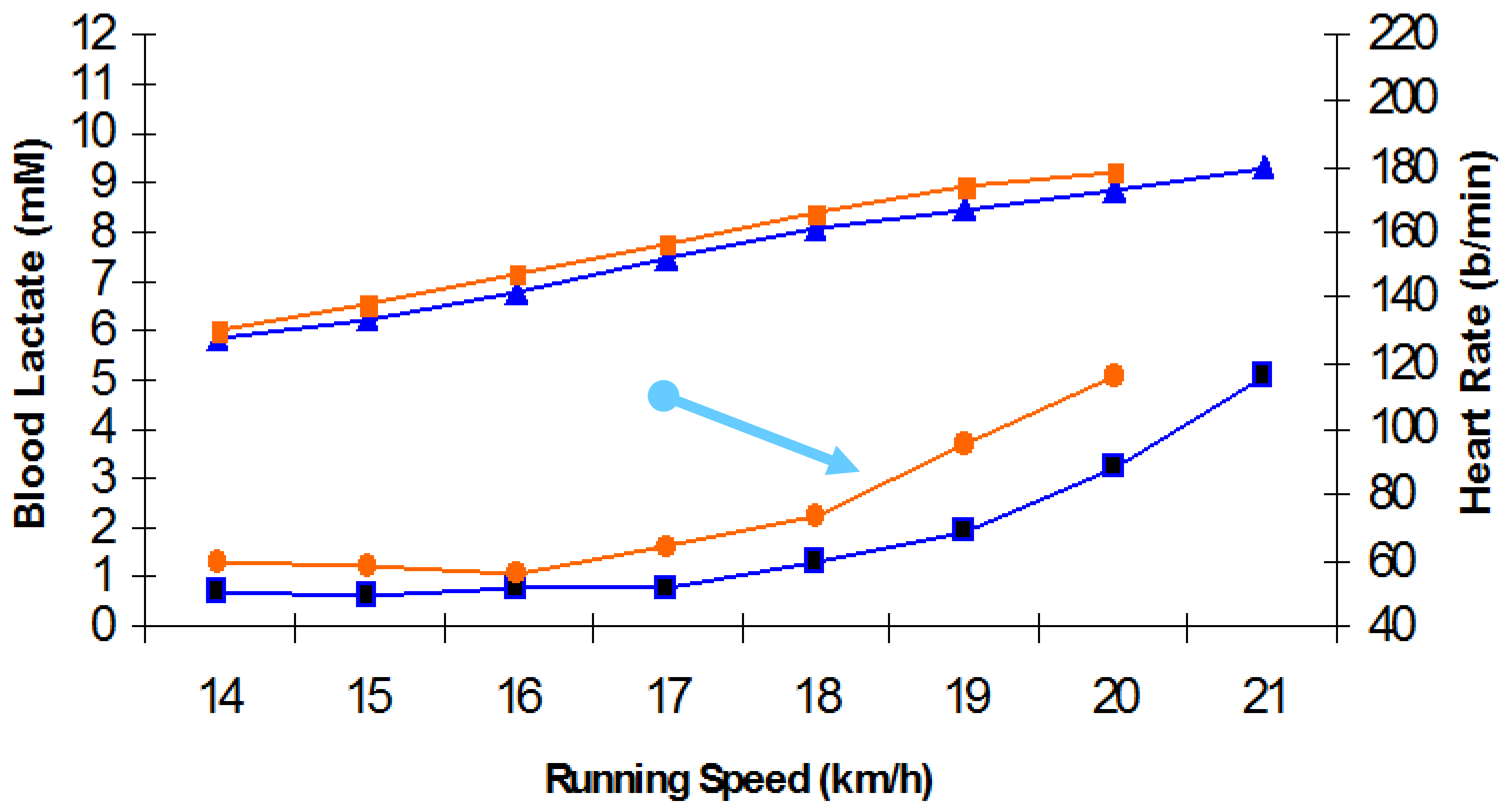
Changes in running economy in explosive training and control conditions



Changes in 5 km performance in explosive training and control conditions

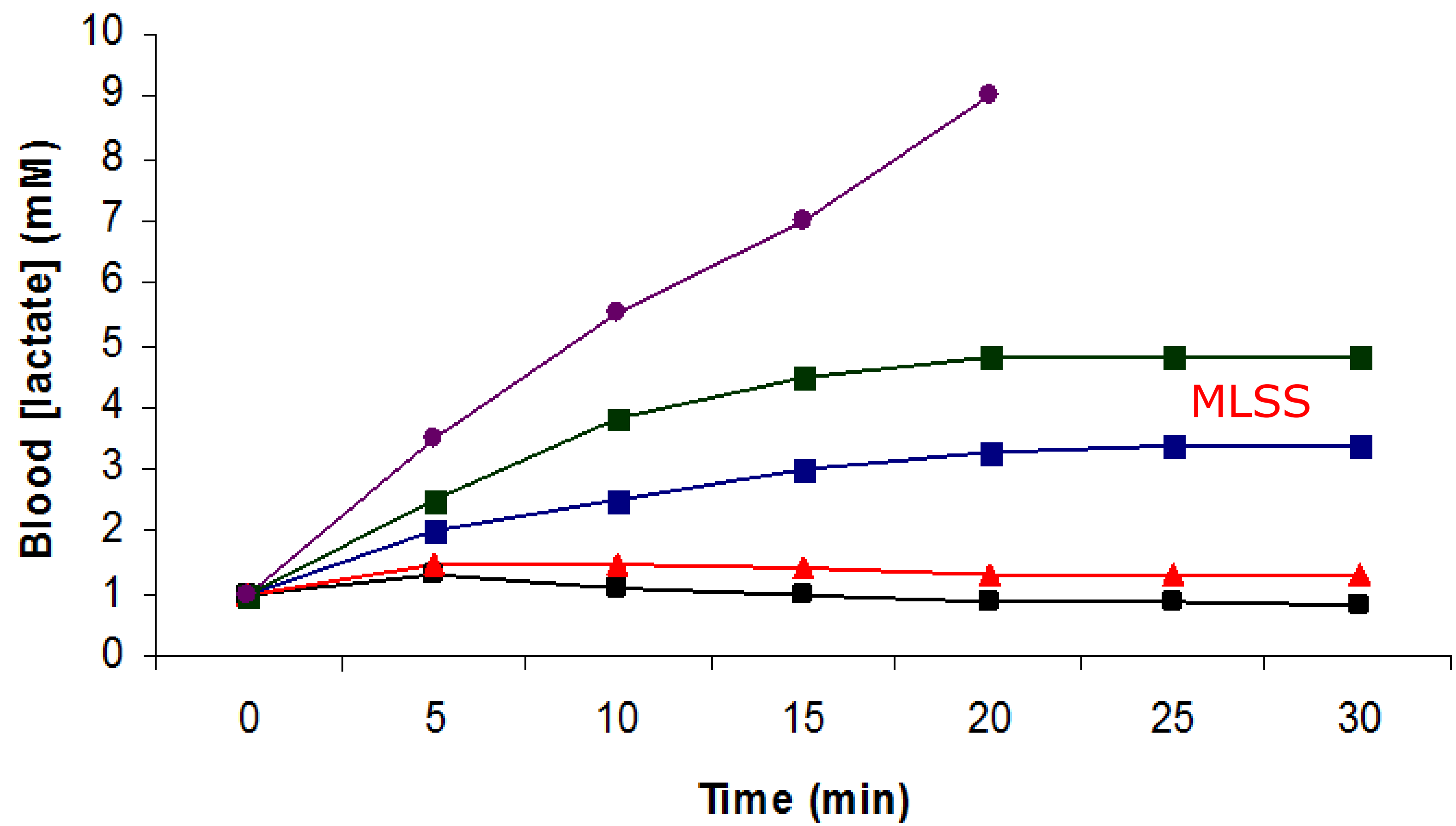


Blood Lactate and HR Response to Incremental Exercise



Blood lactate values are quite sensitive to improved endurance fitness

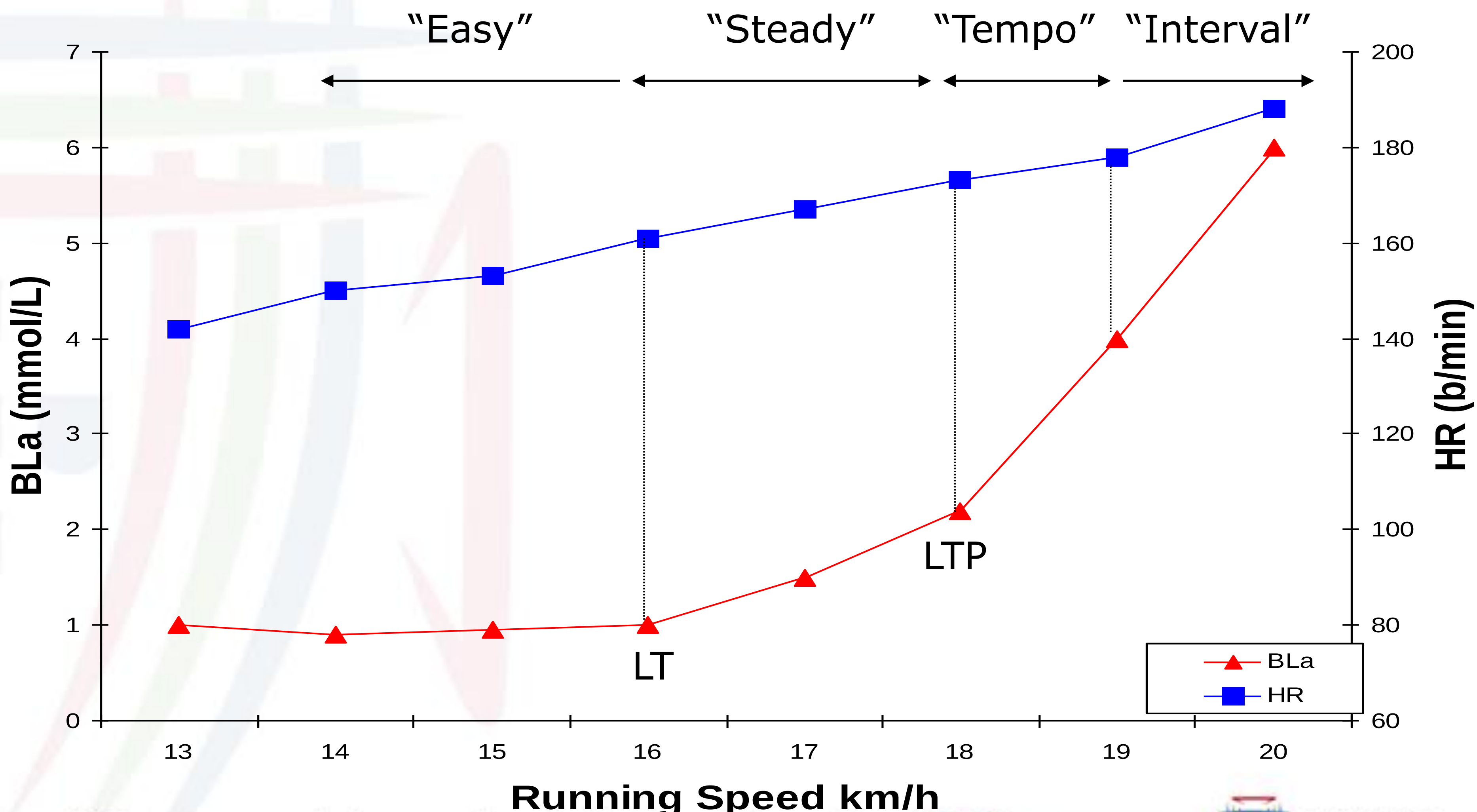
Maximal Lactate Steady State



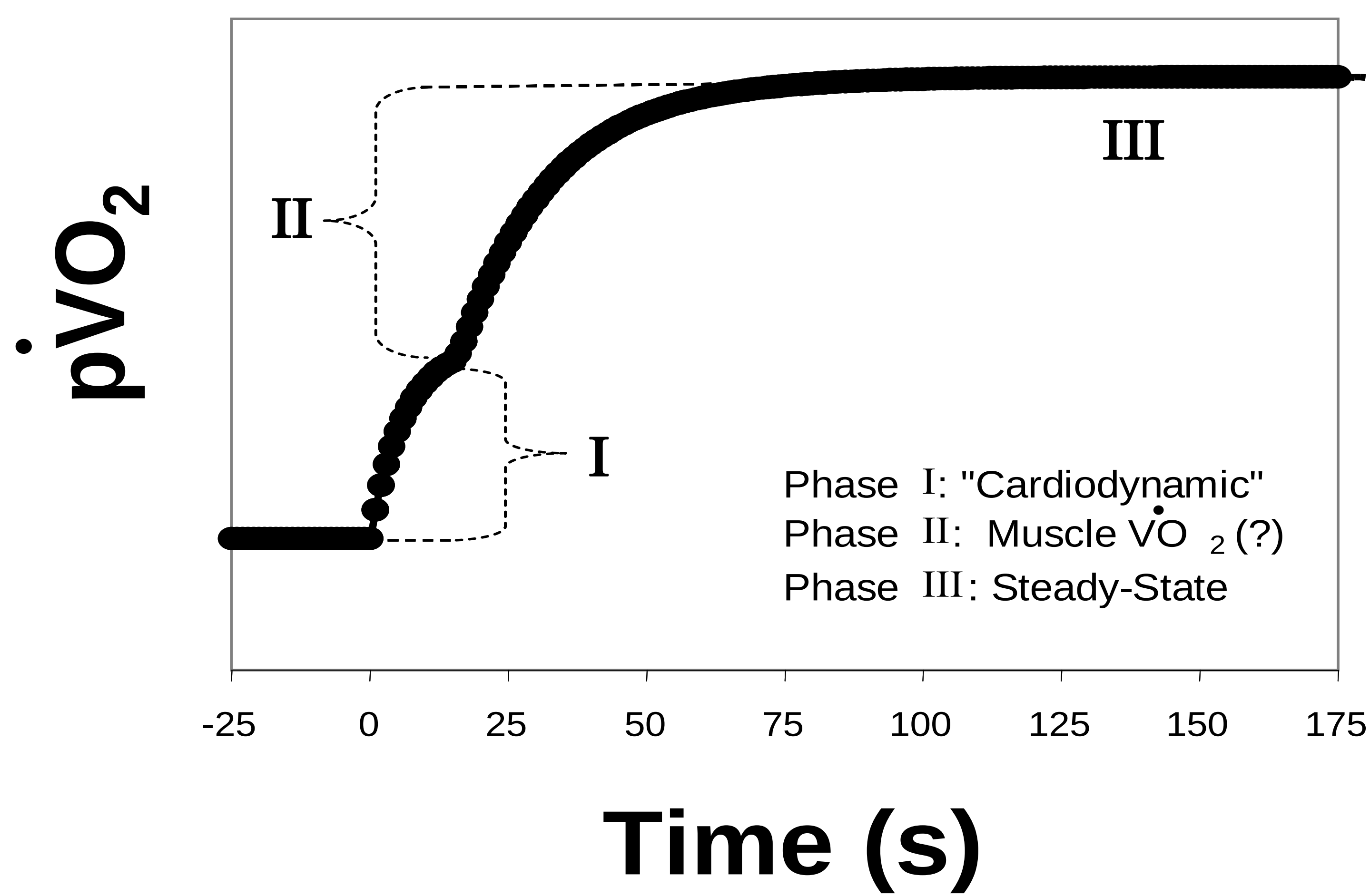
How to Improve LT and LTP?

- The blood [lactate] reflects the balance between muscle lactate production and lactate clearance
- A good volume of decent quality training is necessary to increase muscle mitochondrial density – which should reduce lactate production at any given exercise intensity
- Sustained ‘tempo’ exercise at and above the LTP might help to stimulate adaptation of the body’s ability to ‘clear’ lactate
- Regulating the intensity of continuous endurance exercise is very important in optimising the training effect

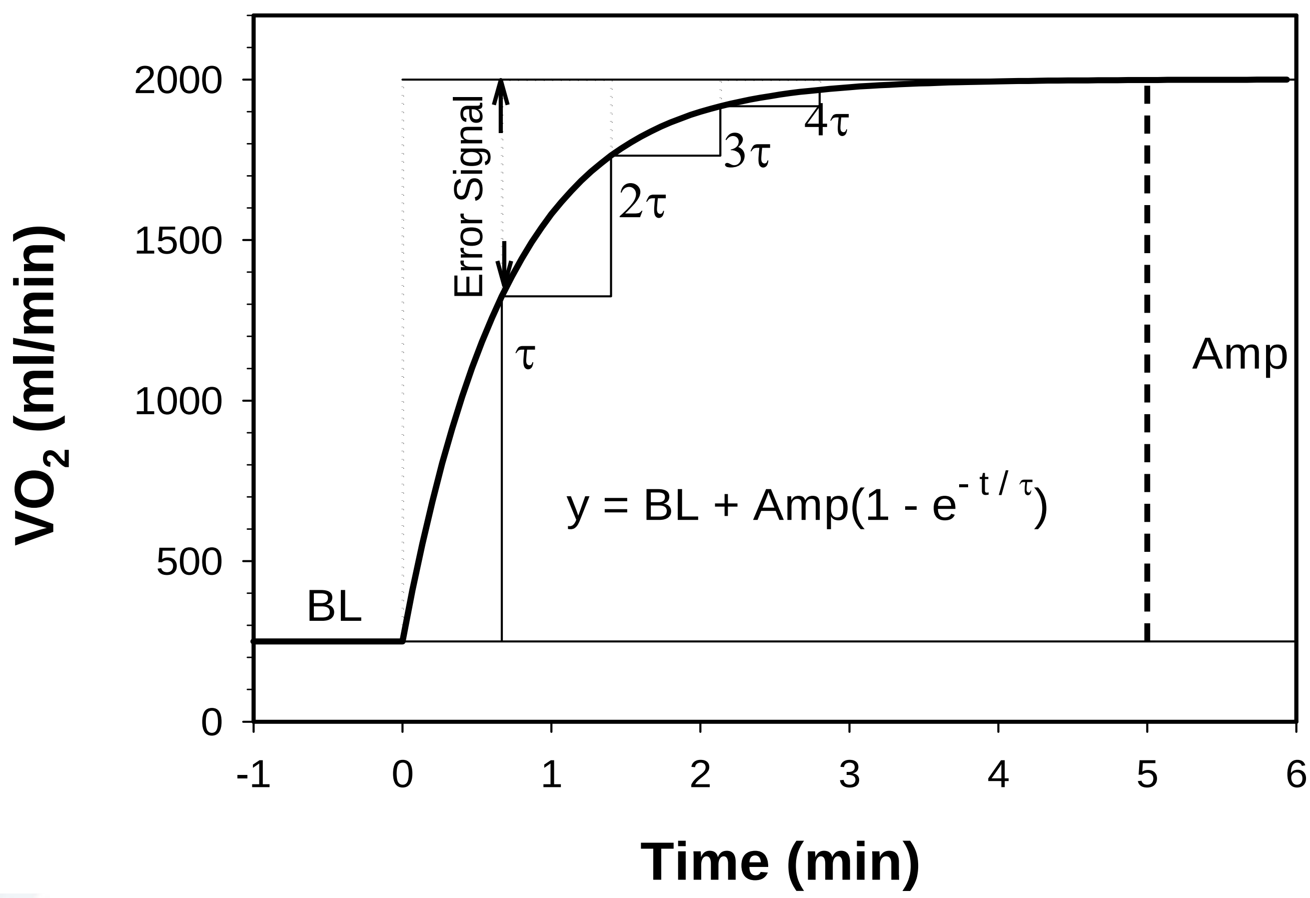
Training Zones



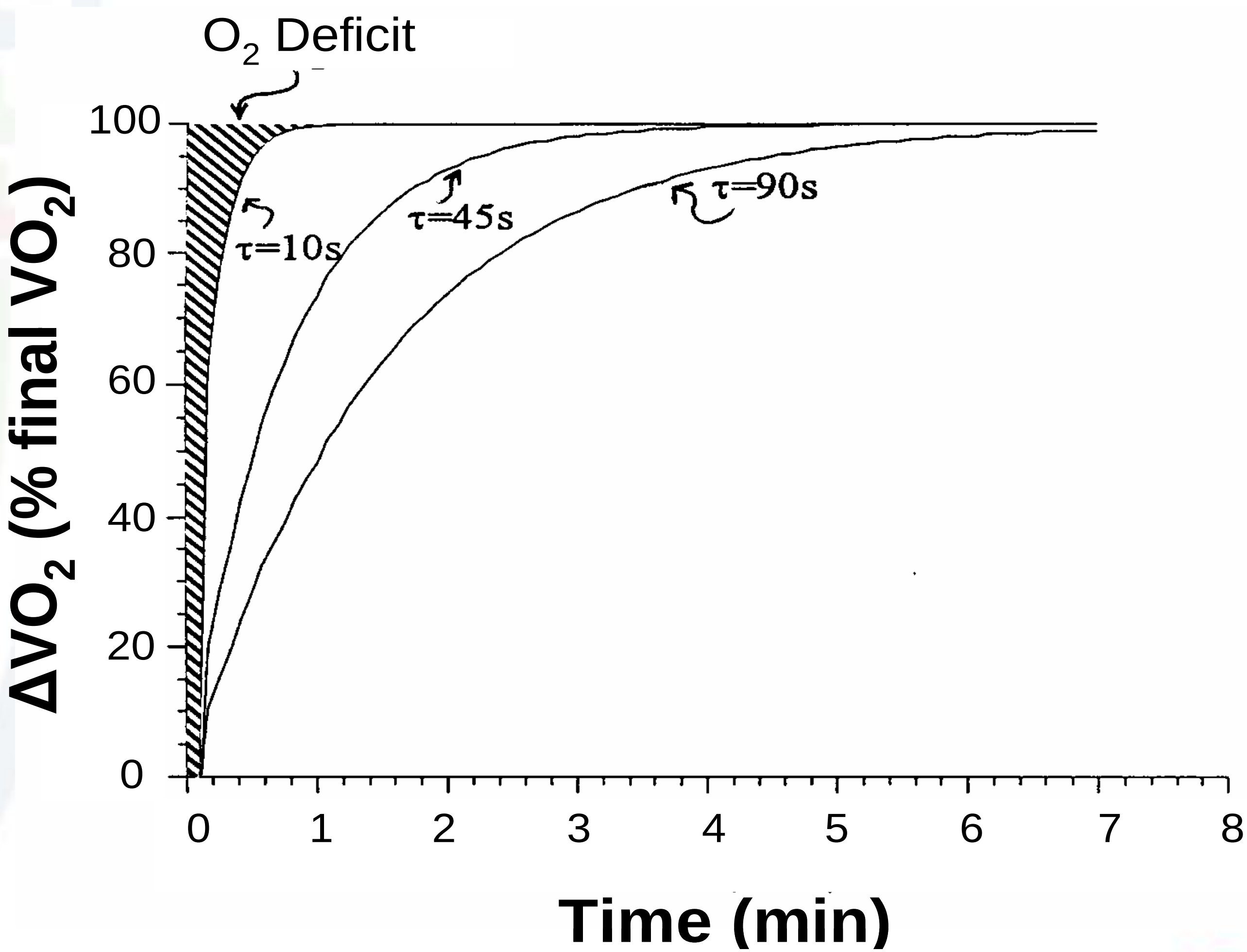
VO_2 Kinetics



Time Constant



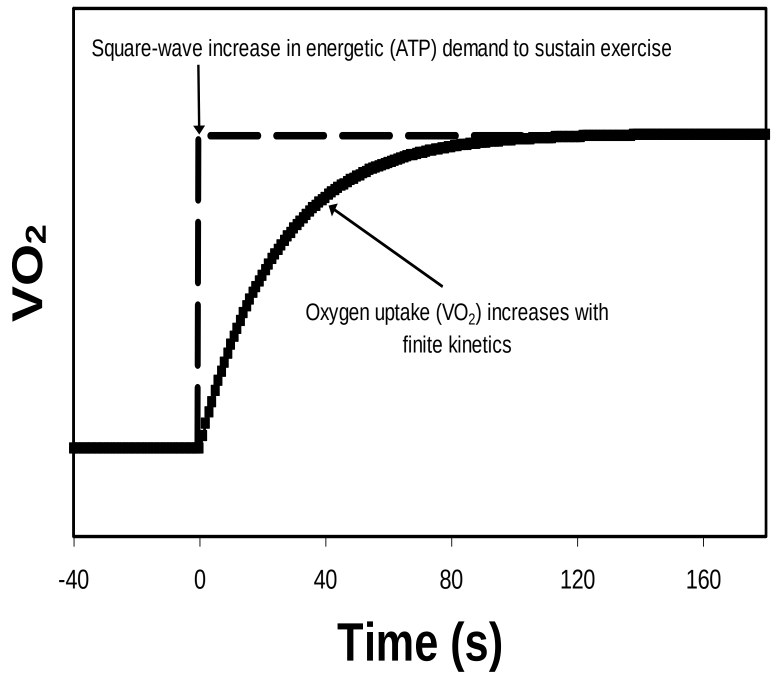
O_2 Deficit



O2 Deficit
100
80
60
40
20
0
ΔVO2 (% final VO2)
τ=10s
τ=45s
τ=90s
0
1
2
3
4
5
6
7
8
Time (min)

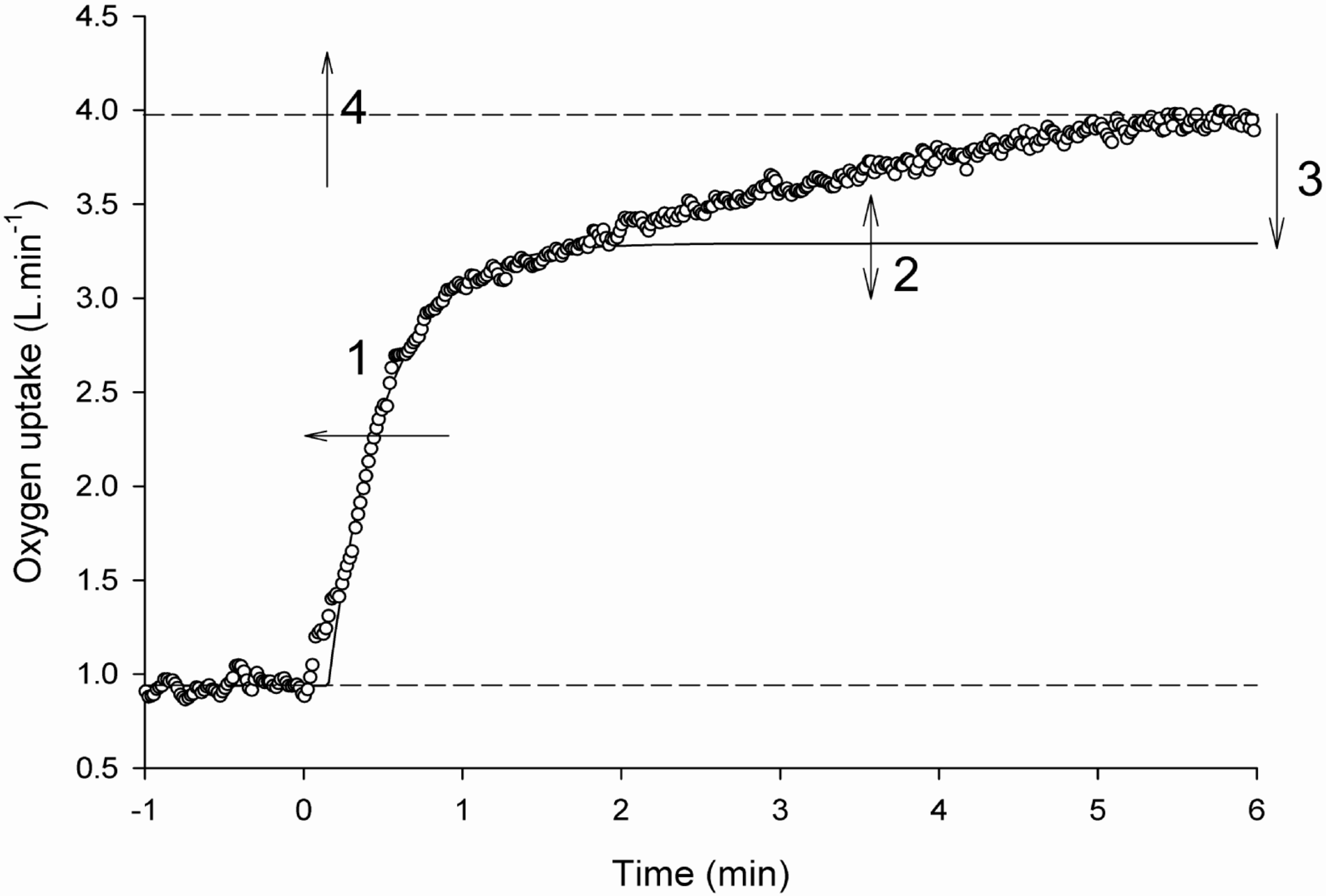
O_2 Deficit and Fatigue

O_2 Deficit = MRT x Amplitude



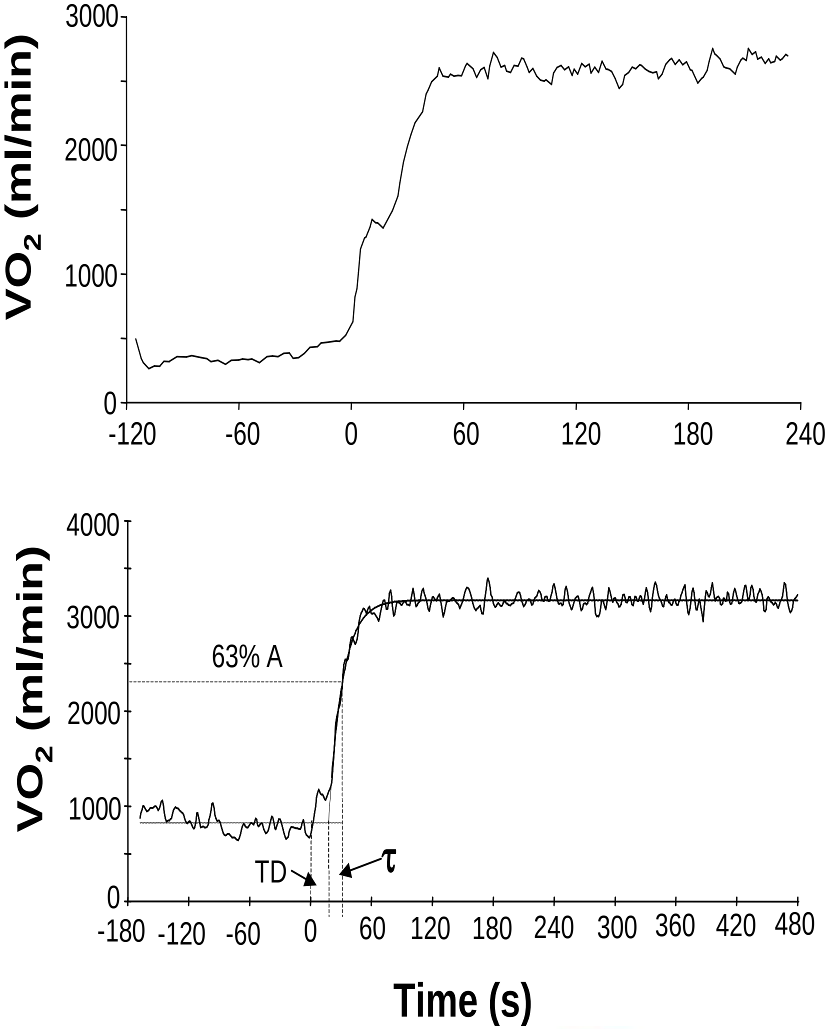
- A LARGER O_2 deficit means:
- greater PCr breakdown
- greater ADP and Pi accumulation
- greater H^+ and lactate accumulation
- greater rate of glycogen degradation

Effects of interventions on Vo_2 kinetics and performance during high-intensity exercise



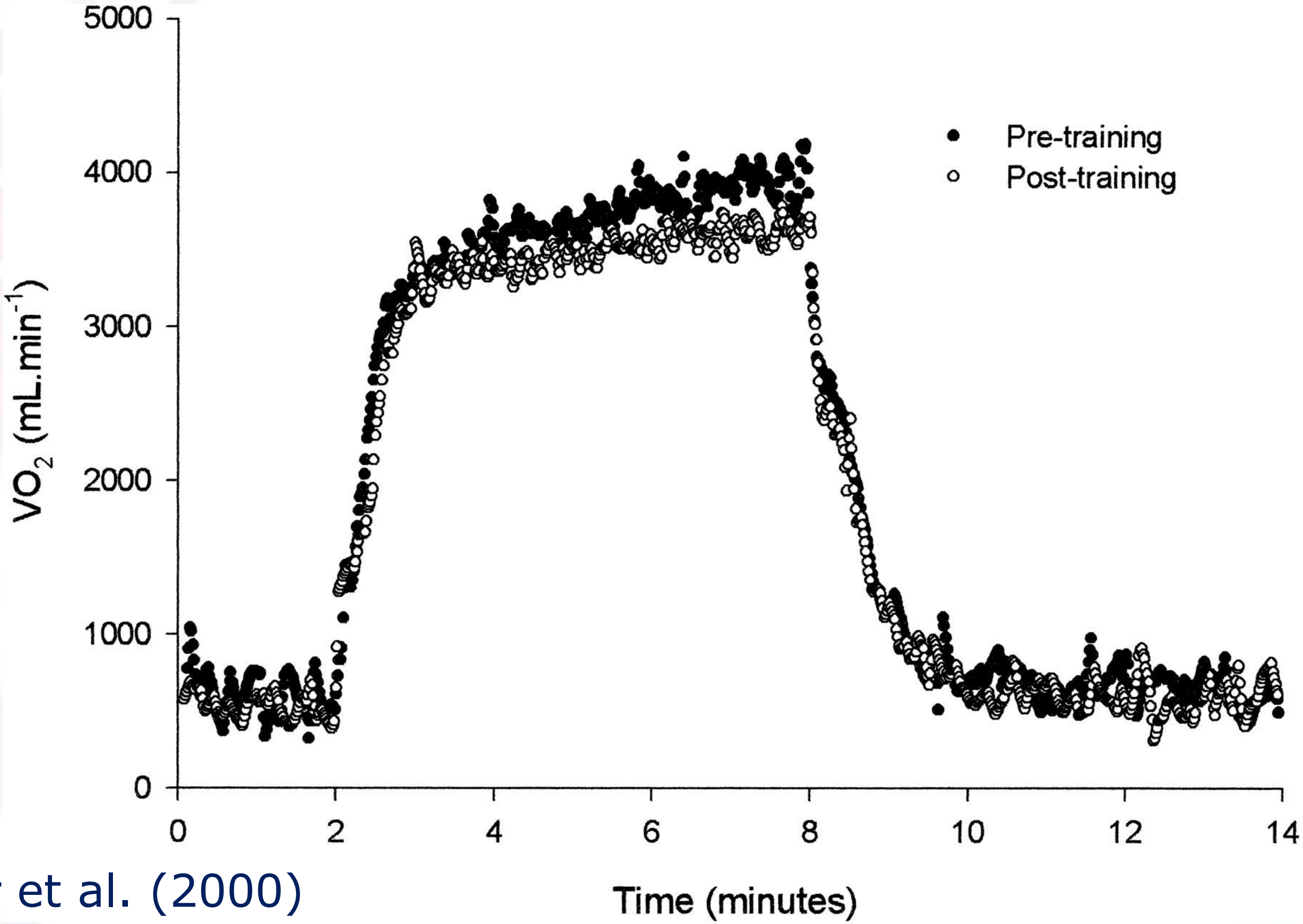
Training

VO_2 kinetics are very fast in elite endurance athletes



Jones and Koppo (2005)

Acute endurance training enhances Vo_2 kinetics



Carter et al. (2000)

Low-intensity or high-intensity training?

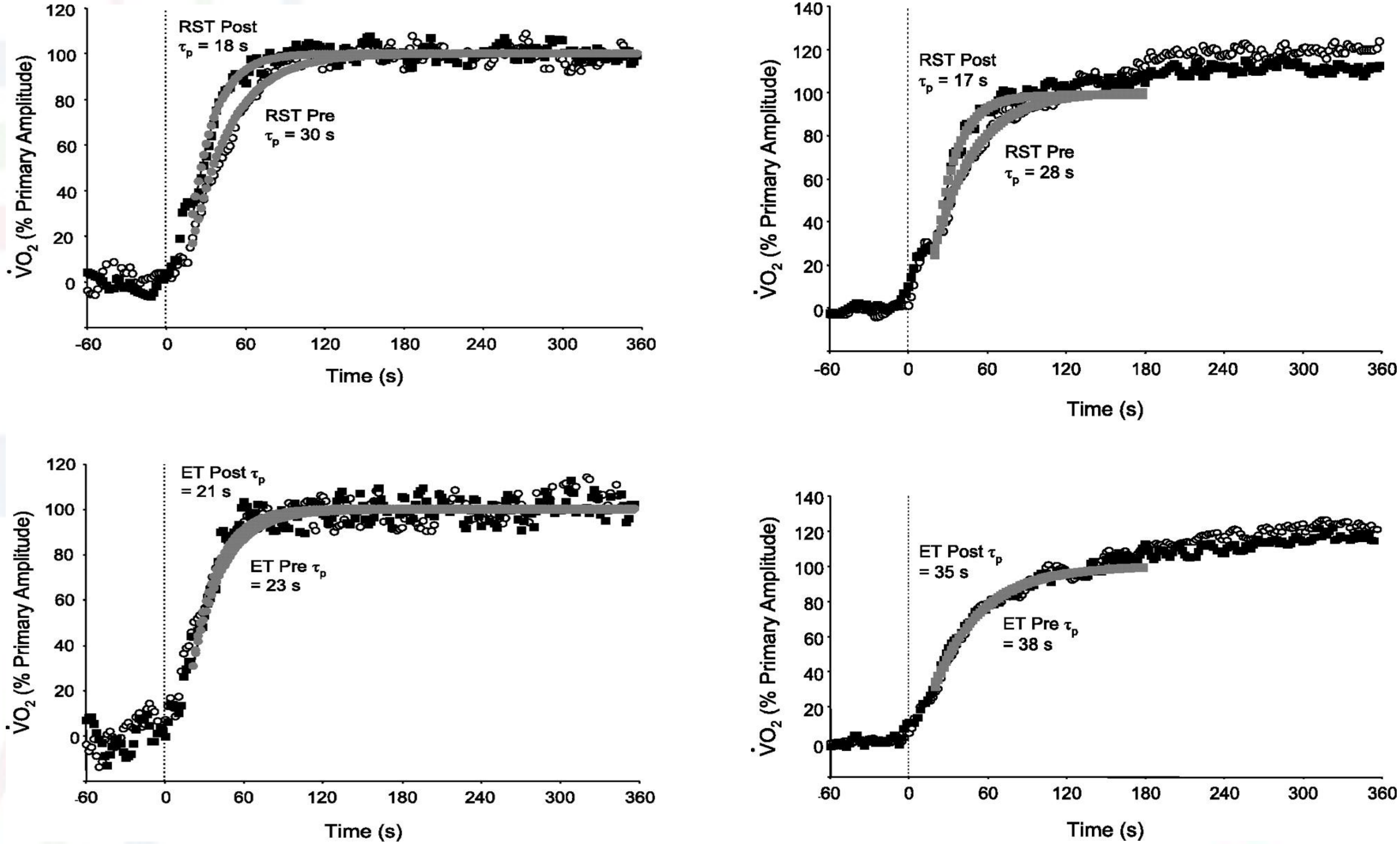
Med Sci Sports Exerc. 2006 Mar;38(3):504-12.
Influence of continuous and interval training on oxygen uptake on-kinetics.
Berger NJ, Tolfrey K, Williams AG, Jones AM.

A continuous training group that completed three to four sessions per week of 30-min duration at 60% VO2peak (LO); an interval training group that completed three to four sessions per week involving 20 x 1-min exercise bouts at 90% VO2peak

Continuous and interval training were similarly effective in reducing the amplitude of the VO_2 slow component

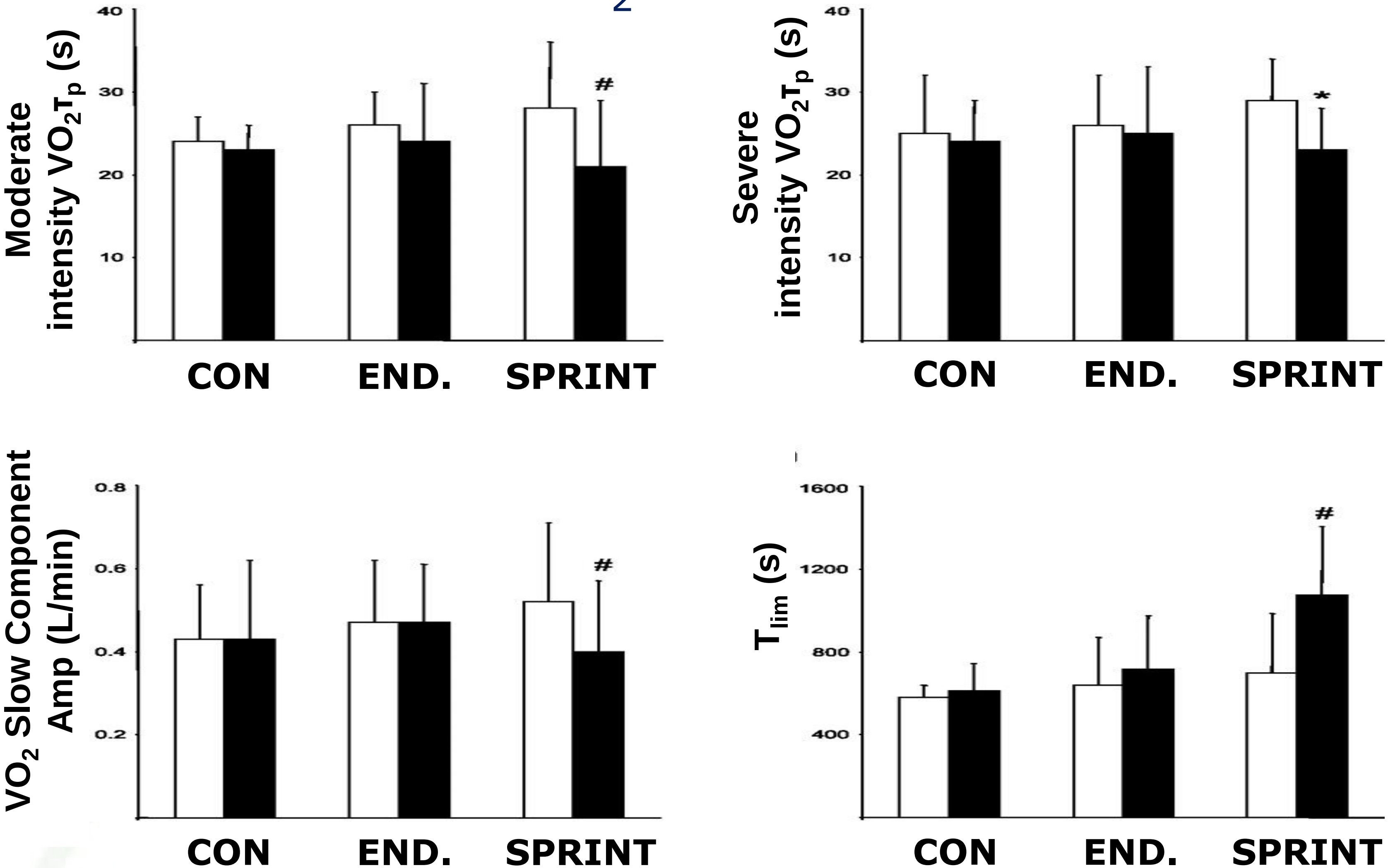
Repeated sprint training also effective in improving VO_2 kinetics

Moderate | **Severe**



Bailey et al. (2009)

Enhanced exercise tolerance correlated with improved VO_2 kinetics

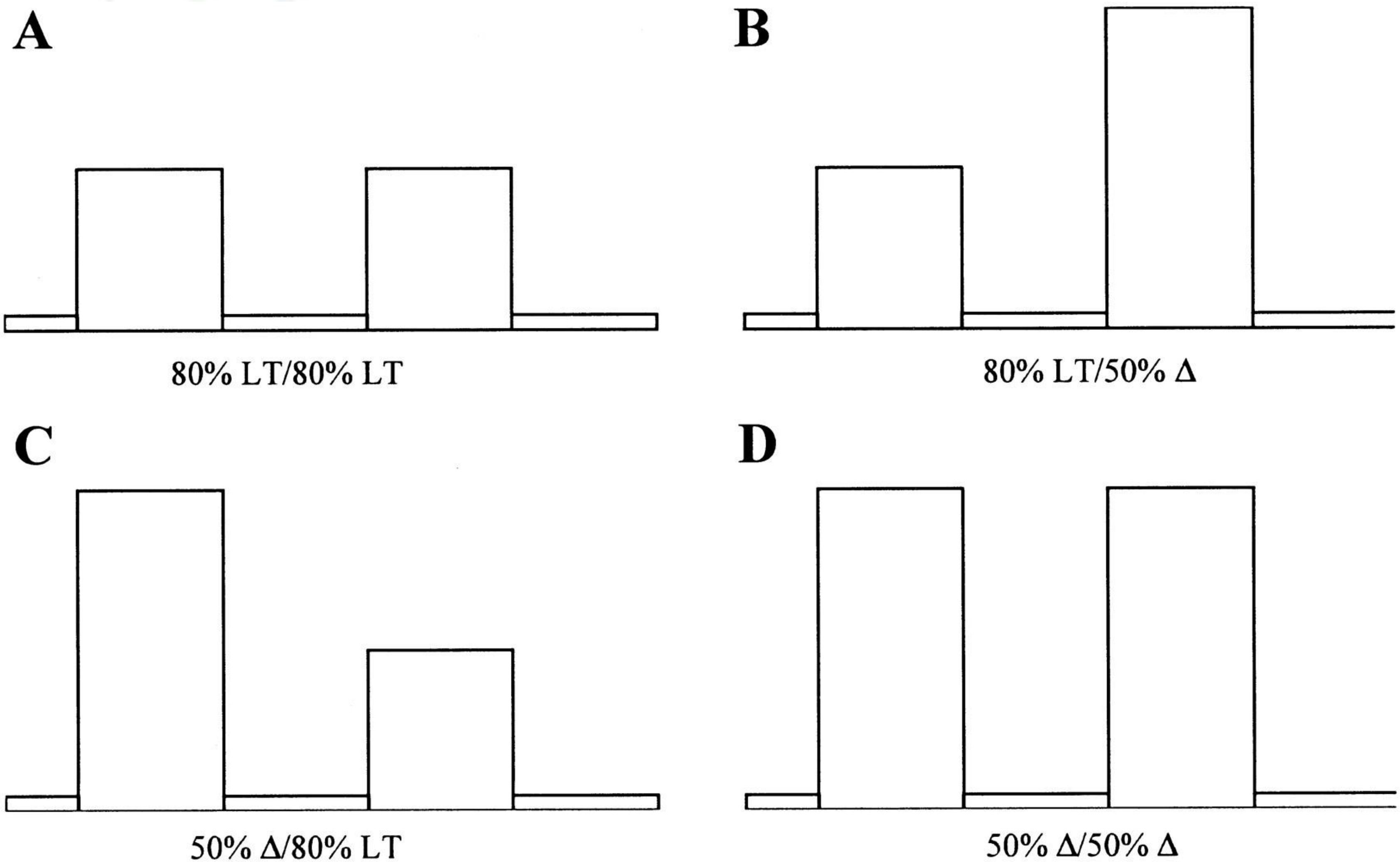


Bailey et al. (2009)

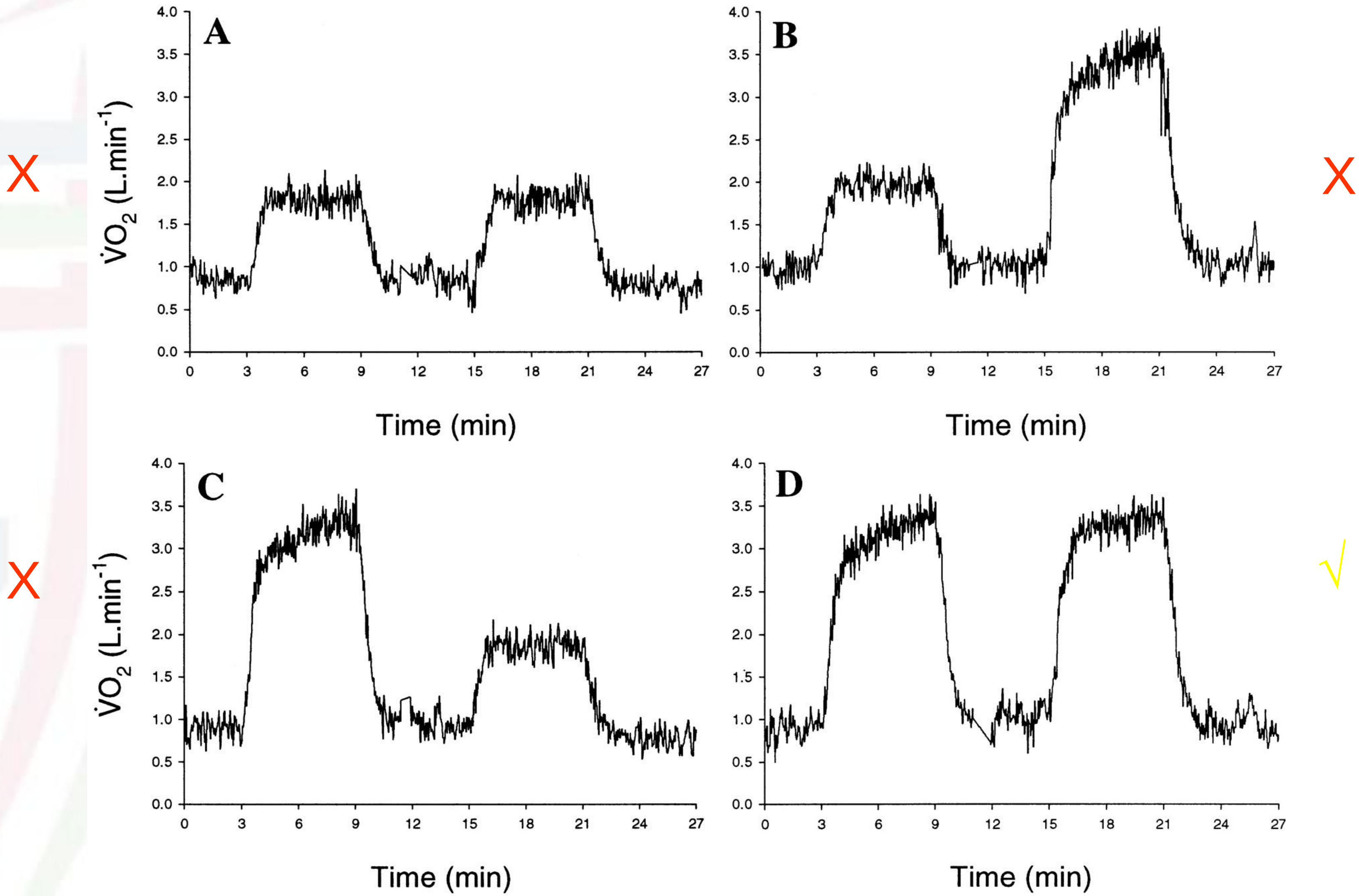
Warm-Up/Priming

Gerbino et al. (1996)

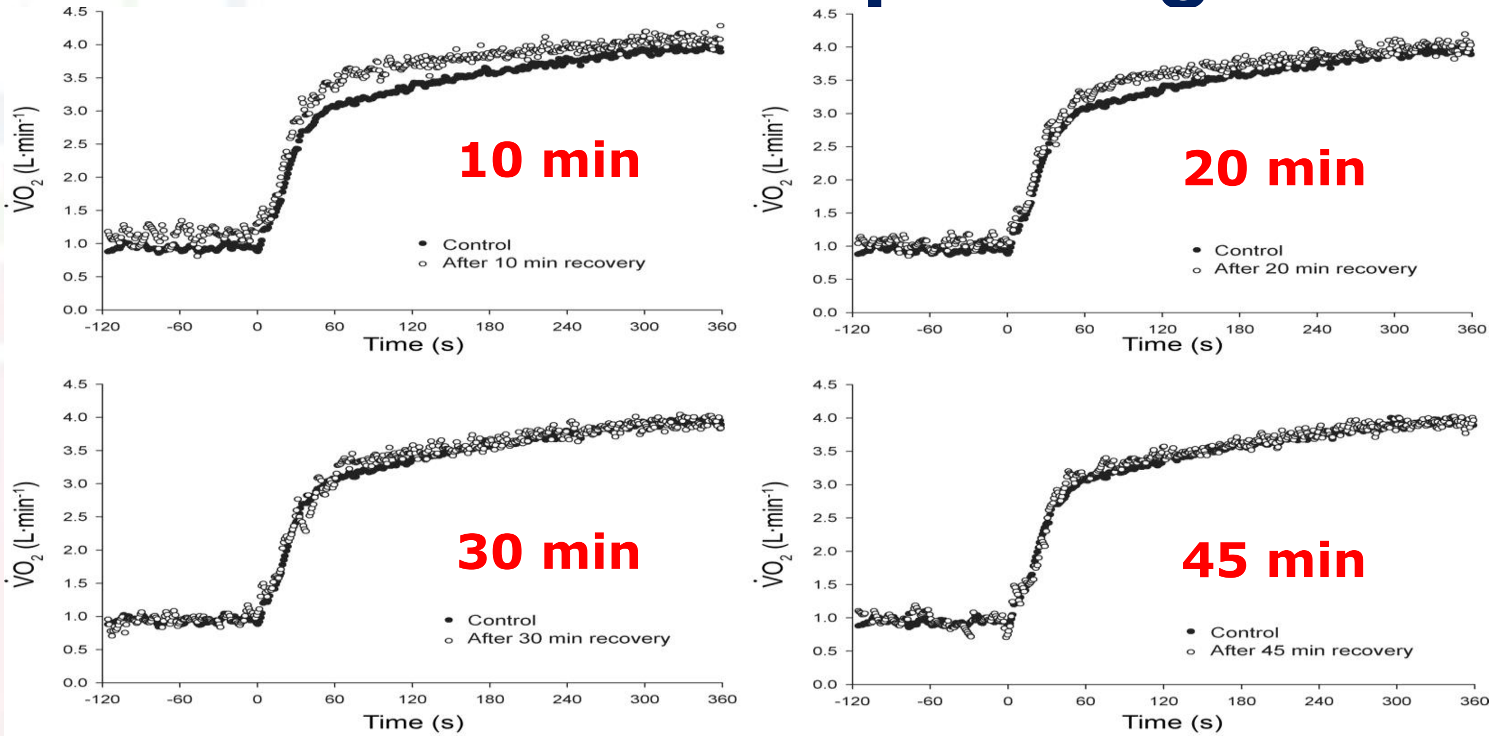
"Priming" Exercise

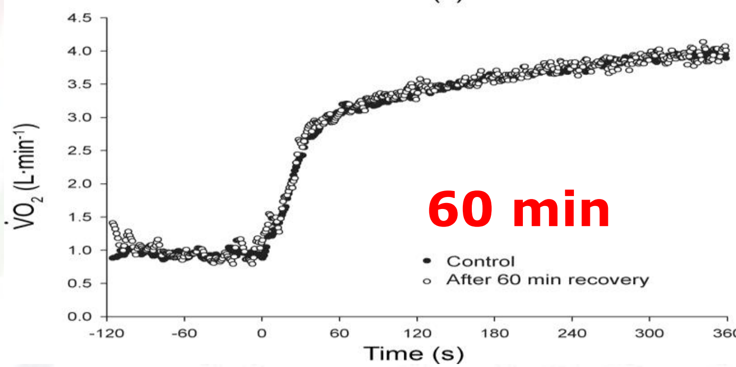


Burnley et al. (2000)



Time course of the priming effect





Burnley et al., JAP, 2006

J Appl Physiol 107: 1743–1756, 2009.
First published October 1, 2009; doi:10.1152/japplphysiol.00810.2009.

Optimizing the "priming" effect: influence of prior exercise intensity and recovery duration on O_2 uptake kinetics and severe-intensity exercise tolerance

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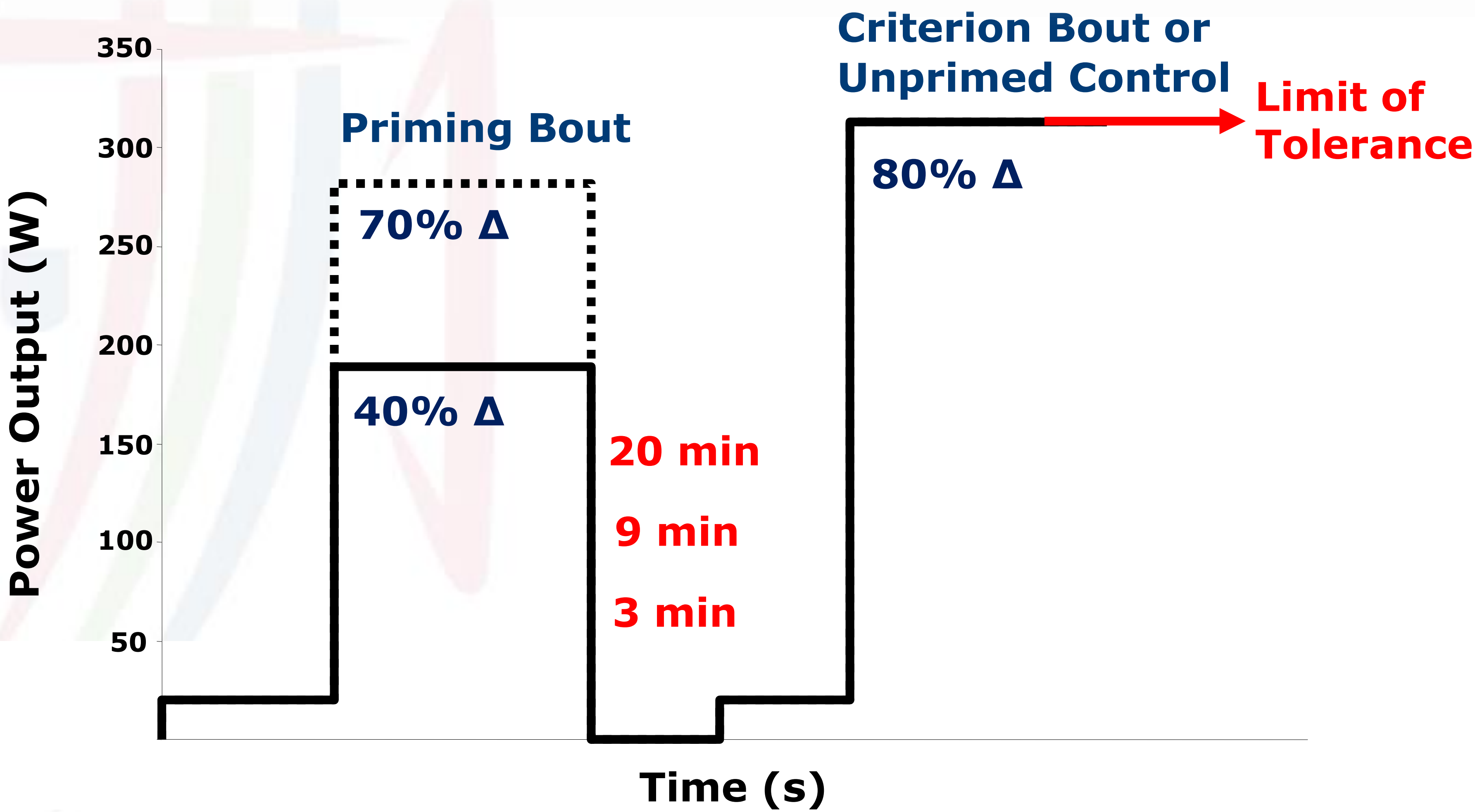
School of Sport and Health Sciences, St. Luke's Campus, University of Exeter, Devon, United Kingdom

Submitted 24 July 2009; accepted in final form 27 September 2009



Interaction of prior exercise intensity and subsequent recovery duration

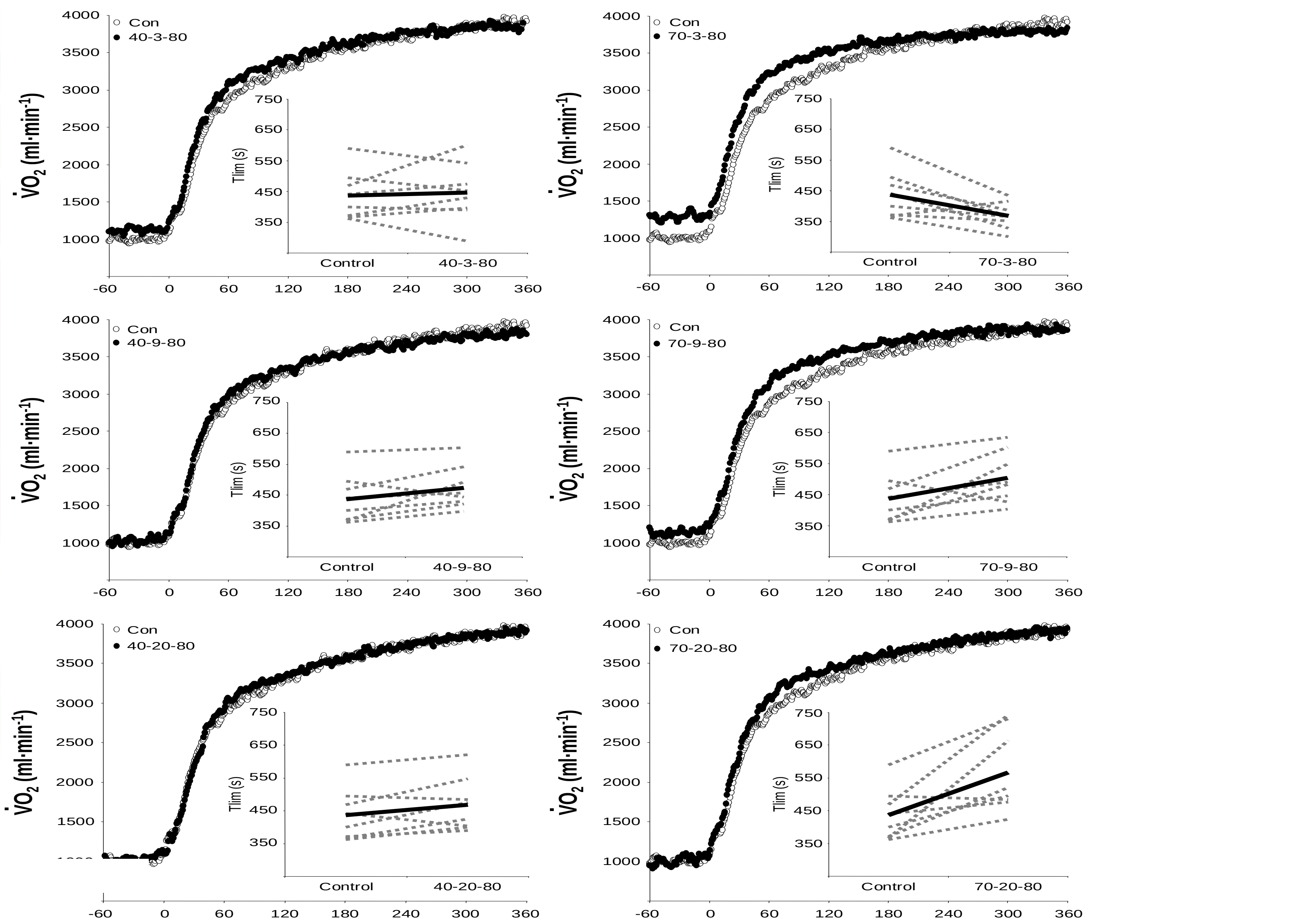
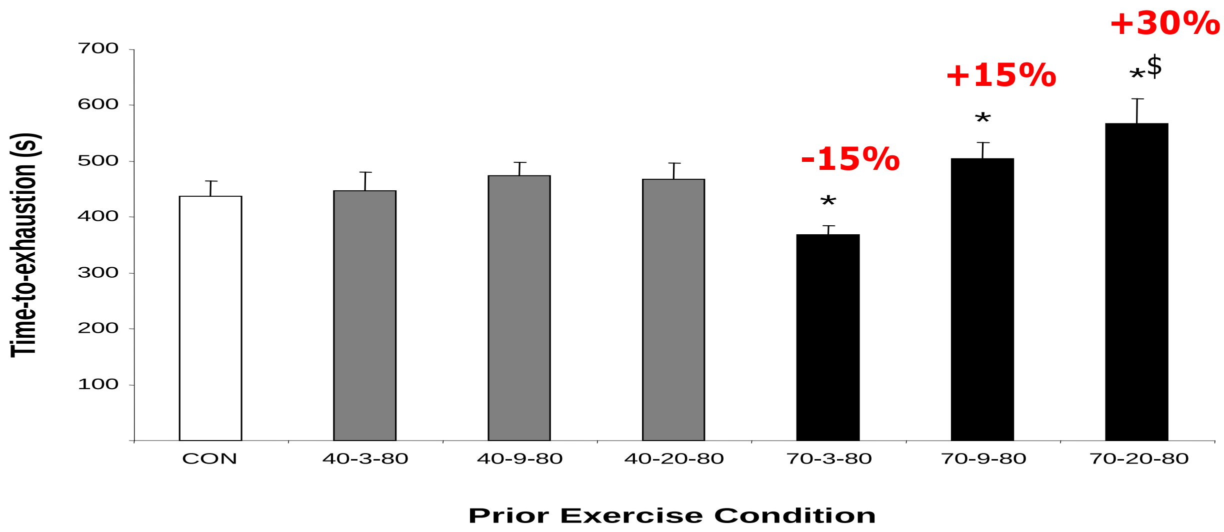


Figure 2

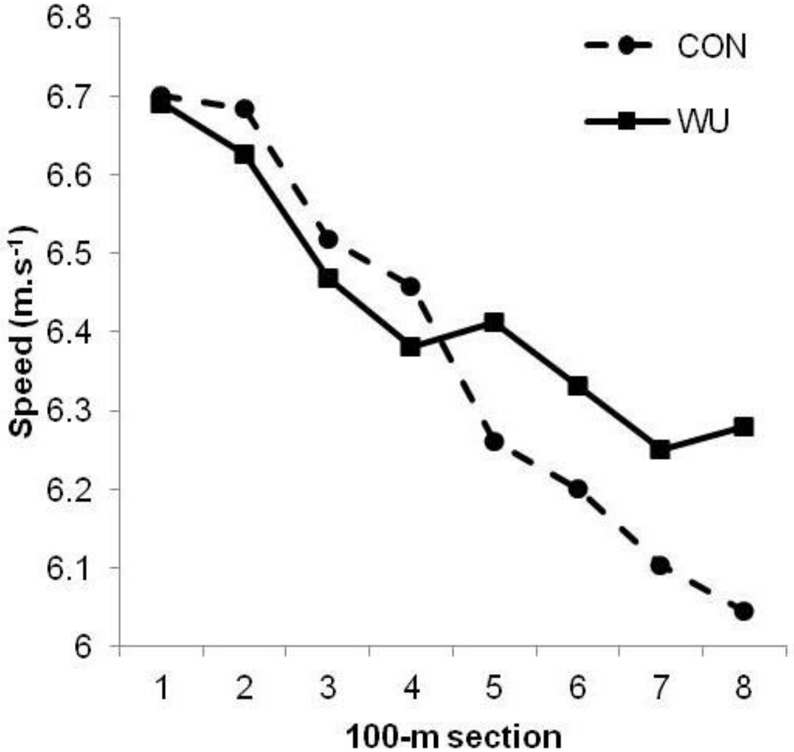
Optimal 'warm-up' enhances performance

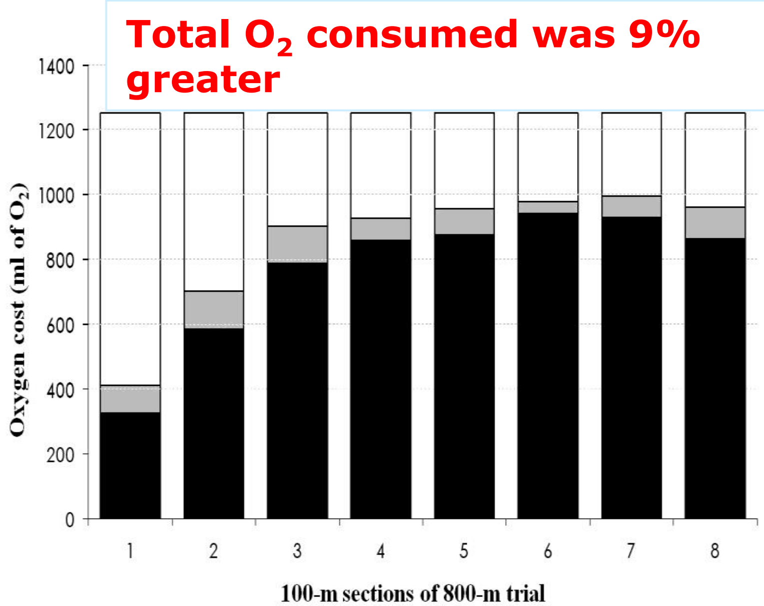


Pre-exercise blood [lactate] of ~ 3 mM appears to be optimal

Prior *high-intensity* exercise coupled with *sufficient* recovery optimizes the balance between preserving the effects of prior exercise on VO_2 kinetics and providing sufficient time for muscle homeostasis to be restored.

Prior high-intensity exercise improves 800-m running performance

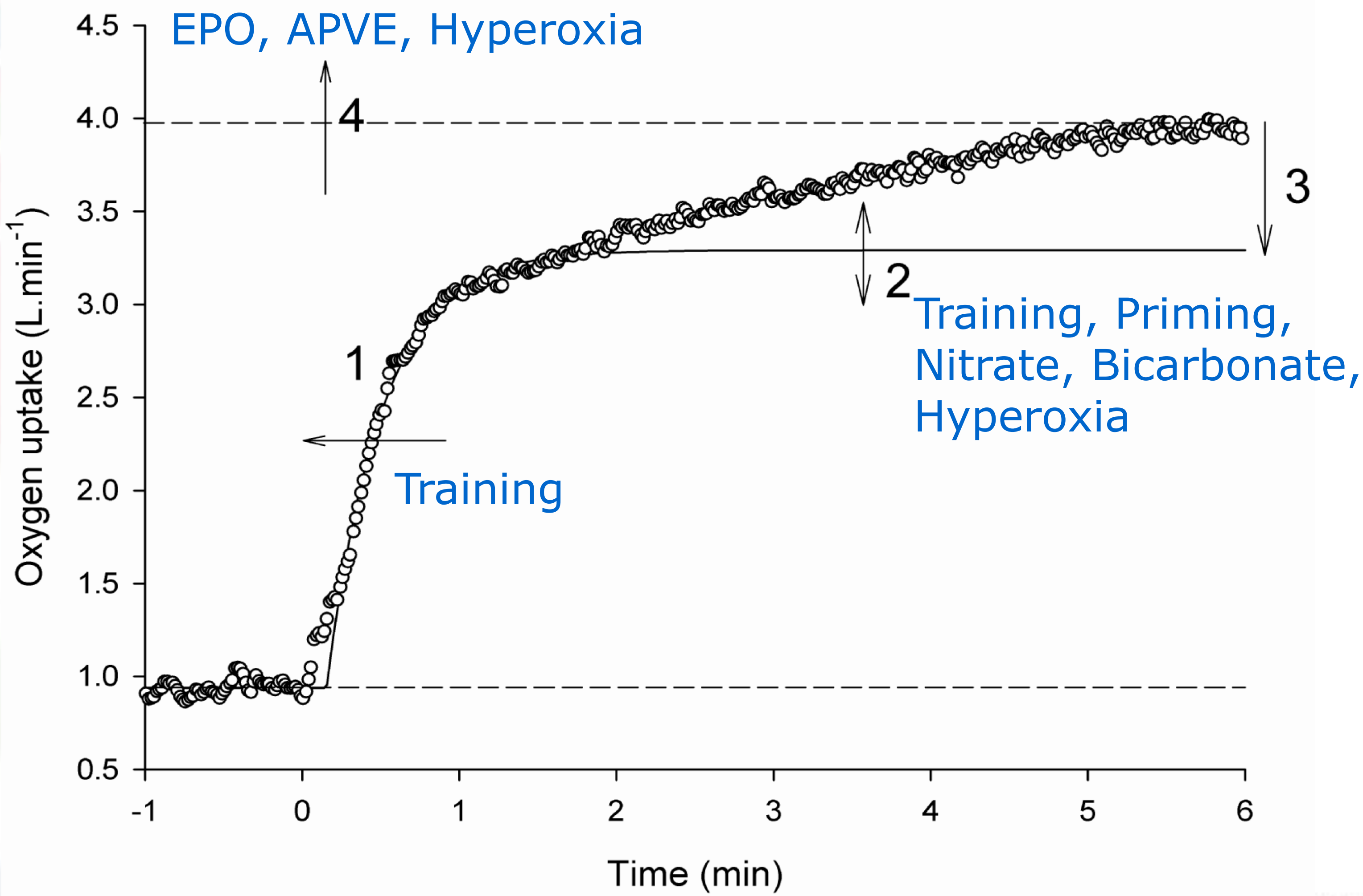




Ingham et al., 2013, IJSPP

"In elite middle-distance athletes, 800-m time-trial performance was significantly faster following HWU (HWU, 124.5 ± 8.3 vs. CON, 125.7 ± 8.7 s, $P<0.05$)."

Effects of interventions on Vo_2 kinetics and performance during high-intensity exercise



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Obrigado pela vossa atenção!

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