Using RPE in training monitoring

from the lecture
'Psychobiology of Endurance Performance'
by S. Marcora, Kent University

Endurance performance in the lab

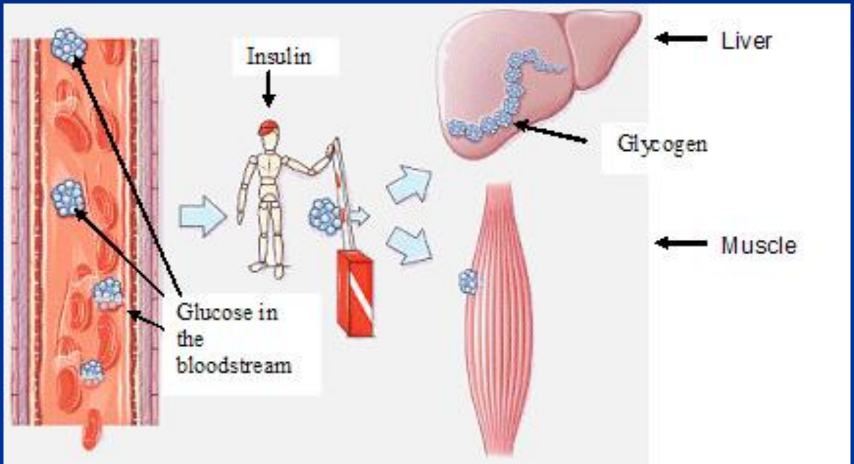
Endurance performance = whole-body exercise > 1 min duration

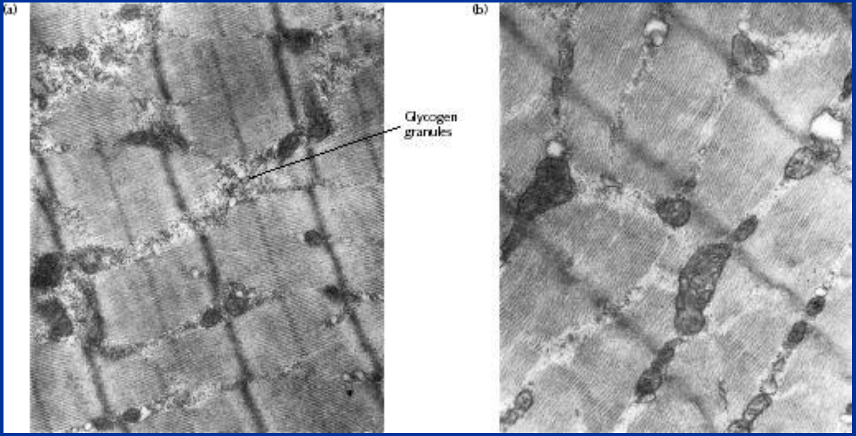
Physiological Models of Endurance Performance

- Energy depletion model
- Muscle fatigue model:
- Peripheral fatigue
- Central fatigue

Energy depletion model assumption:

Prolonged exercise terminates when energy substrates for muscle contraction are depleted





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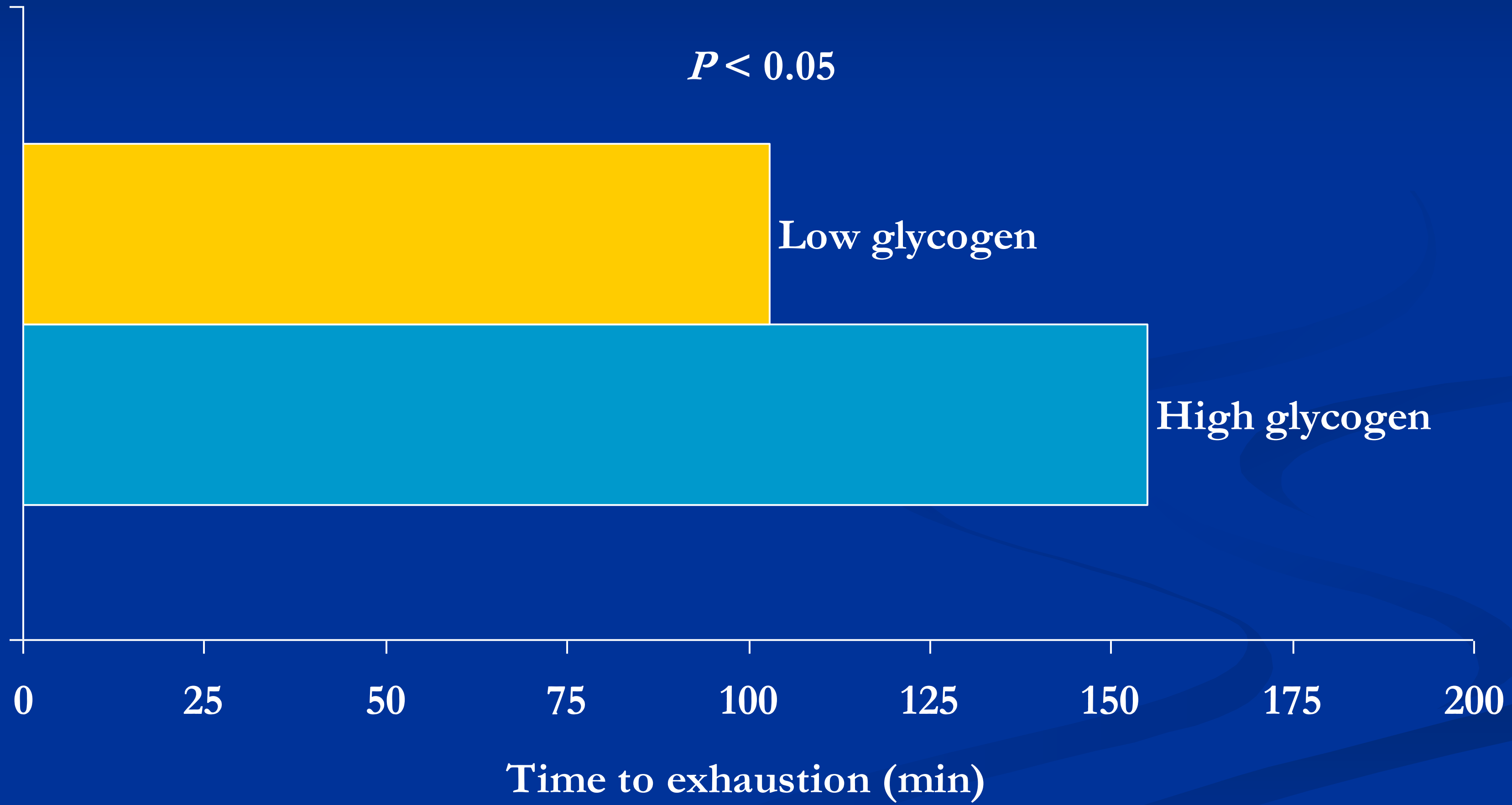

(Baldwin et al., 2003)

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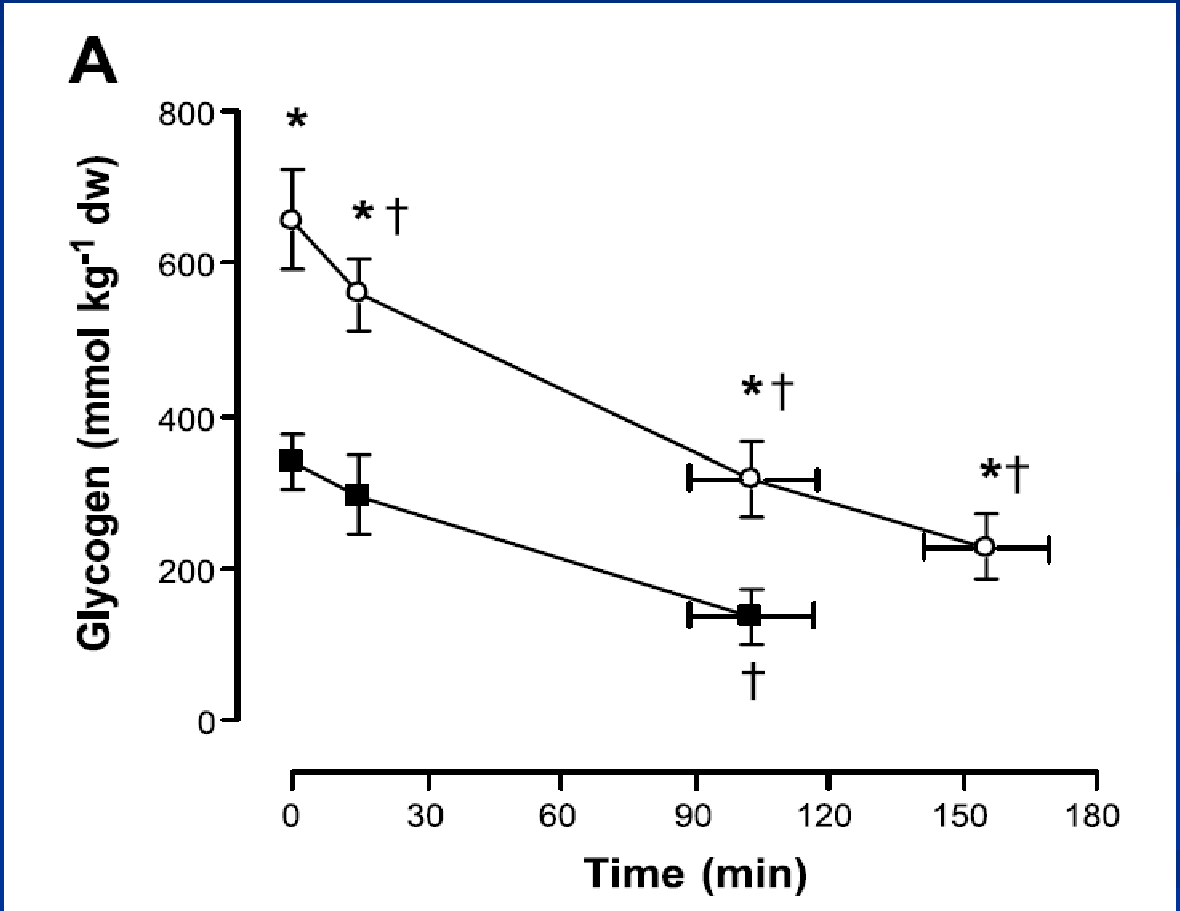
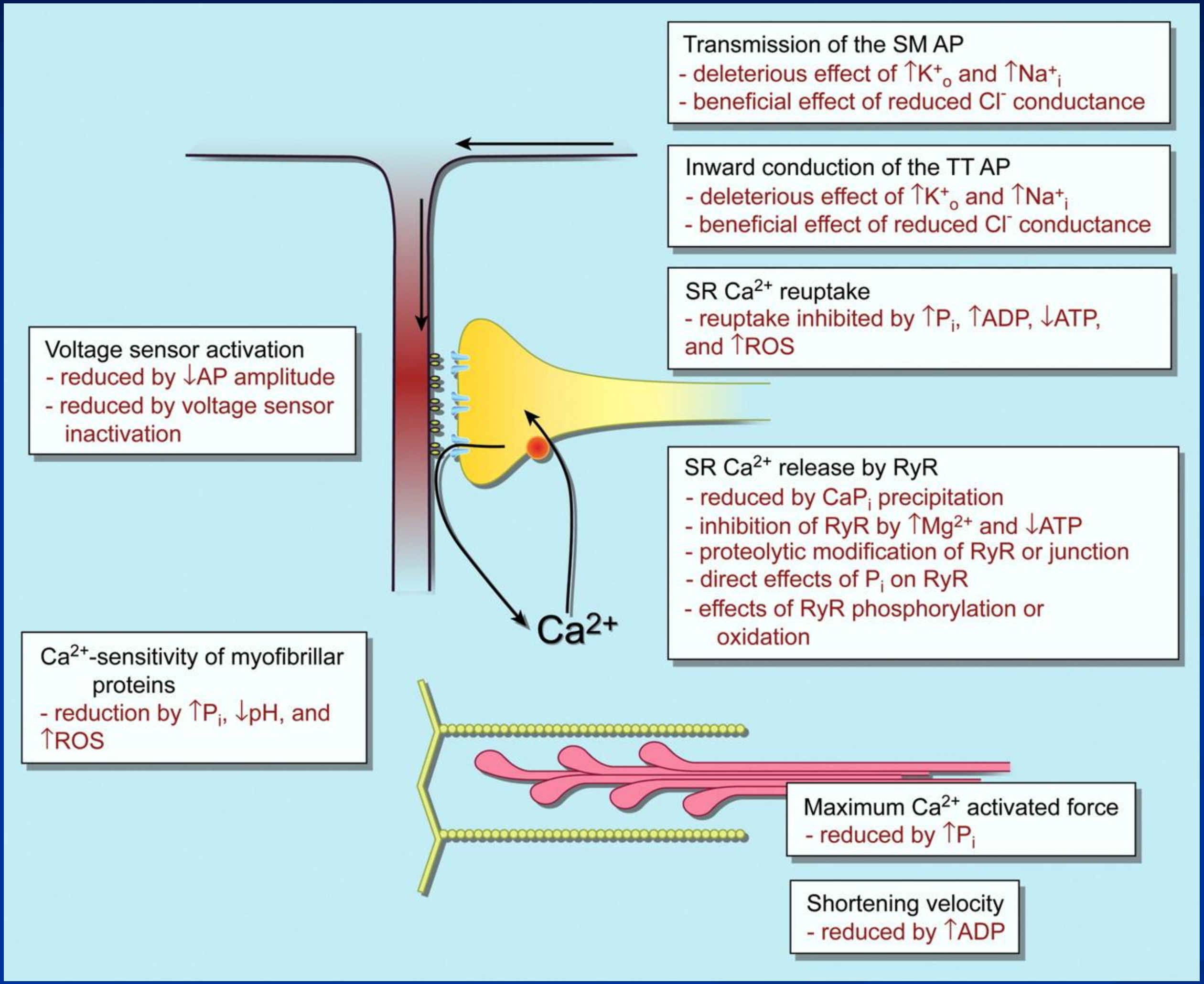


(Baldwin et al., 2003)

Muscle fatigue model

- **A. V. Hill**, in his book *Muscular Activity* (**1926**), adopted the view subsequently accepted widely by exercise physiologists.
- Athletes were best for studies of the limits of voluntary performance because "**with young athletic people one may be sure that they really have gone all out**, moderately certain of not killing them, **and practically certain that their stoppage is due to oxygen-want and to lactic acid in their muscles**".
- Although **no direct evidence was presented to support this view about going "all out"**, Hill appreciated the difficulties if this assumption were not justifiable (Gandevia, 2001).

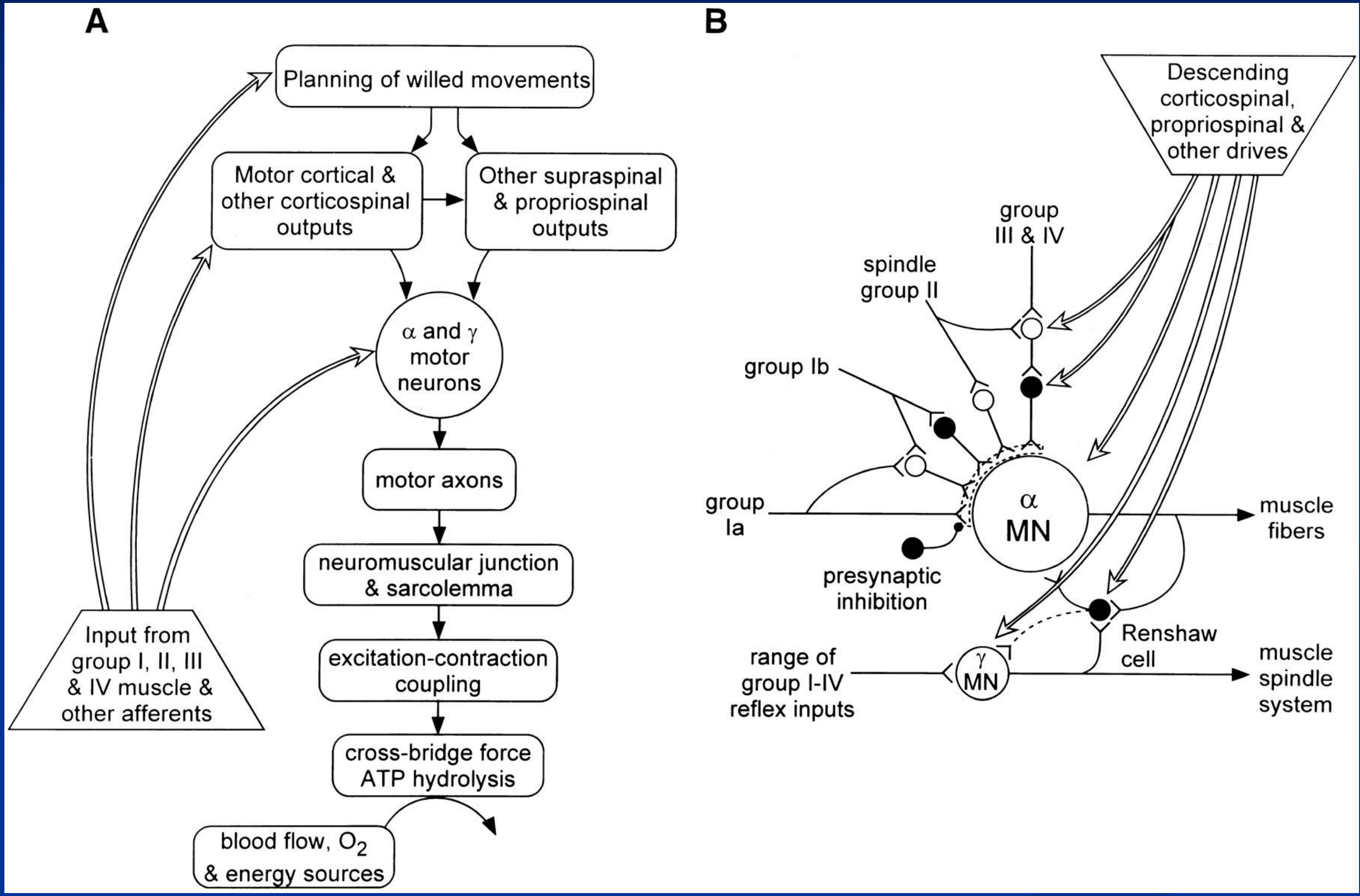
Major mechanisms that contribute to muscle fatigue (peripheral)



Allen, D. G. et al. Physiol. Rev. 88: 287-332 2008;
doi:10.1152/physrev.00015.2007

Physiological Reviews

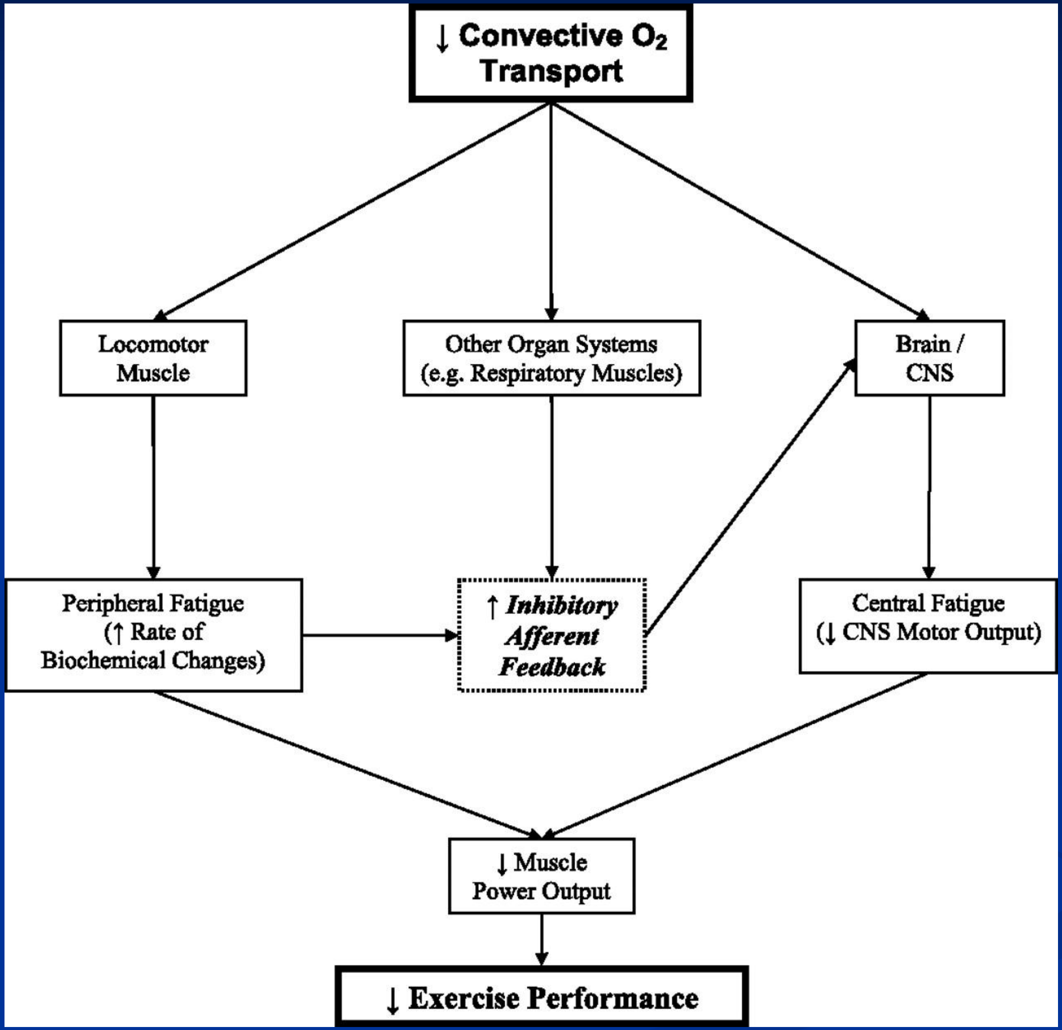
Central Fatigue (spinal and supraspinal)



Gandevia, S. C. Physiol. Rev. 81: 1725-1789 2001

Physiological Reviews

Fig. 5. Hypothetical scheme linking convective O2 transport and exercise performance via its effects on fatigue



Amann, M. et al. J Appl Physiol 104: 861-870 2008;
doi:10.1152/japplphysiol.01008.2007

Journal of Applied Physiology

Effects of hypoxia on time to exhaustion (Amann et al., 2007)

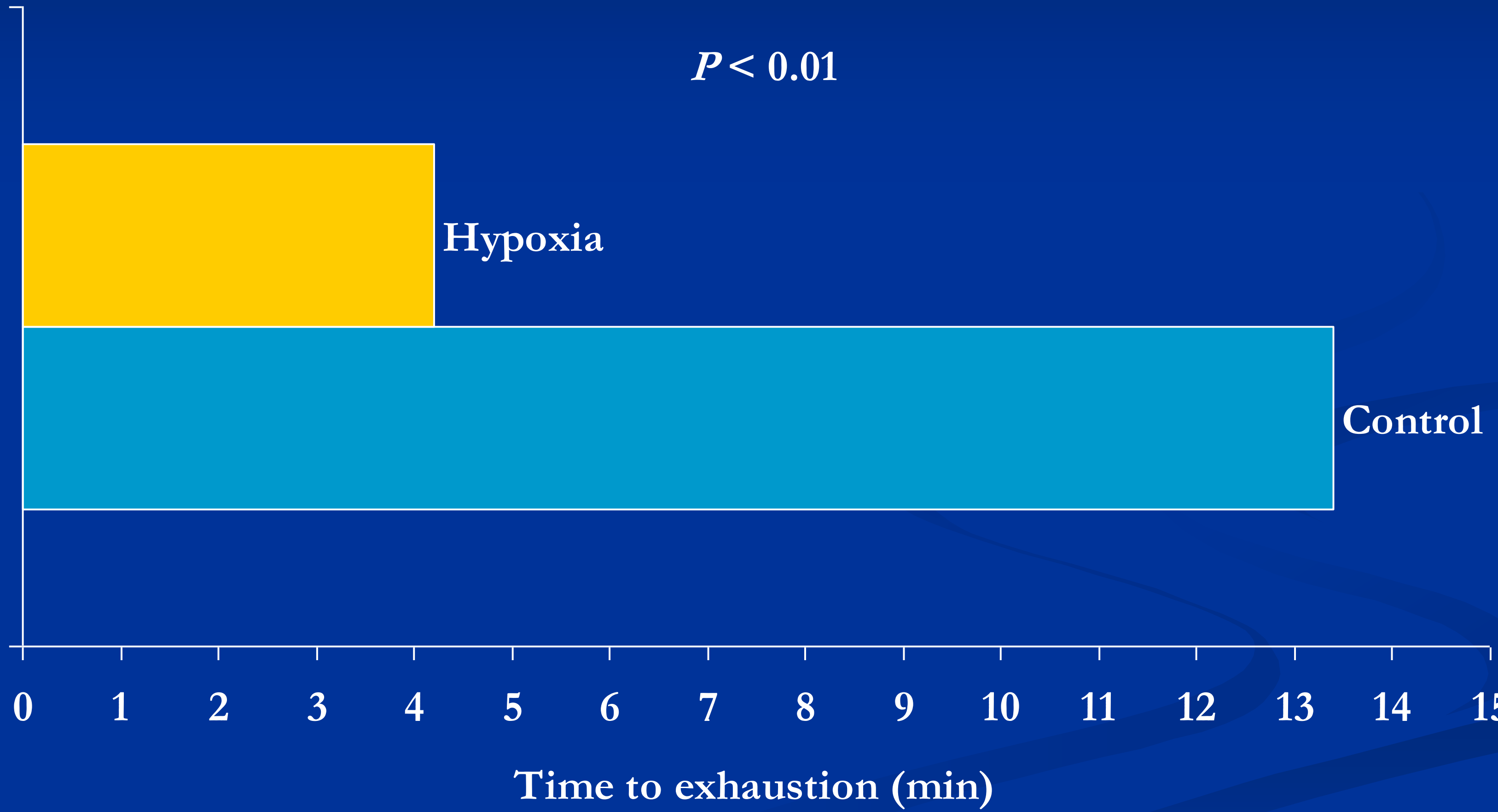
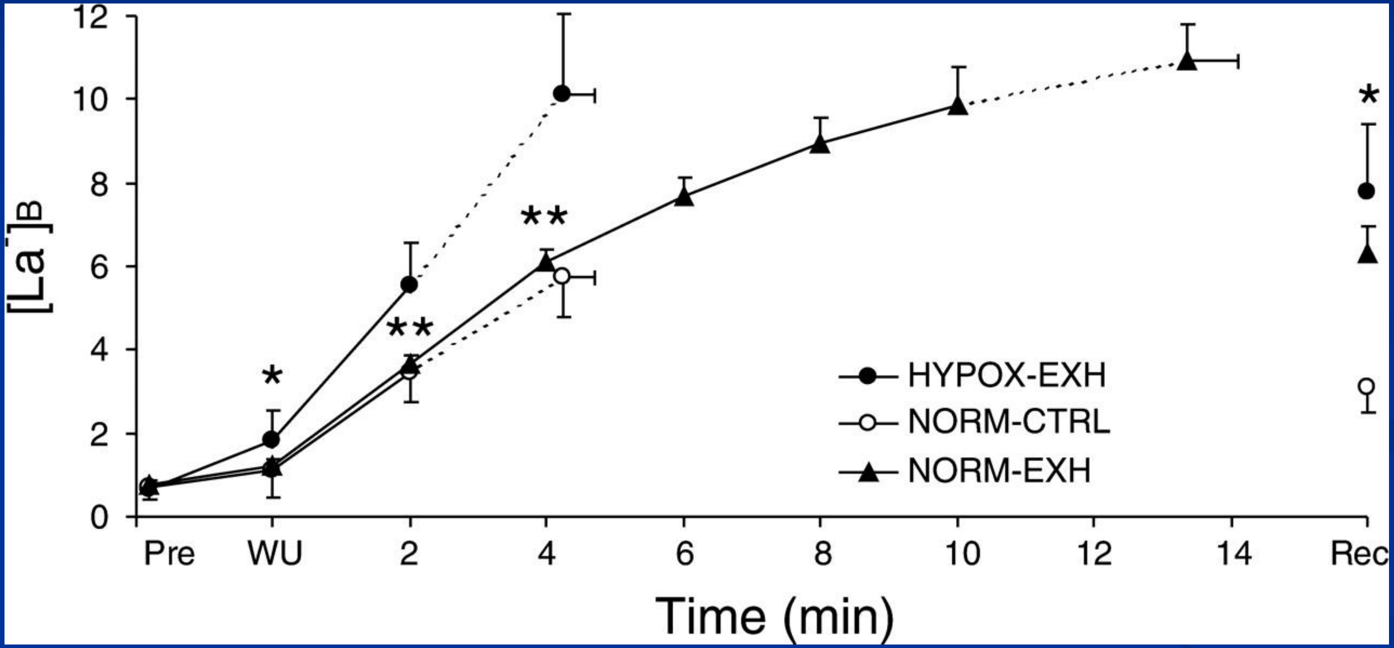


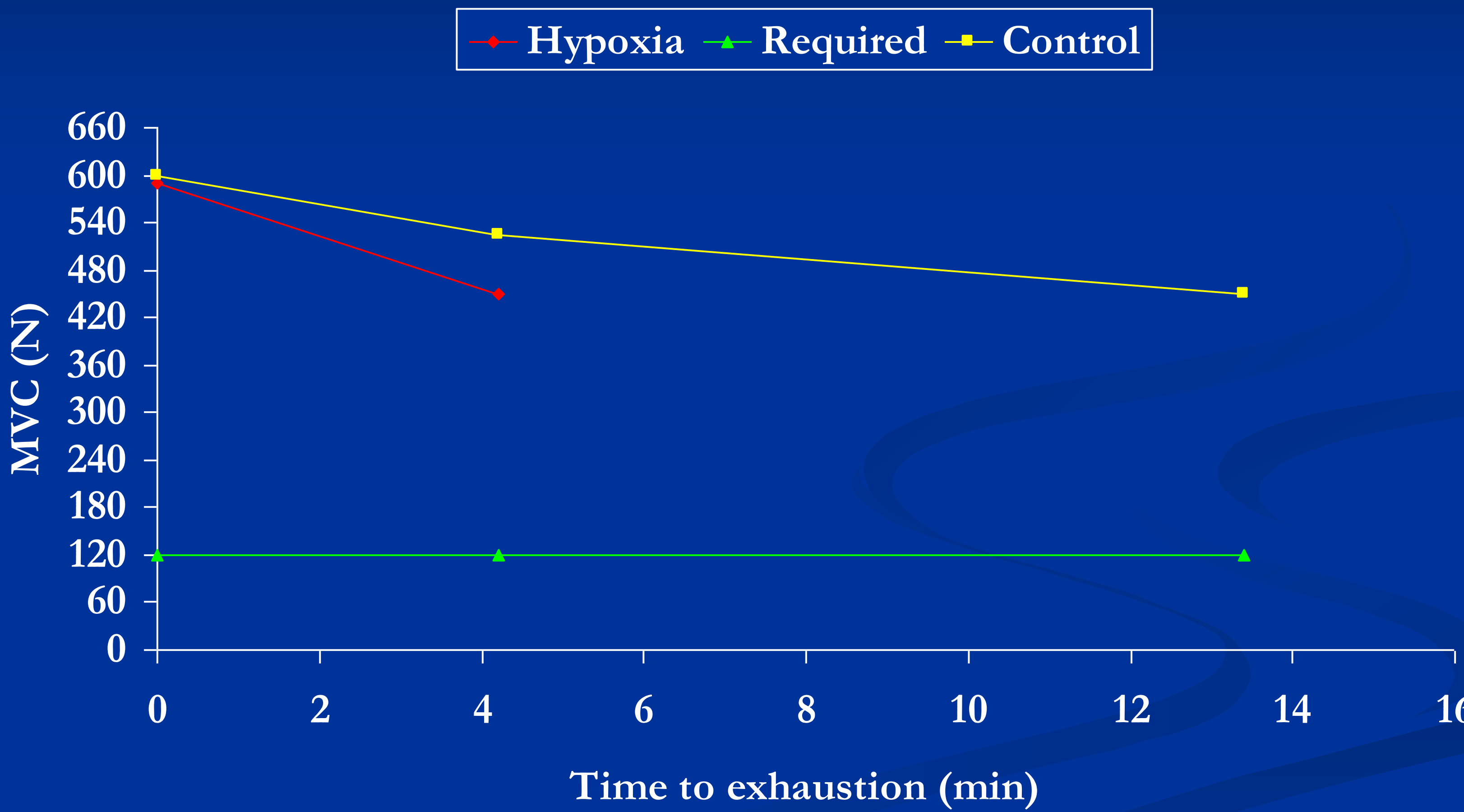
Fig. 5. Blood lactate concentration ([La-]B) measured at baseline (Pre), after 5 min of warm-up at 40% Wpeak, every min of exhausting exercise at ~92% Wpeak, and after ~10 min of recovery (Rec) in HYPOX-EXH, NORM-CTRL, and NORM-EXH; n = 9 subjects



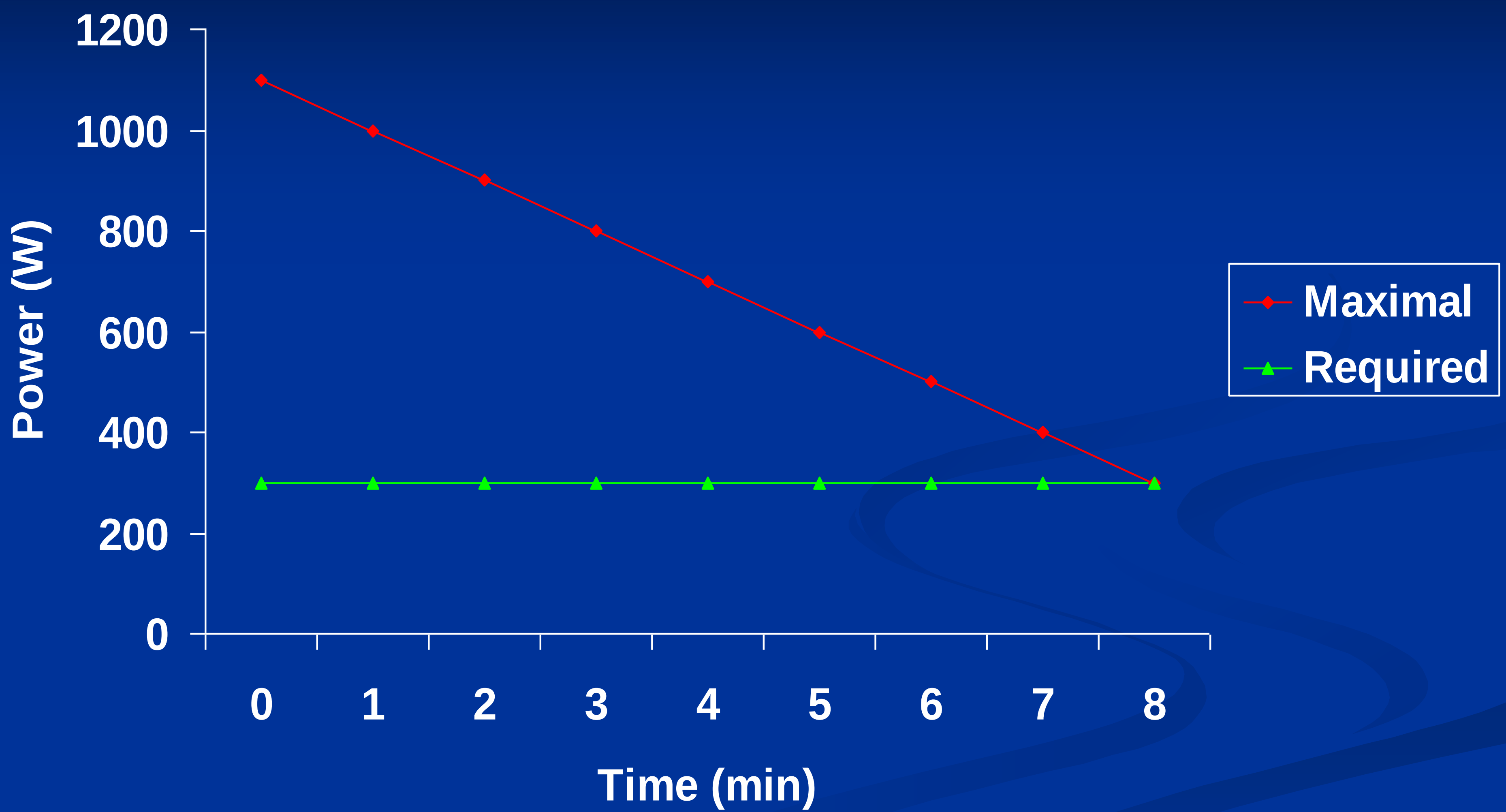
Romer, L. M. et al. Am J Physiol Regul Integr Comp Physiol 292: R598-R606 2007;
doi:10.1152/ajpregu.00269.2006

AJP - Regulatory, Integrative and Comparative Physiology

Effects of hypoxia on time to exhaustion (Amann et al., 2007)

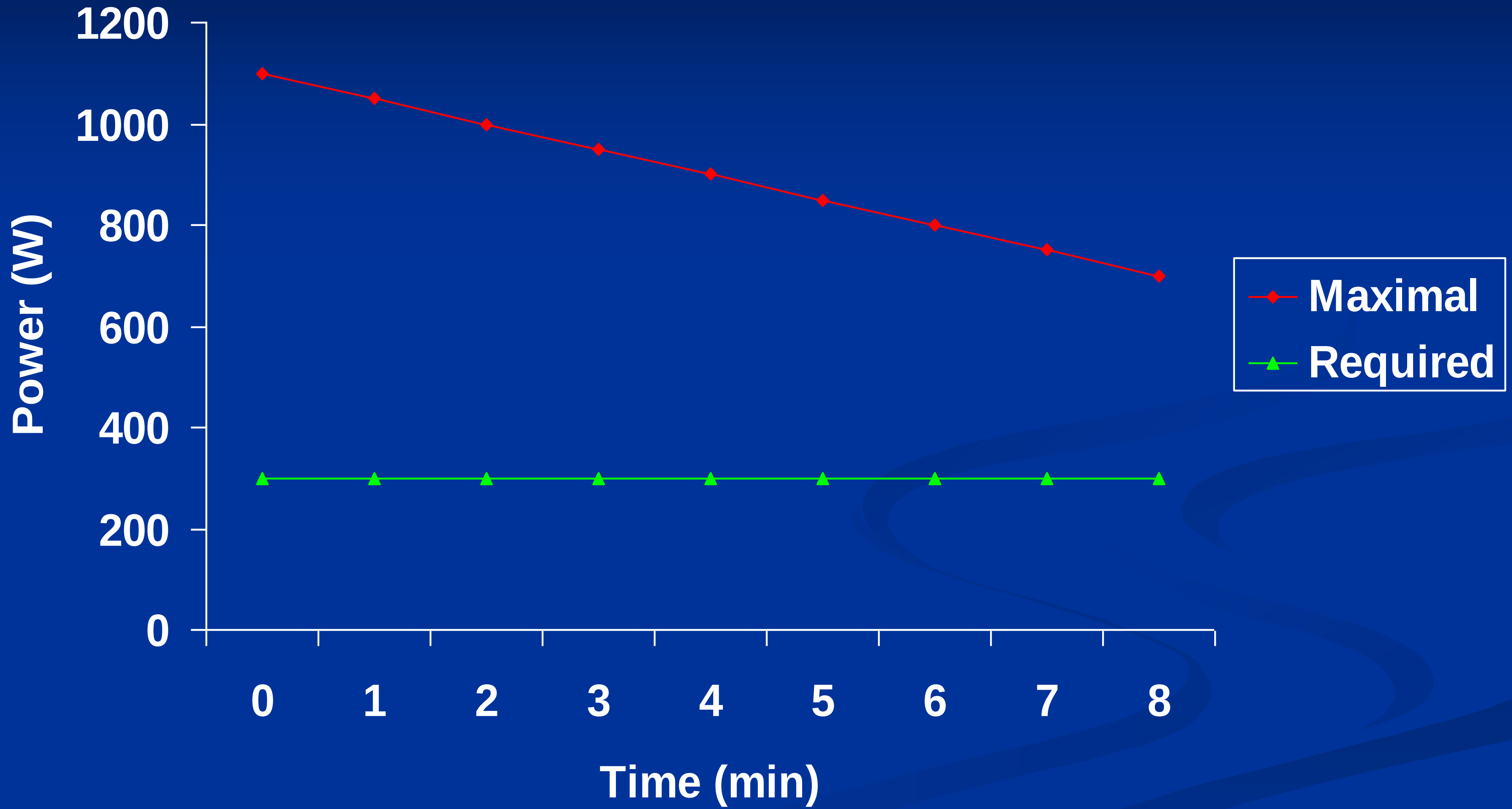


Assumption



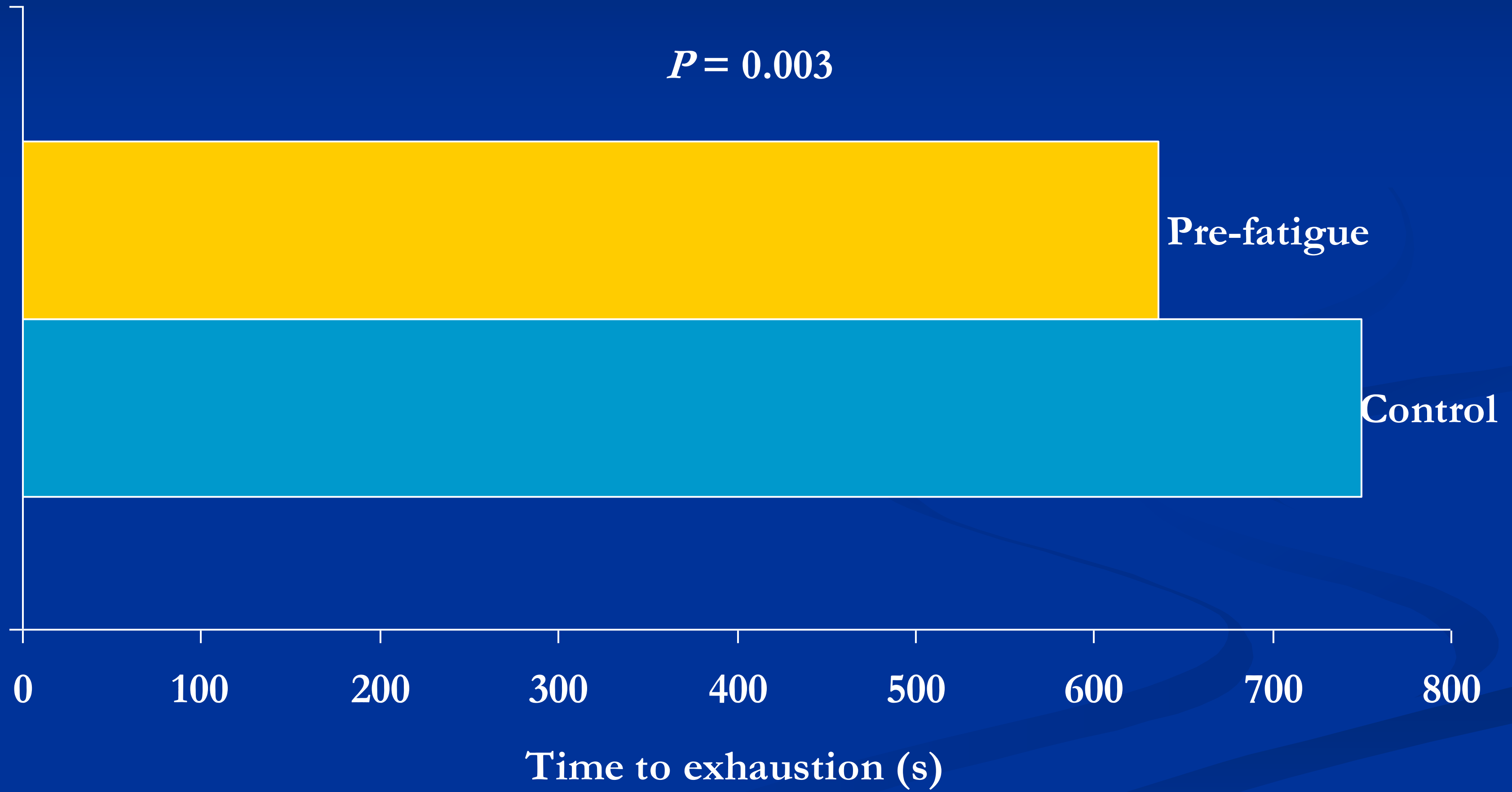
Adapted from Allen DG, Lamb GD, Westerblad H. Skeletal muscle fatigue: cellular mechanisms. Physiological Reviews. 2008; 88: 287-332.

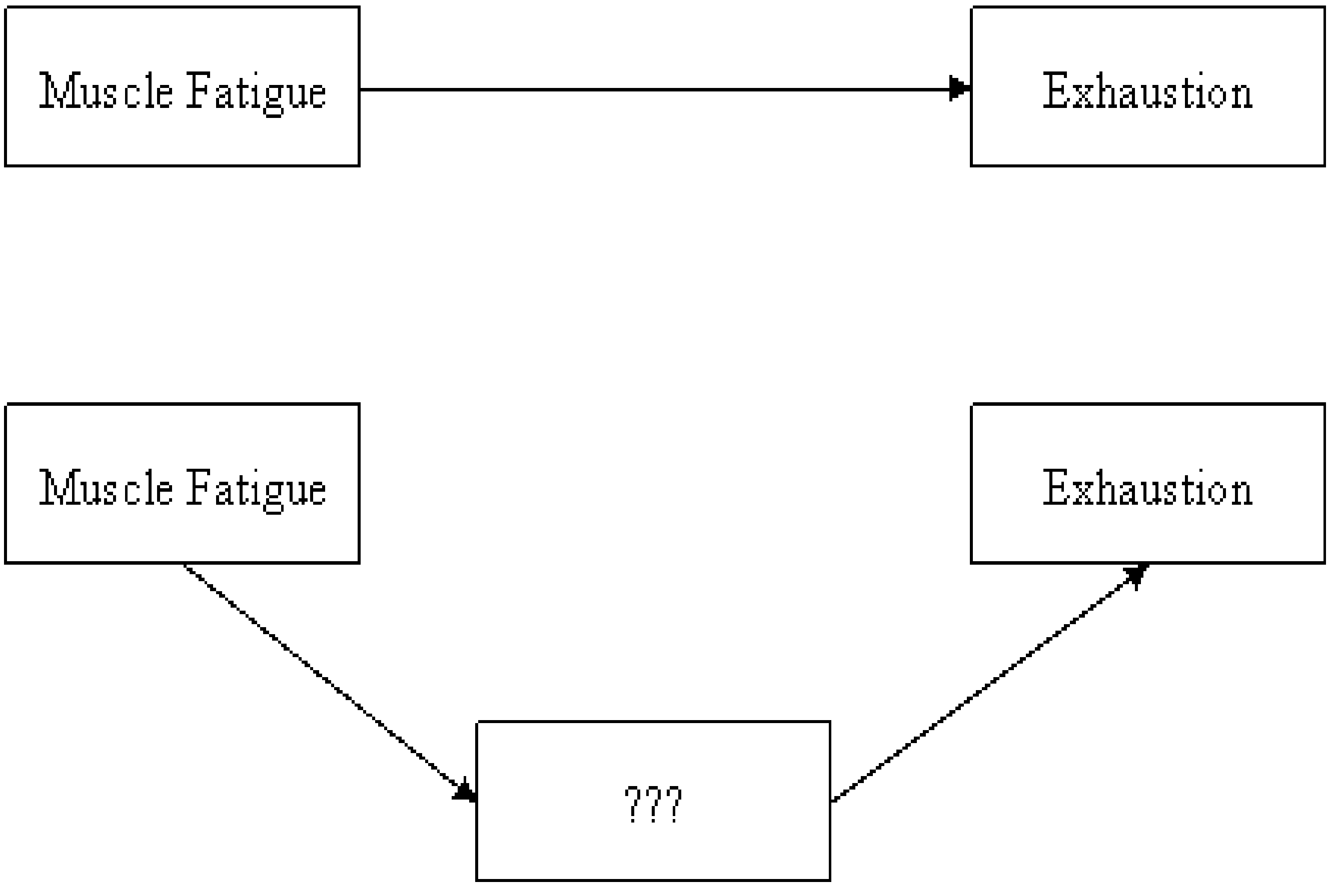
Experimental evidence



Marcora et al. (manuscript in preparation)

Effect of muscle fatigue on performance during high-intensity cycling exercise




Muscle Fatigue
Exhaustion
Muscle Fatigue
Exhaustion
???

Gandevia (2000)

- Exercise physiologists have long sought to identify a particular cardiovascular, respiratory, or metabolic variable directly associated with the termination of exercise at the point commonly called exhaustion. Severe muscle fatigue may be present at this point. During exercise, many factors change at an intracellular level within muscle, and its perfusion and metabolic regulation also change, but identification of a factor or combination of them that stops conventional human exercise has proven difficult.

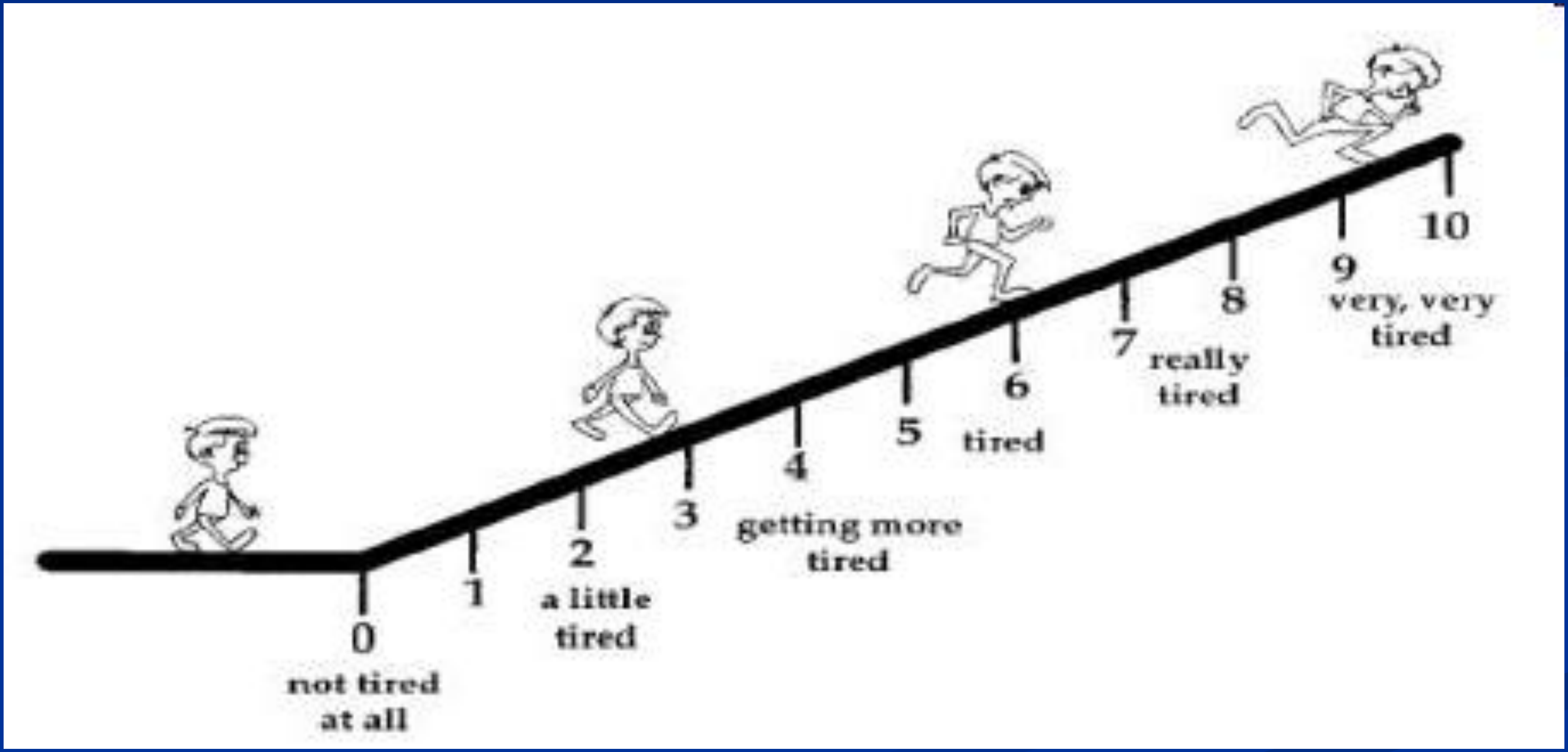
Rating of Perceived Exertion (Borg, 1965)

6	no exertion at all
7	extremely light
8	
9	very light
10	
11	light
12	
13	somewhat hard
14	
15	hard (heavy)
16	
17	very hard
18	
19	extremely hard
20	maximal exertion

RPE Scale

0	Nothing at all
1	Very Light
2	Light
3	Moderate
4	Somewhat Heavy
5	Heavy
6	
7	Very Heavy
8	
9	
10	Very, Very Heavy
11	Maximal

Pictorial scale for children



Paradigm shift

Physiological models: **endurance performance as the product of a mindless biological machine**
(exhaustion = task failure)

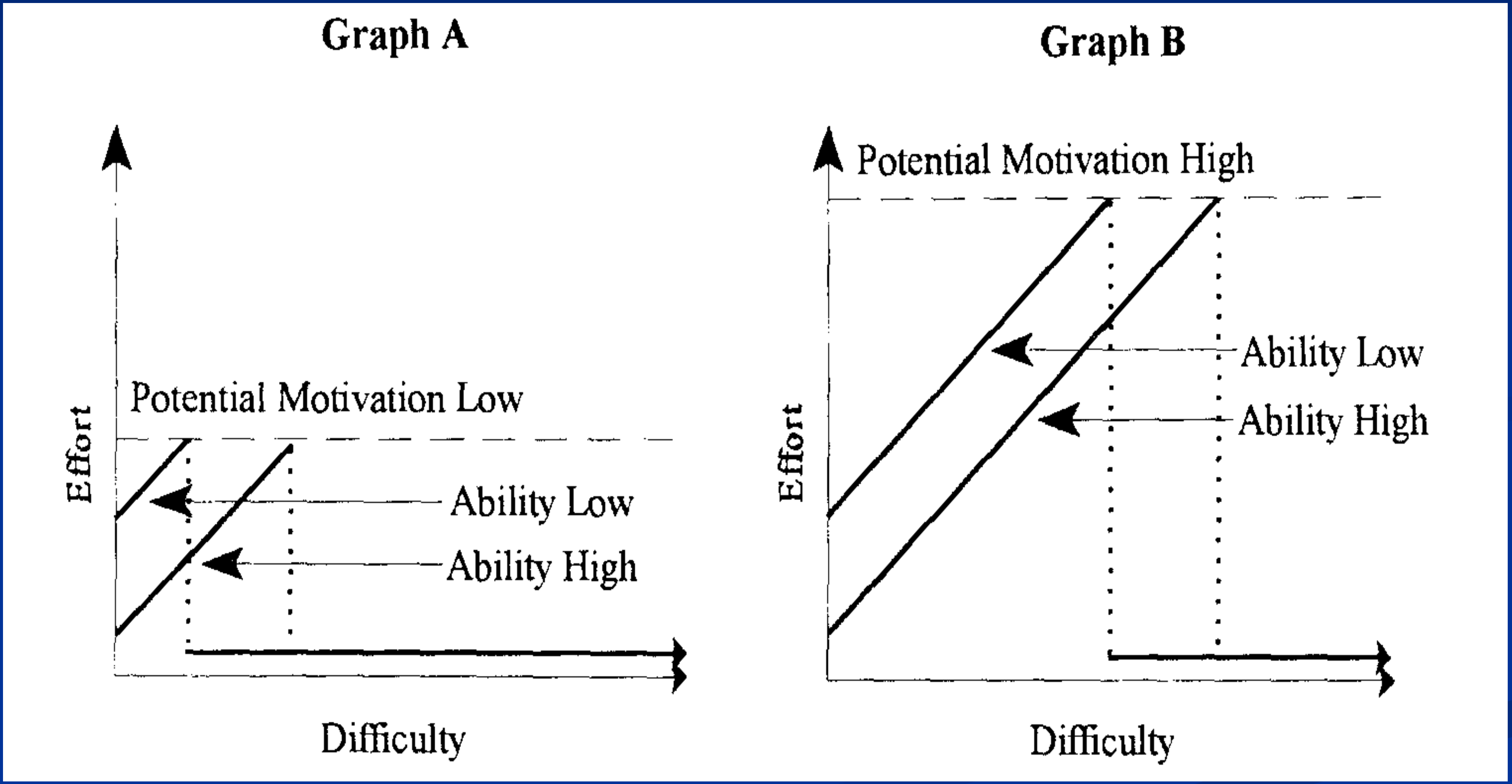
↓ ↓ ↓ ↓

Psychobiological model: **endurance performance as a motivated behaviour**
(exhaustion = task disengagement)

Psychological Determinants of Endurance Performance

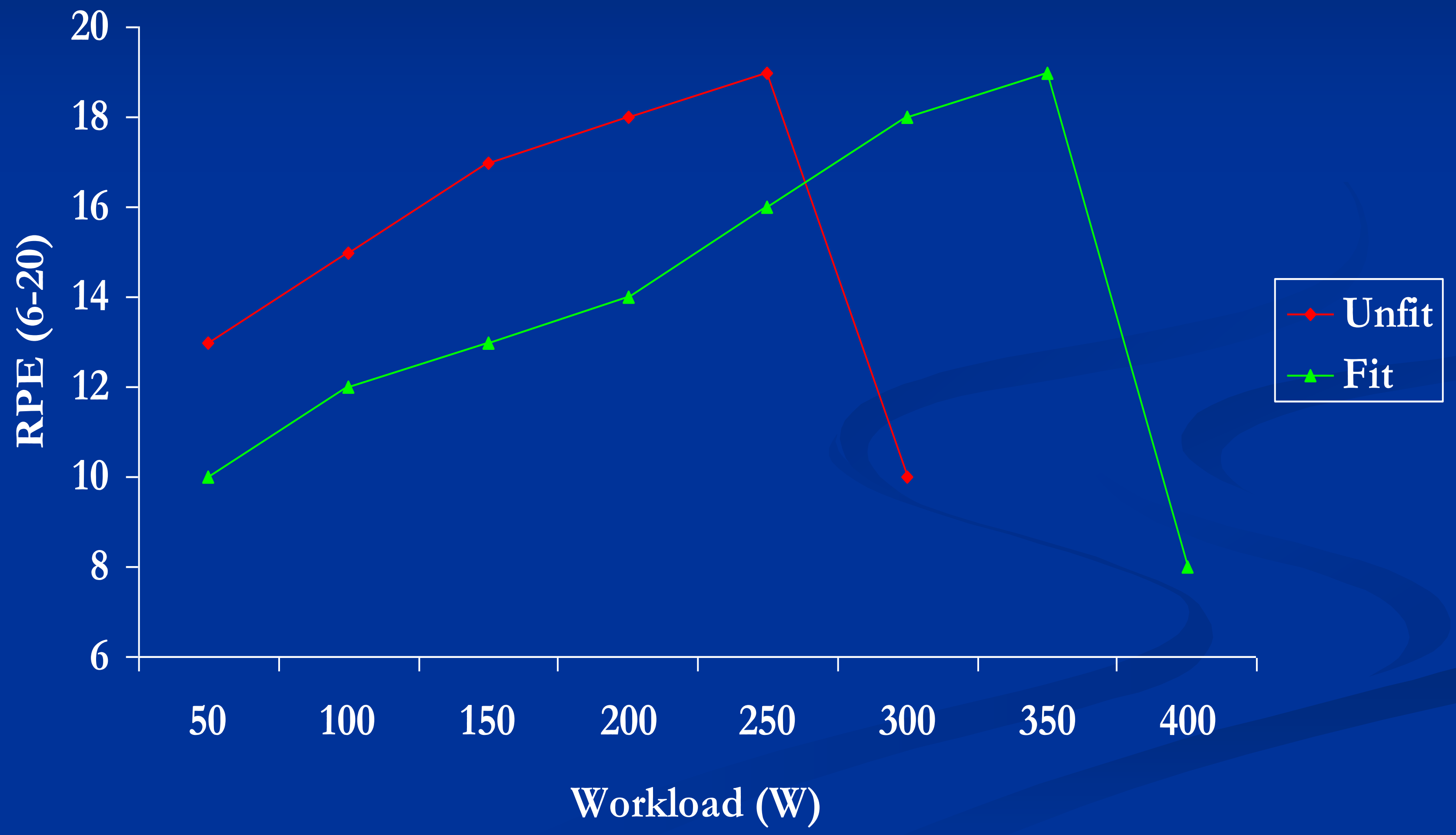
- Motivational:
- **1) Potential motivation**
- Cognitive:
- **2) Perceived exertion**
- **3) Knowledge of total distance to be covered**
- **4) Knowledge of distance covered/remaining**
- **5) Previous experience** (i.e., memory of perceived exertion at different exercise intensities and durations)

Motivational Intensity Theory



(Brehm, Wright, Gendolla)

Perceived exertion during an incremental exercise test



Potential Motivation and Endurance Performance

The dynamogenic factors in pacemaking and competition

- First study in social psychology was published by Norman Triplett in 1898 (Strube, 2005).
- Triplett noticed that cyclists tend to have faster times when riding in the presence of other cyclists than when riding alone.
- He then demonstrated this effect in a controlled, laboratory experiment with children performing a task on a rudimental ergometer. Children performed better in pairs than when performing by themselves.
- Triplett discussed several possible explanations for his findings and concluded that the "bodily presence of another contestant participating simultaneously in the race serves to liberate latent energy not ordinarily available" (social facilitation).

Wilmore JH. Influence of motivation on physical work capacity and performance. *Journal of Applied Physiology* 24: 459-463, 1968.

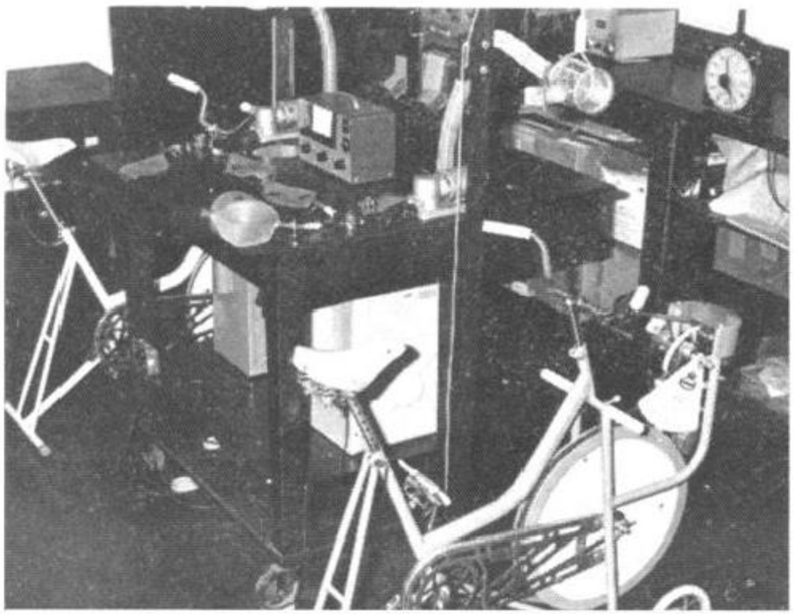
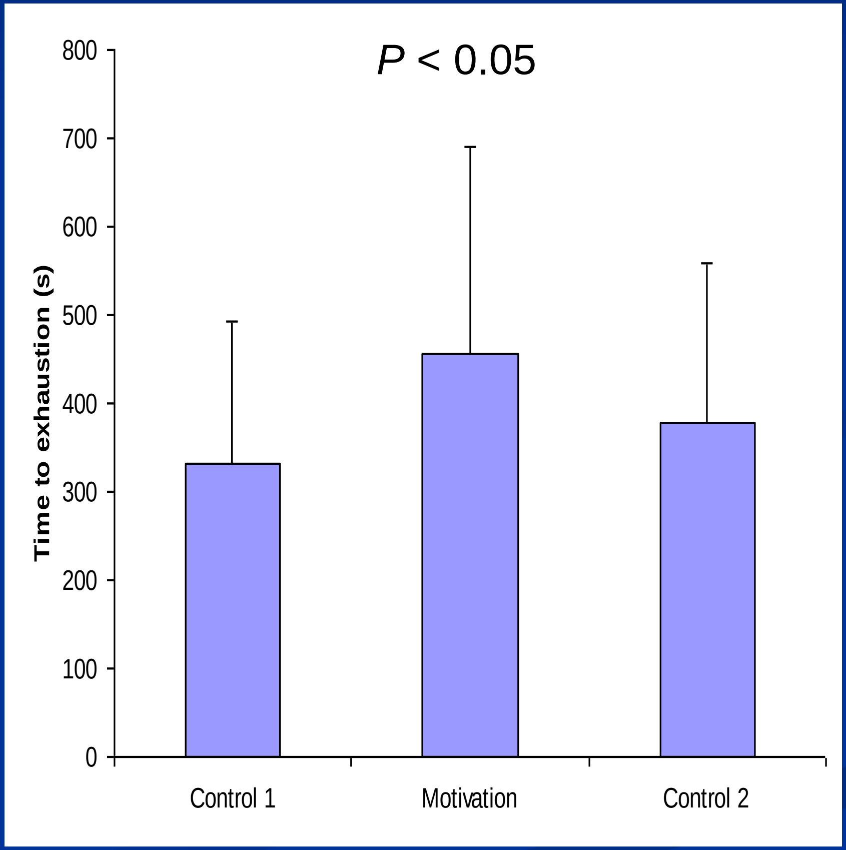


FIG. 1. Physical arrangement which permitted the simultaneous testing of endurance capacity of two paired subjects under condition E. It should be noted that the subjects were placed side by side, each having an independent but identical system for monitoring and collecting expired air and each having an unhindered view of the timer which indicated the duration of the test.

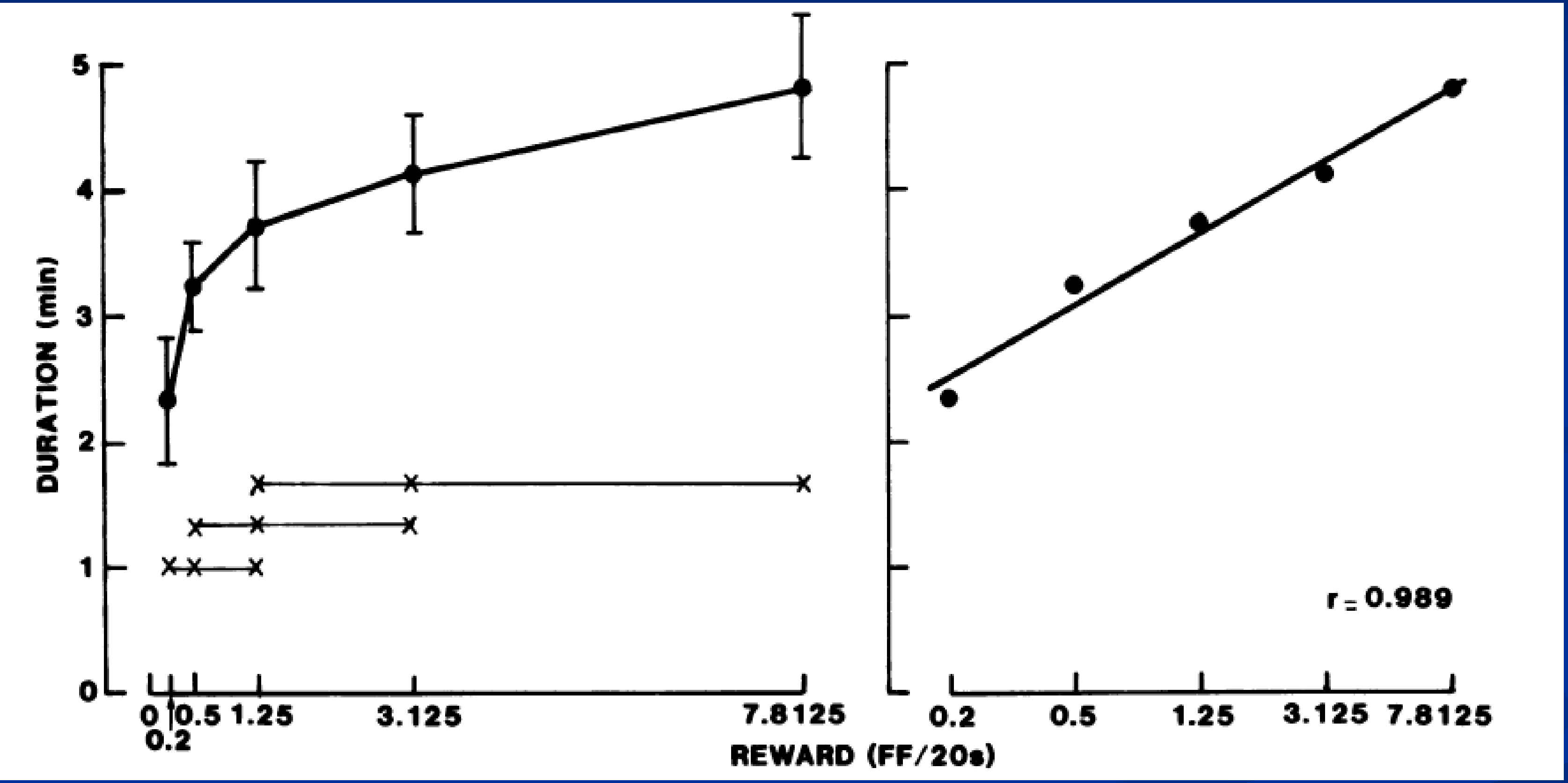


Social Facilitation

Monetary incentive and muscle endurance

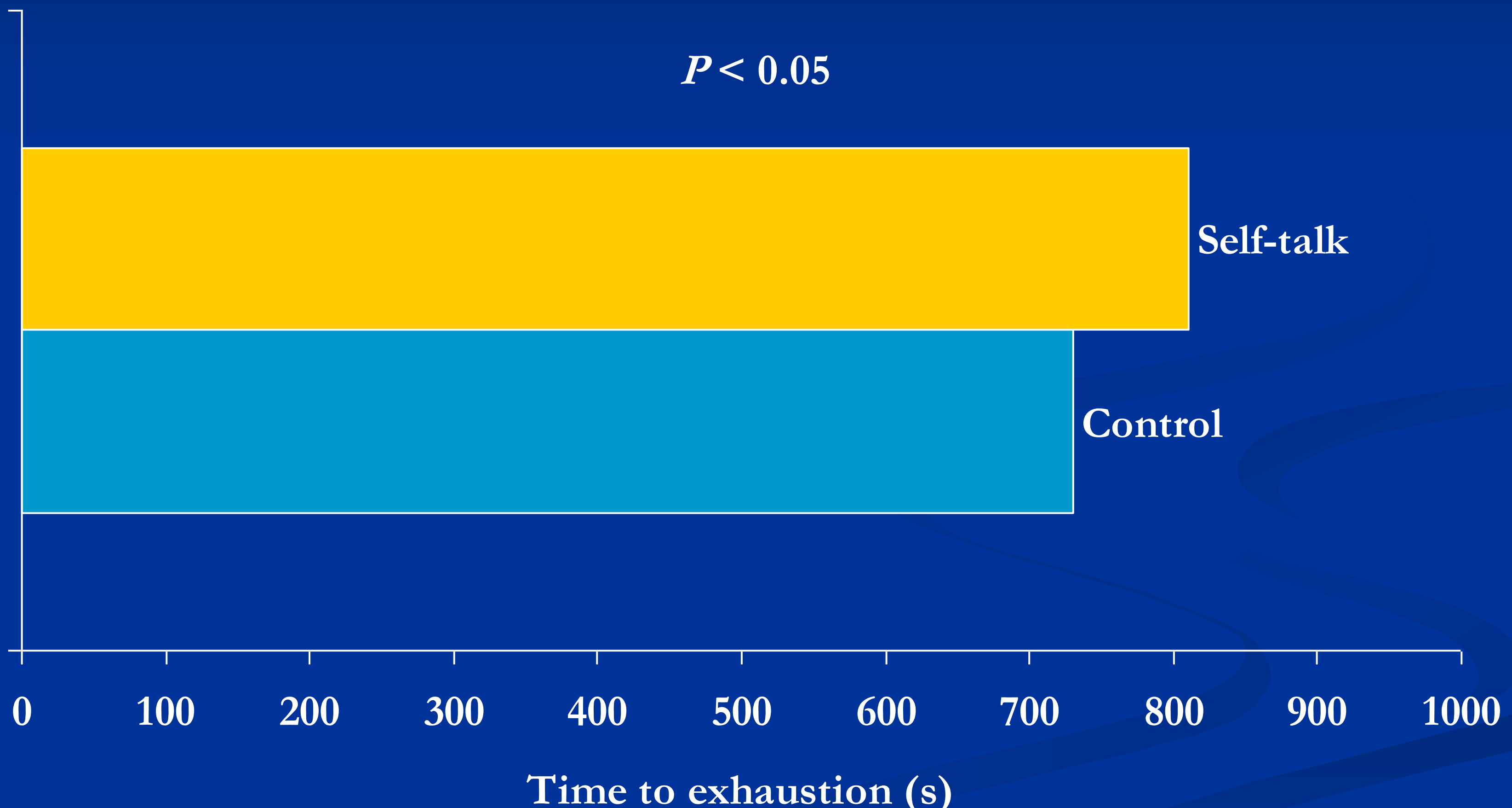
(Cabanac M. J Exp Anal Behav. 1986)

Monetary incentive and muscle endurance



(Cabanac M. J Exp Anal Behav. 1986)

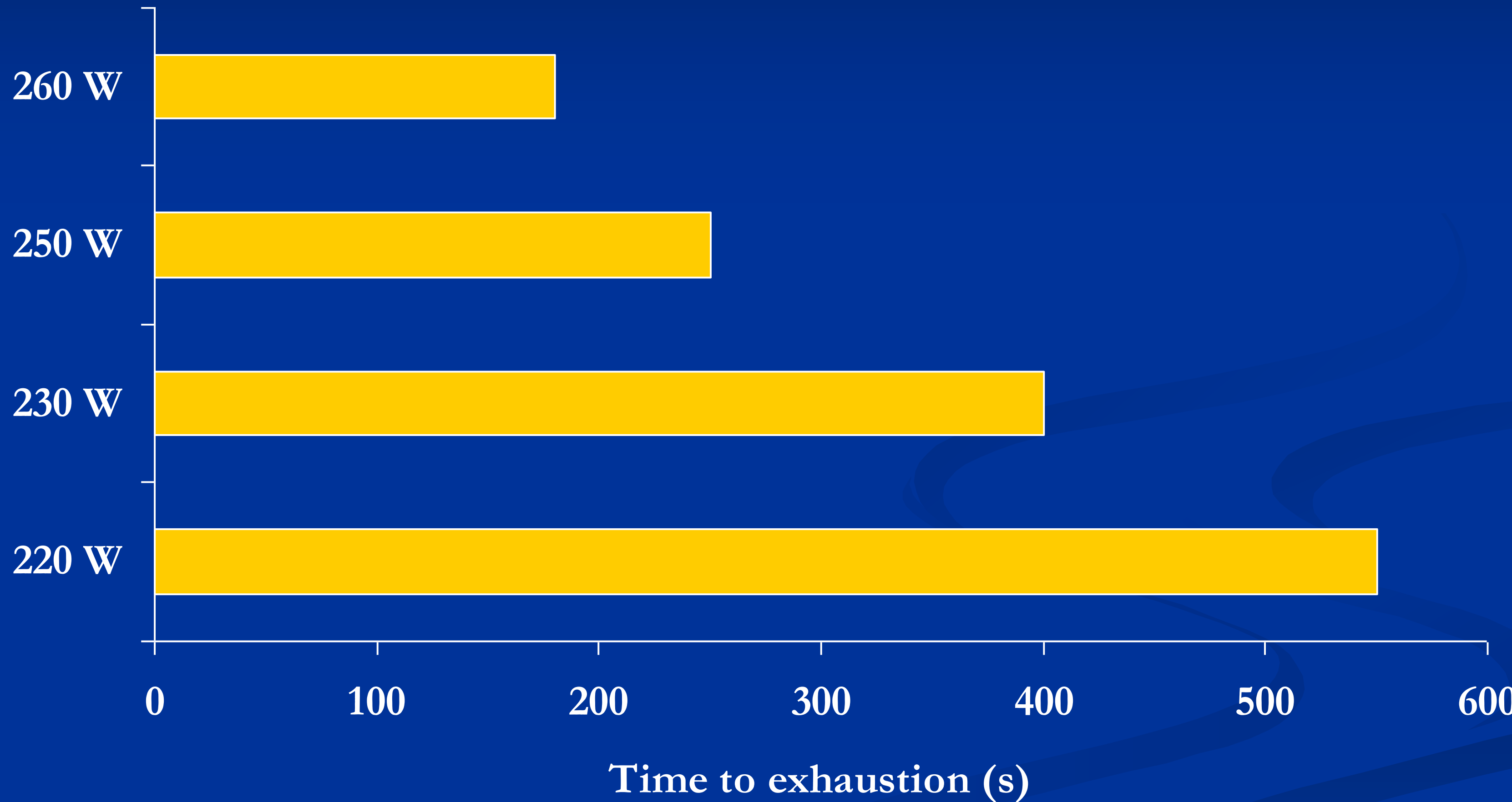
Effect of motivational self-talk on high intensity cycling performance



(Marcora et al., unpublished results)

Perceived Exertion and Endurance Performance

Power/duration relationship for cycling (same person, same motivation)



(adapted from Nakamura et al., 2005)

Perceived exertion as the key variable

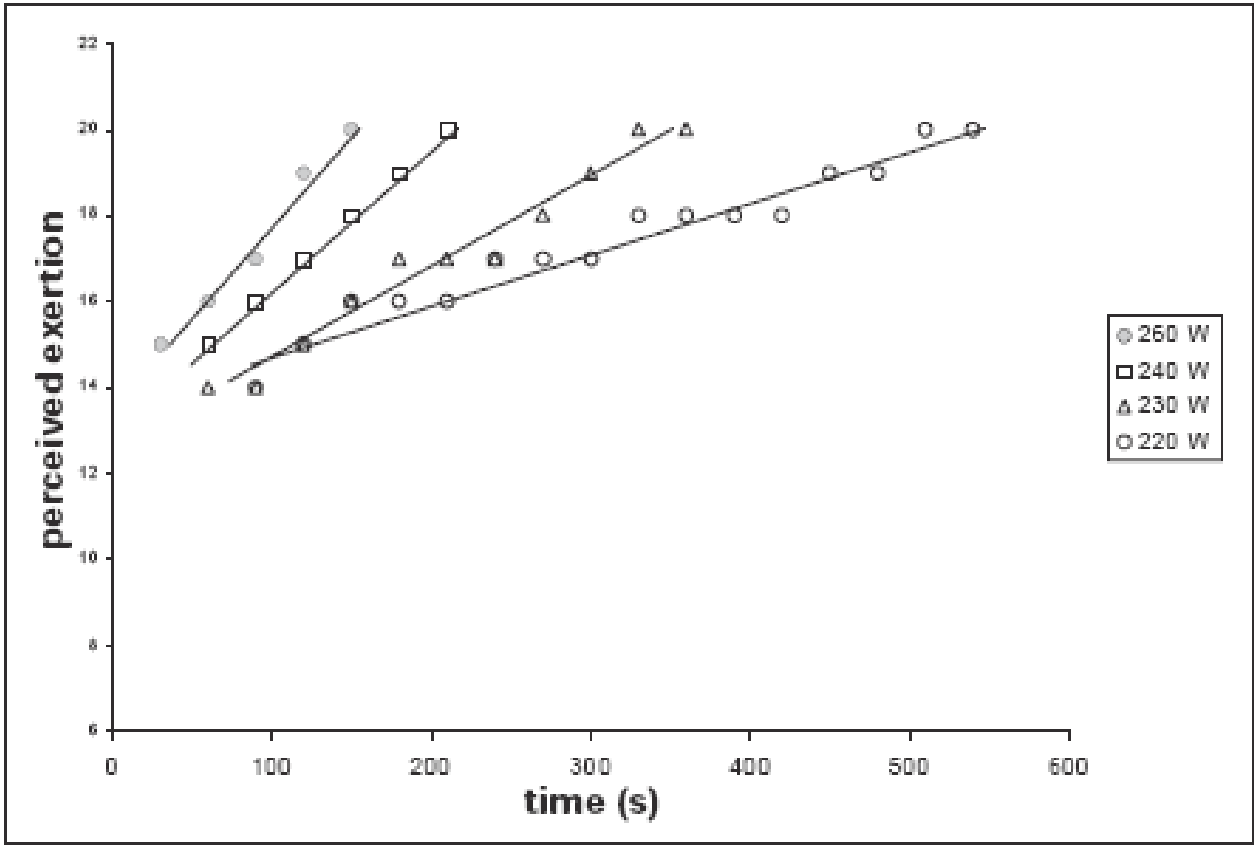
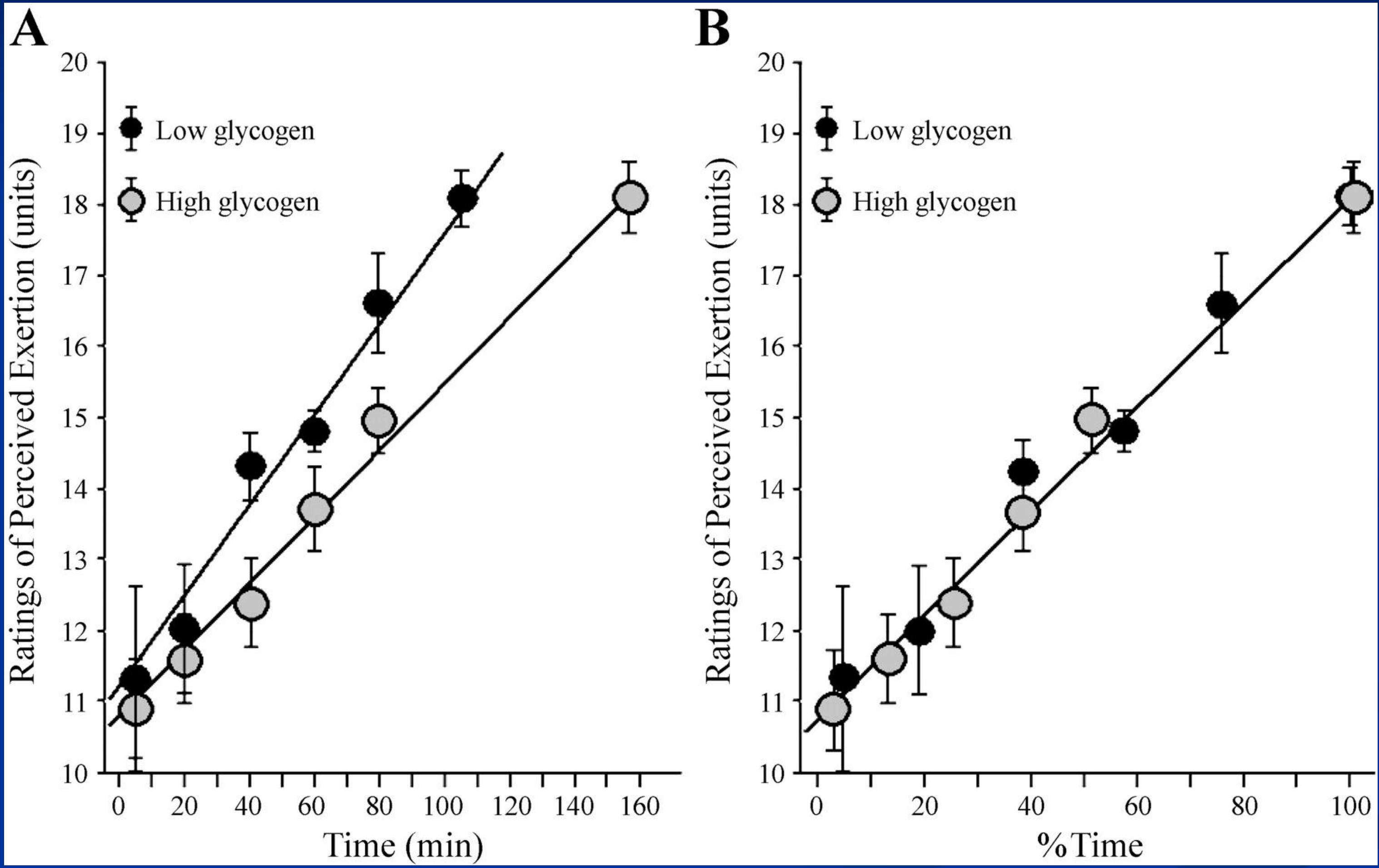


Fig. 2 – *Increase on the perceived exertion along time in exhaustive rect-angular tests of a representative subject*

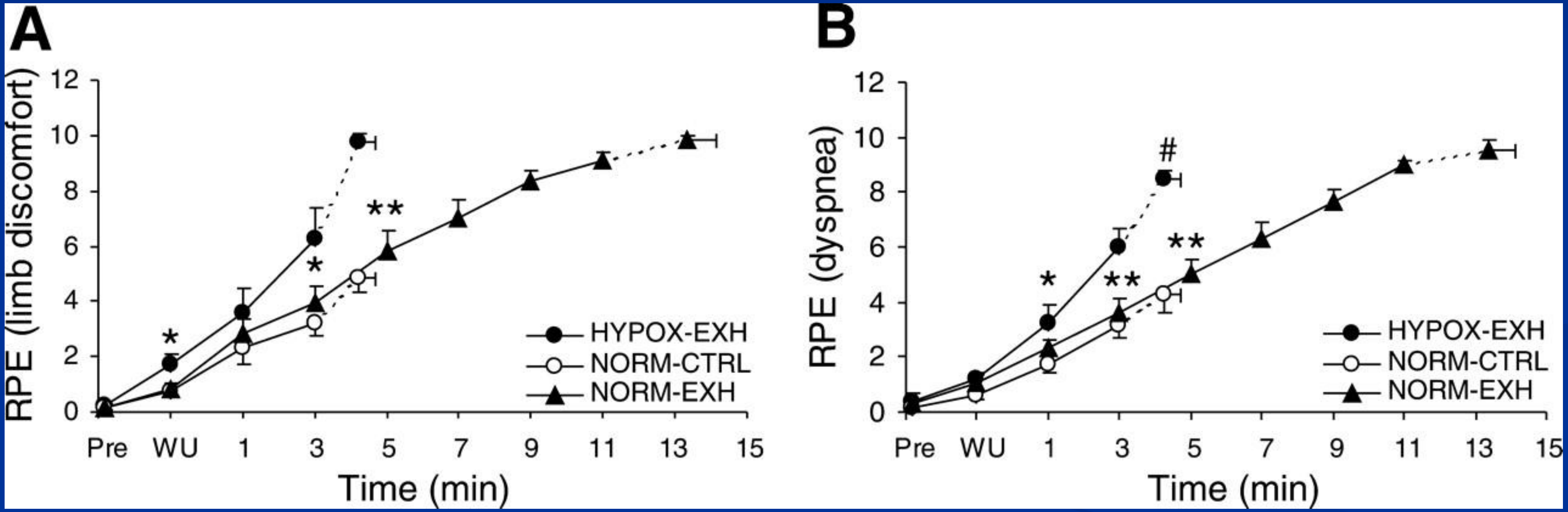
(Nakamura et al., 2005)

Experimental evidence: Glycogen study



Timothy D. Noakes (on Baldwin et al. data). *Journal of Applied Physiology*, 2004

Experimental evidence: Hypoxia study



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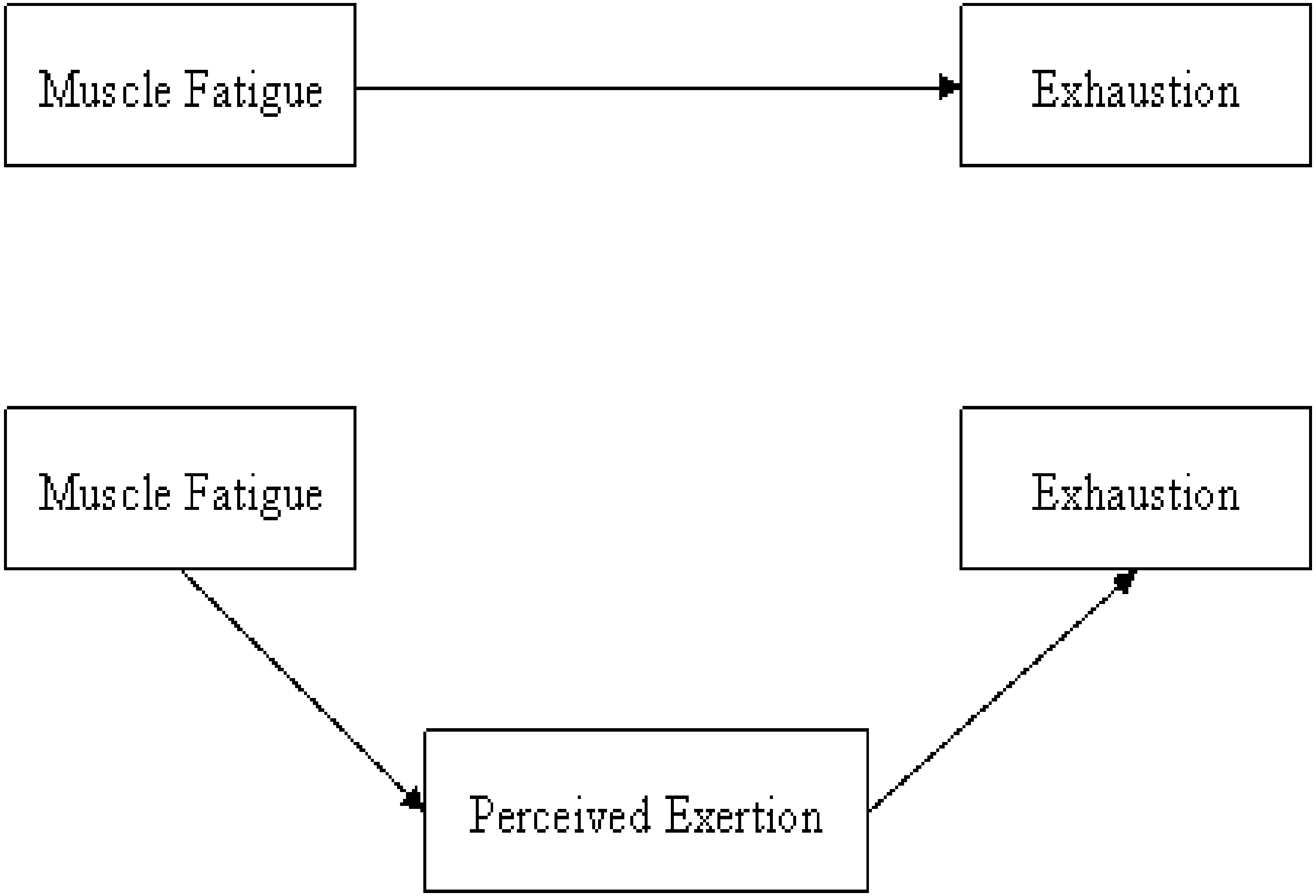
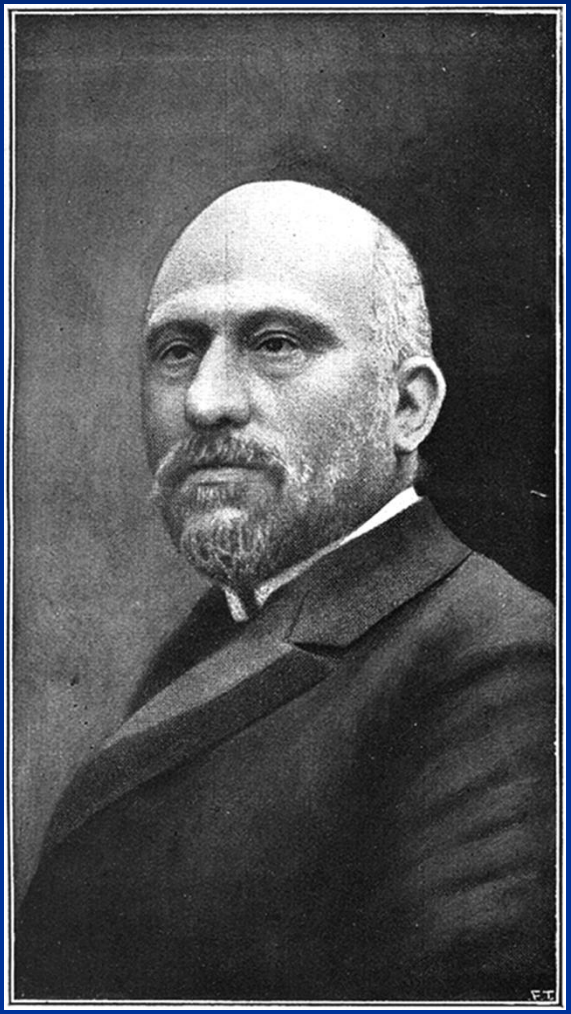
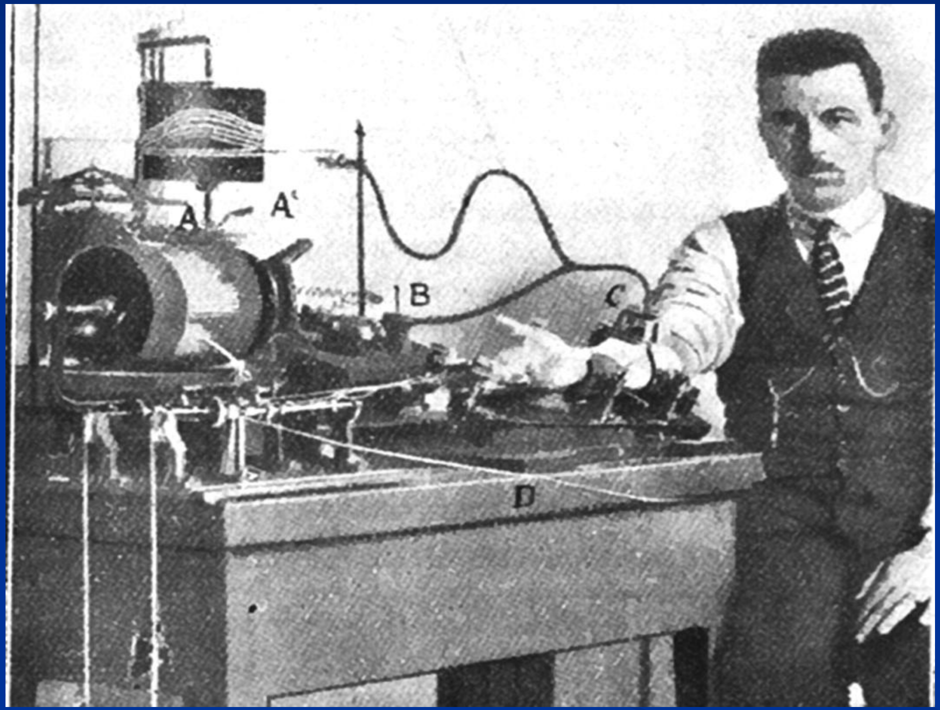

Muscle Fatigue
Exhaustion
Muscle Fatigue
Exhaustion
Perceived Exertion

Mental fatigue and physical performance

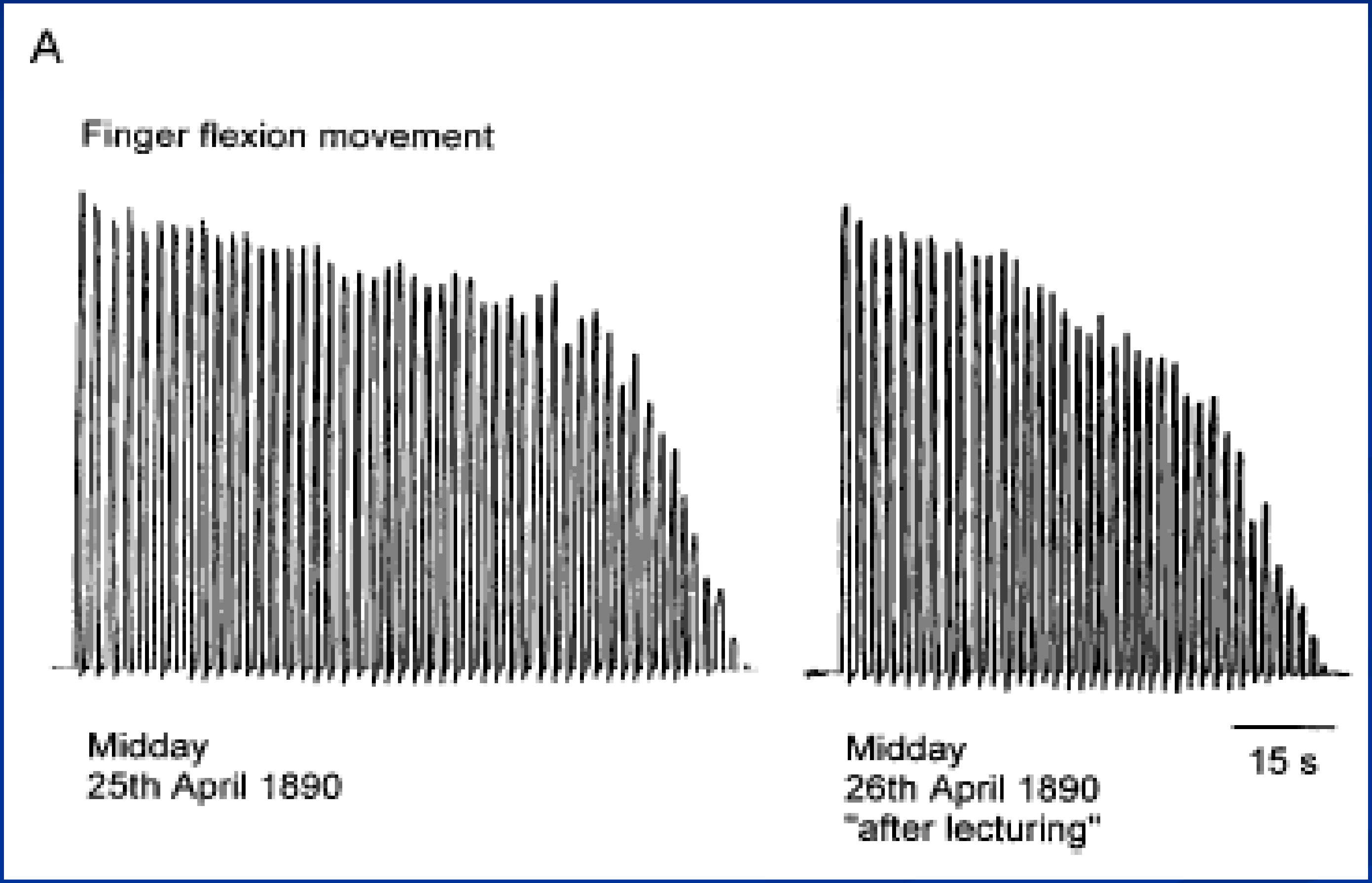




Italian physiologist Angelo Mosso

(1846–1910)

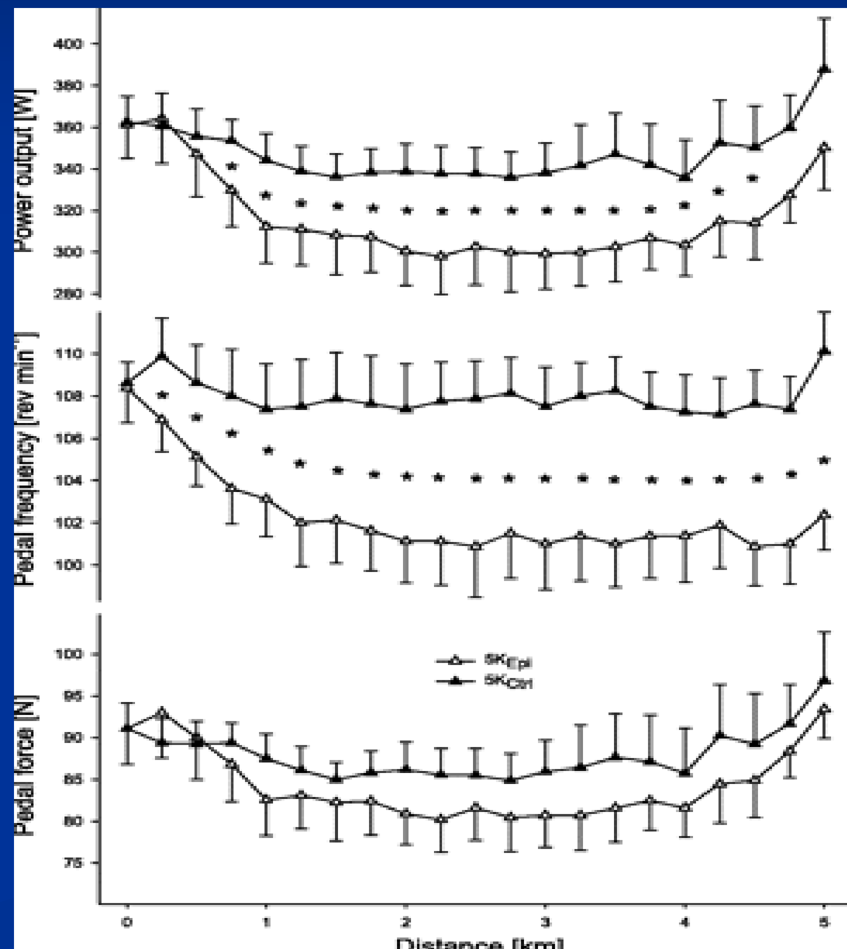
Mental fatigue and physical performance



In Gandevia (2001)

Current evidence on brain and endurance performance

- Correlative evidence (EMG) (Amann et al., 2008).
- Previous experimental studies using psychoactive drugs or dietary interventions (e.g. BCCA > tryptophan > serotonin) to manipulate brain neurotransmission showed effects mainly in rats, not humans. Also these effects are significant mainly at high ambient temperatures (Meeusen et al., 2006).



Summary and conclusions

- Mental fatigue impairs not only cognitive but also physical performance in humans
- These results provide experimental evidence that the brain can limit endurance exercise performance in temperate environment in humans
- This effect is mediated by perception of effort, not cardiorespiratory or musculo-energetic factors