

The Anaerobic Threshold: What it is and How to Estimate it

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THRESHOLD ESTIMATION

What to do – and why!

What not to do – and why!

Whipp BJ. Unpublished
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THE “ANAEROBIC” THRESHOLD

(lactate; lactic acidosis; ventilatory;
gas exchange; ...)

IS IT “ANAEROBIC”?:

- a. Yes: O_2 not used in the lactate formation**
- b. No: Phosphocreatine decreases at all work rates**
- c. Maybe: Are there regions in the contracting muscles where the PO_2 is “critically” low?**

no definitive resolution at present

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Lactate Threshold

Functionally Important

- Upper limit of “moderate” intensity
- Relevant to endurance capacity
- Averages 50-60% of $\dot{V}O_2$ max

AKA, in CPET:

- Anaerobic threshold*
- Lactic acidosis threshold
- Gas exchange threshold
- Ventilatory threshold
- etc.

Affected by:

- Cardiovascular health / disease
- Skeletal muscle metabolism and training/detraining state

Applications:

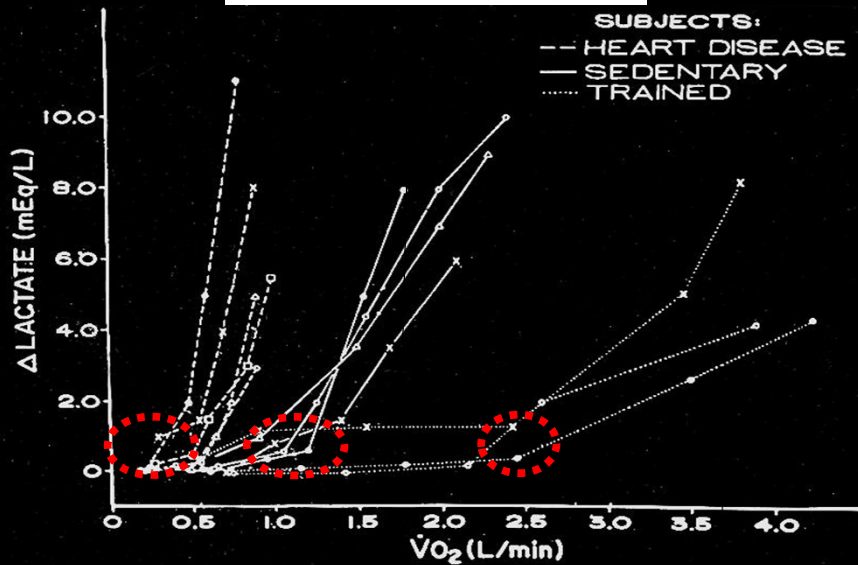
- Assessing the normalcy of an individual’s integrative systemic function
- Optimize training intensity for prehab, rehab and sports performance
- Clinical risk assessments:
 - Prior to major thoracic or abdominal surgery
 - Survival in cardiovascular diseases

* Wasserman & McIlroy, Detecting the threshold of anaerobic metabolism in cardiac patients during exercise; 1964, Am J Cardiol. 14:844-52

Courtesy of Dr. K.E. Sietsema (with modification)

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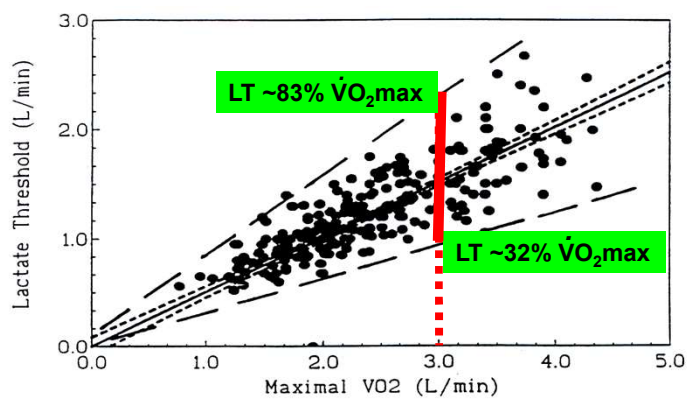
Lactate Threshold



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Modified from Wasserman K, Whipp BJ. Am. Rev. Respir. Dis. 112:219-249, 1975.

The Lactate Threshold averages ~50% of $\dot{V}O_{2max}$



Whipp BJ. Physiological benefits and detriments of high altitude training: In: *The Altitude Factor in Athletic Performance*. Proc. British Olympic Association Symposium, Lilleshall, December 1993, pp. 142-150.

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The Metabolic Acidosis of Exercise

Contributors to H⁺ buffering

$$\text{pH} = \text{pK}_1 + \log \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} = \text{pK}_2 + \log \frac{[\text{NaPO}_4^-]}{[\text{H}_2\text{PO}_4^-]} = \text{pK}_3 + \log \frac{[\text{Pr}^-]}{[\text{HPr}]} = \text{pK}_4 + \log \frac{[\text{org}^-]}{[\text{H org}]}$$

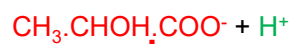
Yielding CO₂

Modified from Handbook for Fellows.
Div. Resp. Med., Harbor General Hospital. 1967

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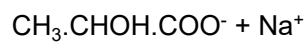
Anaerobic Metabolism: Buffering of Lactic Acid

Lactic Acid + Sodium Bicarbonate

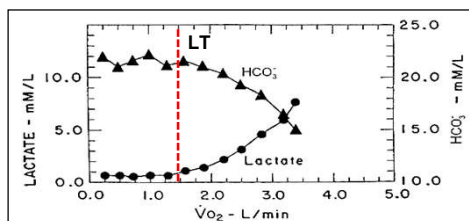


Sodium Lactate

Carbonic Acid



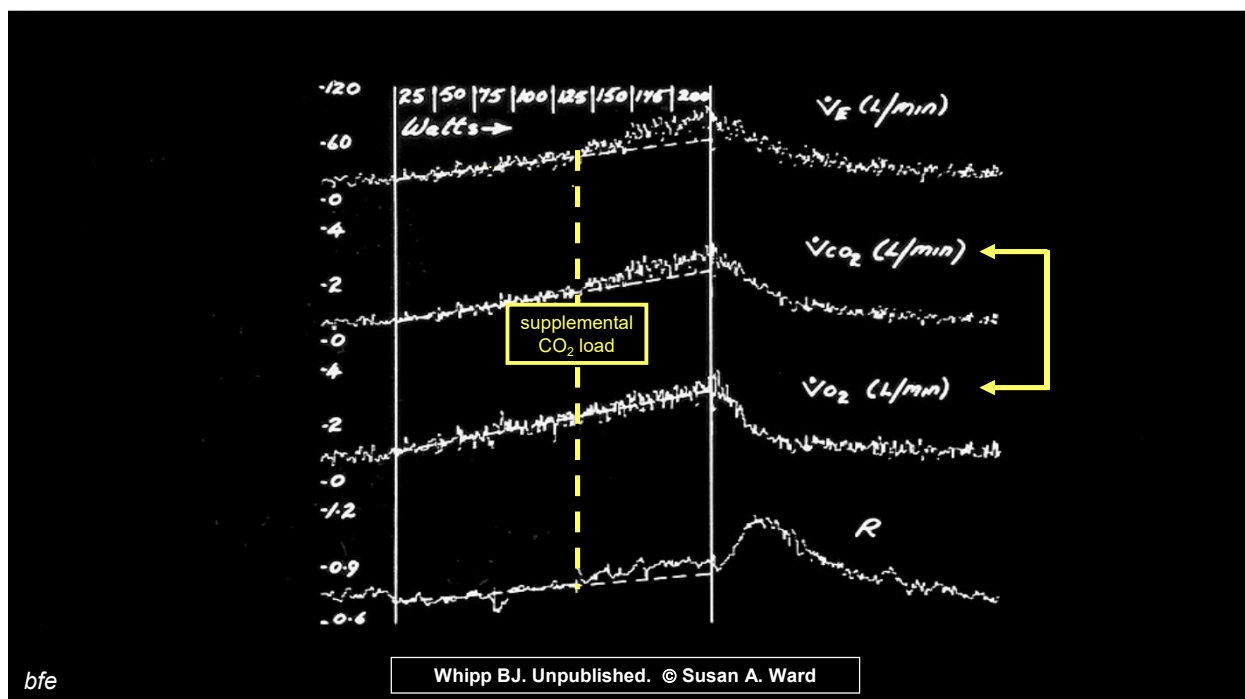
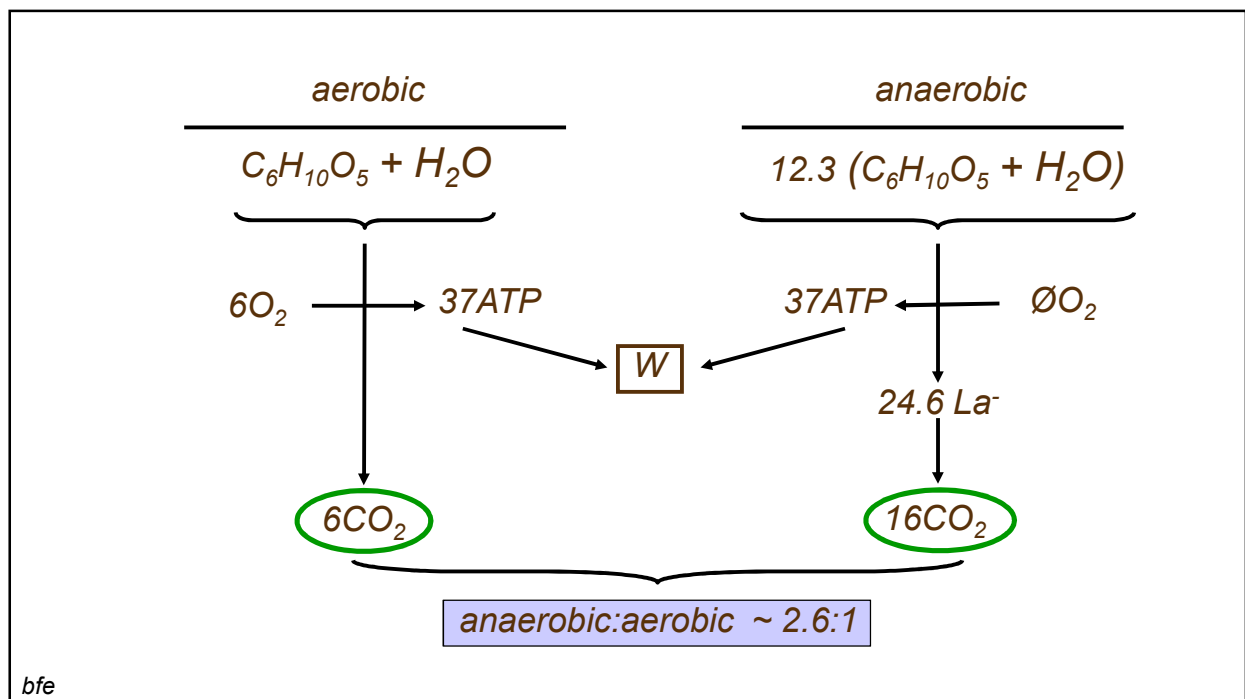
supplemental to
aerobically-produced CO₂ -
therefore increasing $\dot{V}\text{CO}_2$

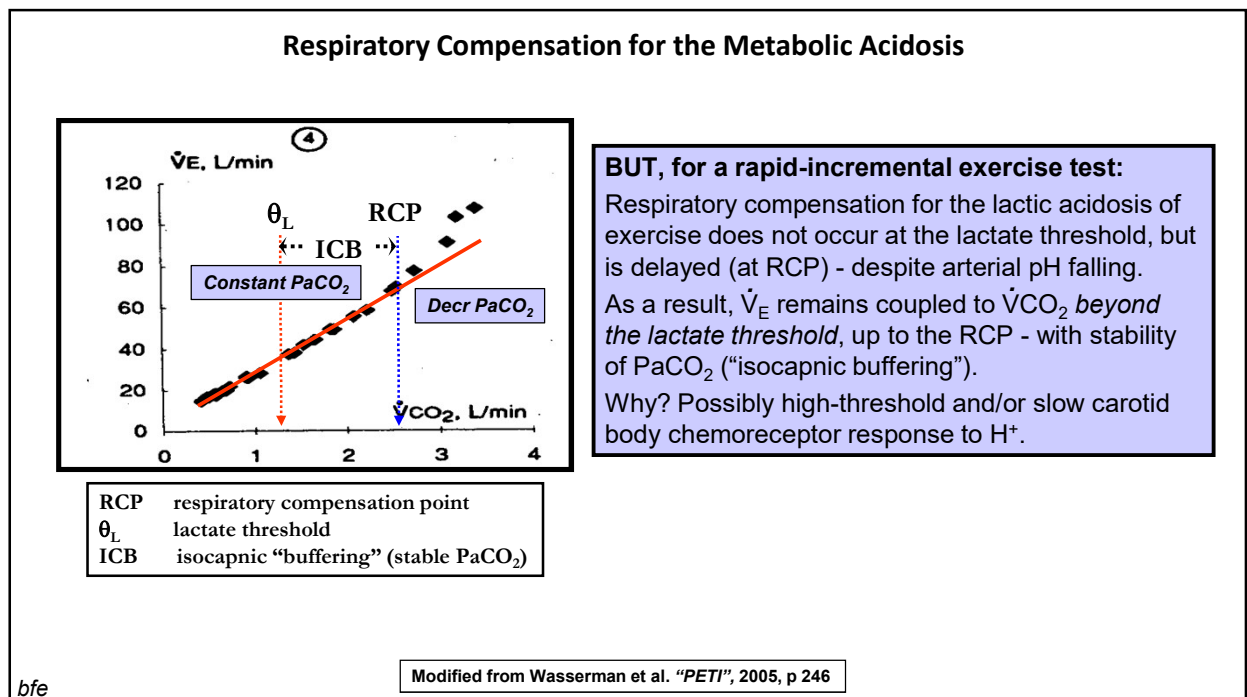
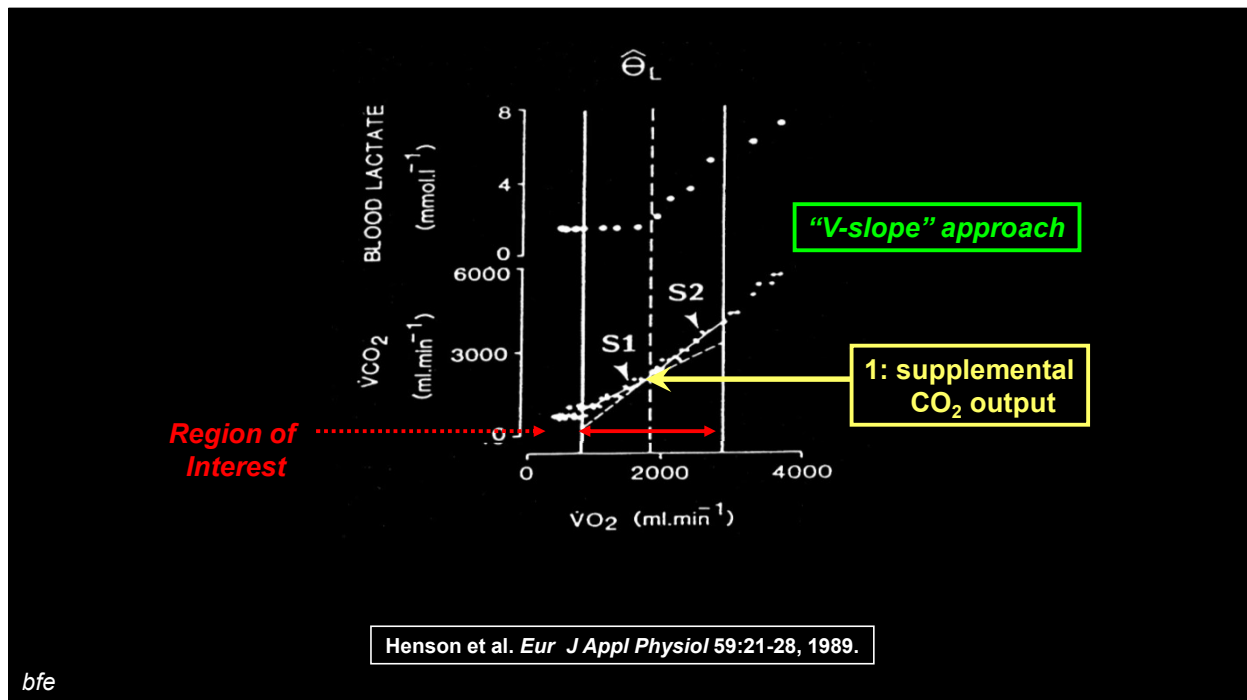


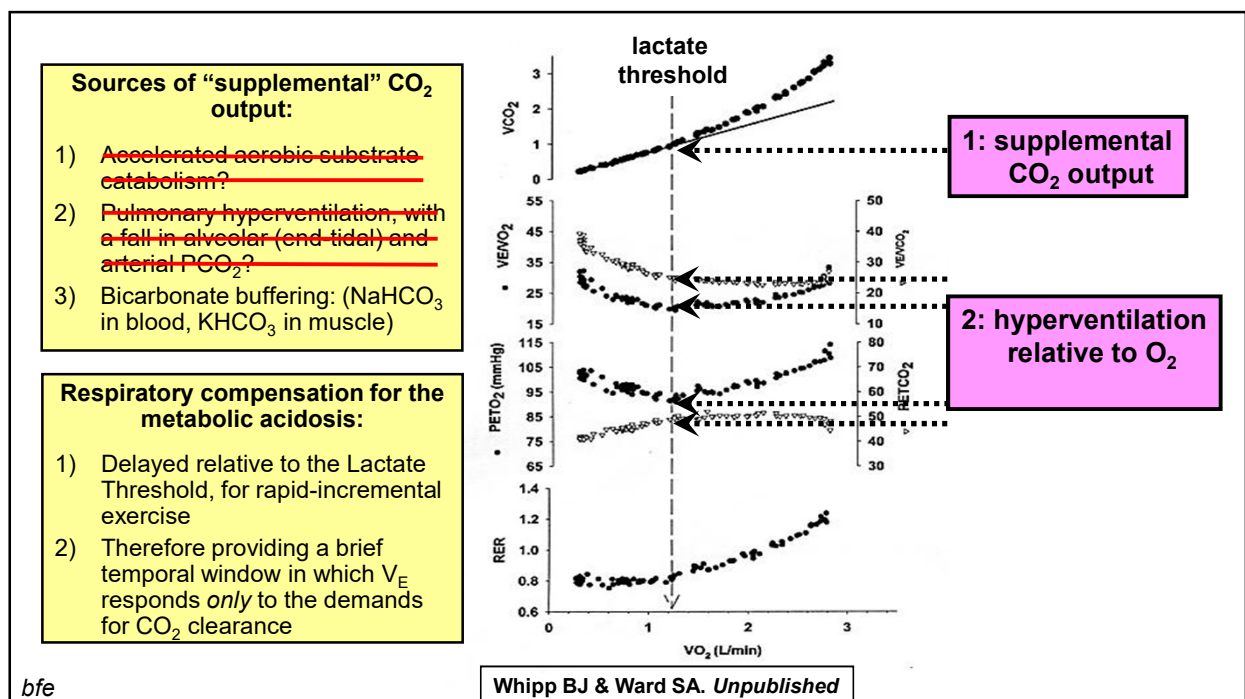
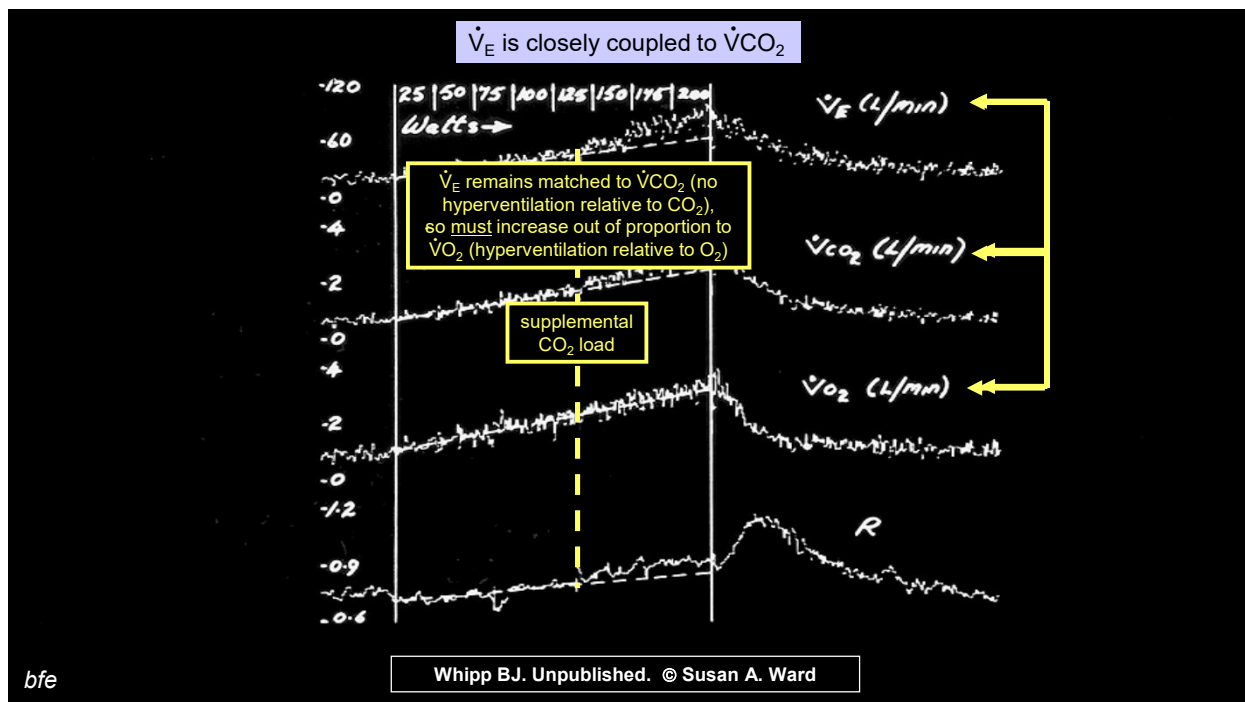
Wasserman et al. *J Appl Physiol* 59:935-940, 1985

Whipp BJ. Unpublished.

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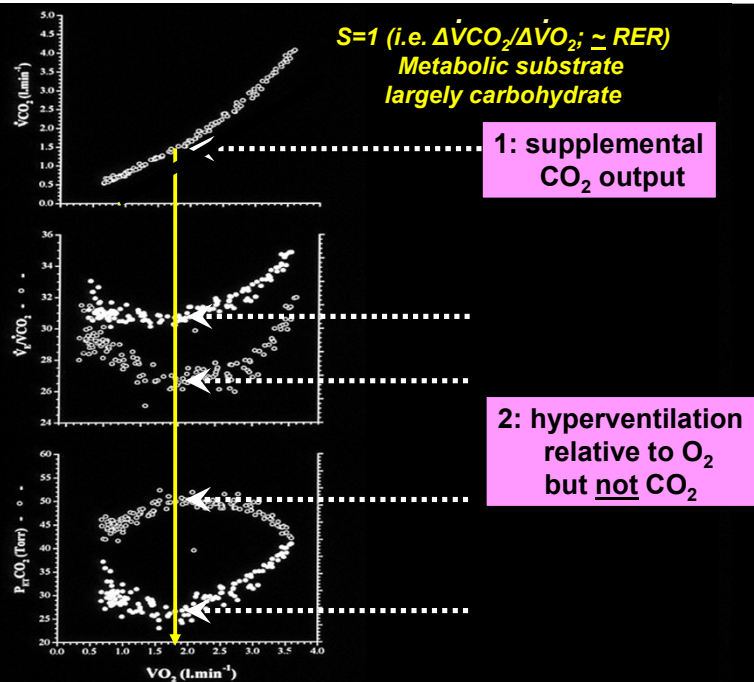




"Modified V-slope" approach

Sue et al. *Chest* 94:931-938, 1988

Useful when:
V-slope relationship has
no clear break-point;
and/or
ventilation is constrained
from increasing further
(e.g. COPD)



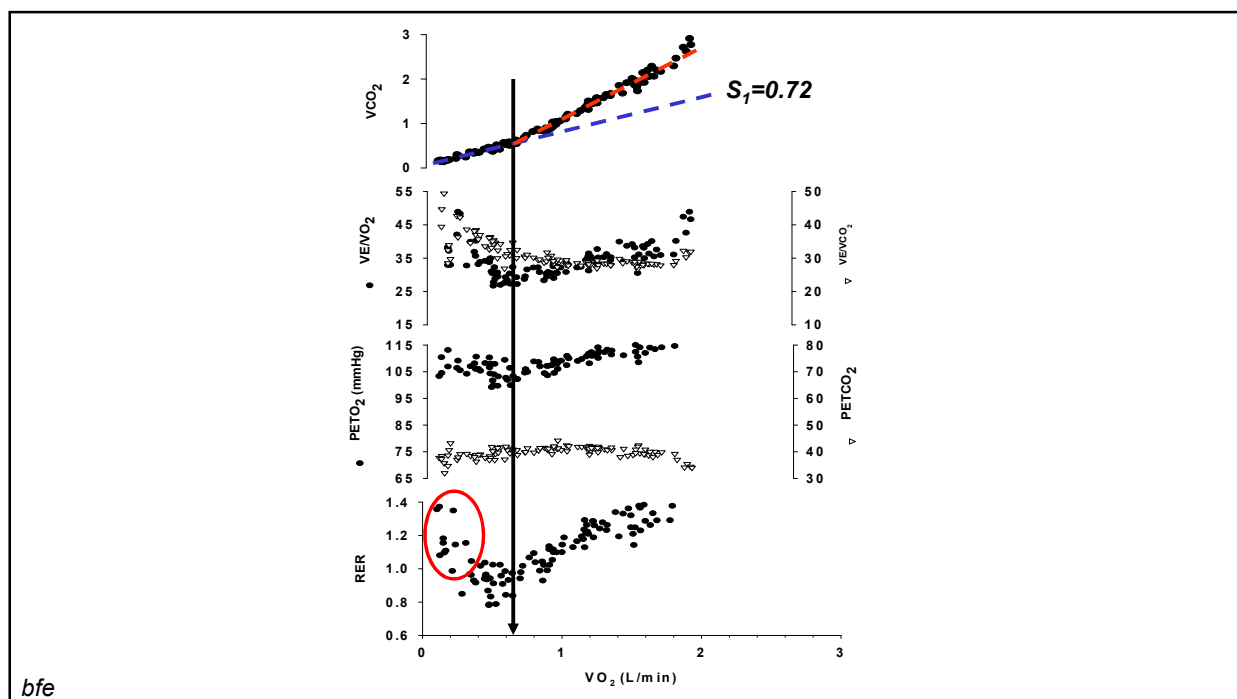
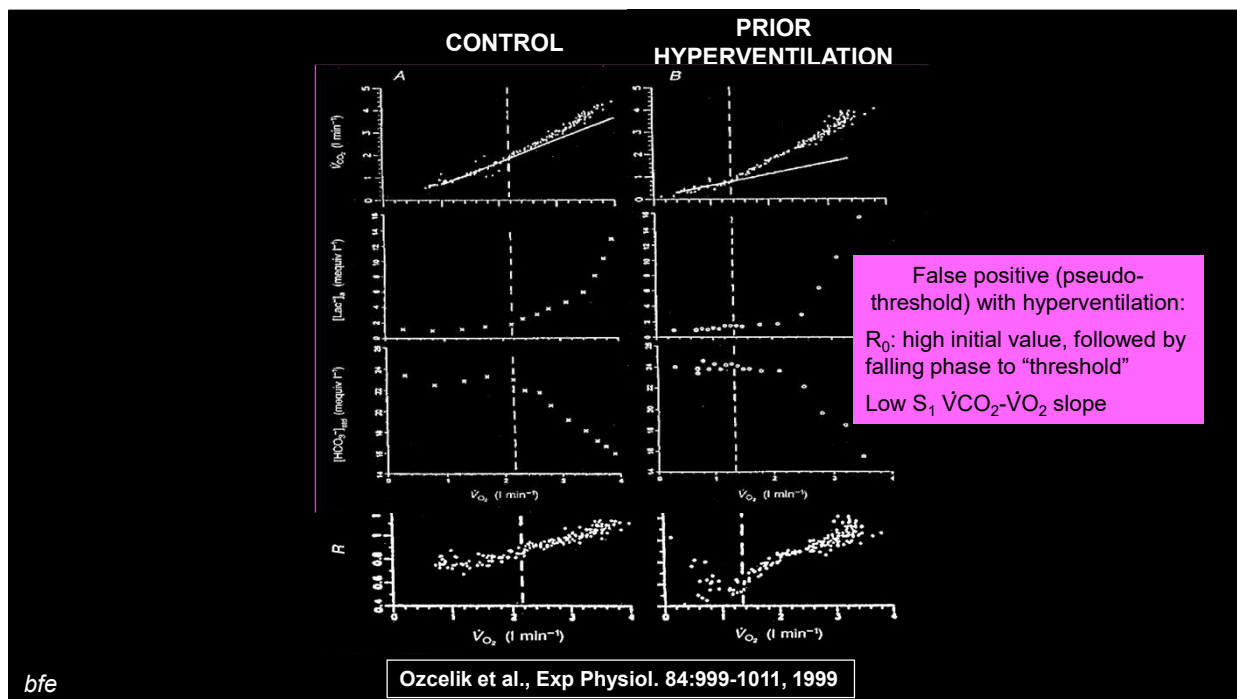
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Some "Be Carefuls"!

*$\dot{V}CO_2$ can begin to increase faster than $\dot{V}O_2$:
not just because it begins to be "produced" faster,
but also because its rate of "storage" begins to slow
or stop!!*

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$$R_0 / S_1$$

If $R_0 / S_1 \ll 1.0$, then likely a θ_L

However,

If $R_0 / S_1 \gg 1.0$, then likely a 'pseudo' θ_L

R_0 : initial respiratory exchange ratio
 S_1 : S_1 slope

Ozcelik et al., Exp Physiol. 84:999-1011, 1999

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TONACDONOHO

Threshold
Of

Non

Aerobic

Carbon

Dioxide

Output

Not

Of

Hyperventilatory
Origin

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