Topic 3: Determination of the Lactate and Ventilatory Thresholds

Review of Physiology, Methods of Detection, and Application

Laboratory Manual Section 03

HPHE 6720
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Goals for this Topic

- Understand the physiological origins of lactic acid/lactate
- Understand the concepts of the lactate threshold and ventilatory threshold
- Become familiar with the protocols, equipment, testing procedures to measure LT/VT
- Become familiar with the analysis methods to determine the LT/VT
- Understand the relationship between performance and the LT/VT
Physiology of Lactate Production

One cause of lactate threshold: Fate of pyruvate is lactate when mitochondrial hydrogen shuttle cannot keep pace with accelerated rate of glycolysis (increased rate of glycolytic production of NADH+ H+).
Lactate During Exercise

Figure 5.1 Representation of the pattern of blood lactate accumulation in relation to power output during (a) incremental exercise and (b) constant intensity steady-state exercise. During incremental exercise, blood lactate remains unchanged through a wide range of exercise intensities (A) and then above a certain power output (B) lactate rises sharply. During constant intensity exercise, lactate increases with time up to a constant rate (C), which is K in this example.

Lactate During Exercise

Figure 5.2 Comparison of blood and muscle lactate from literature studies.
**Definition of Lactate Threshold**

- Lactate threshold is defined as the workload, or exercise intensity, at which lactate begins to accumulate in the blood.

**Physiological Basis of LT**

The physiological basis of lactate threshold includes:
- Low muscle oxygen
- Accelerated glycolysis
- Recruitment of fast-twitch fibers
- Reduced rate of lactate removal

Potential causes of lactate threshold
**Methods of Detection of LT**

- **Two-Line Regression Model**

- **Fixed Blood Lactate Concentrations**
  - 2.0, 4.0 mmol/L

- **Individual Anaerobic Threshold (IAT)**

\[ y = 1.5671 + 0.22837x \quad R^2 = 0.44104 \]
\[ y = -12.873 + 7.5232x \quad R^2 = 0.94208 \]
Methods of Detection of LT

Fixed Blood Lactate Concentrations

The point during incremental exercise at which ventilation increases out of proportion to the increase in oxygen uptake.
VT - Physiological Basis

- The increase in H+ from lactic acid dissociation is buffered by bicarb system
- The end result is an increase in CO₂
- Ventilation increases in order to rid body of excess CO₂

\[ H^+ + HCO_3^- \leftrightarrow H_2CO_3 \leftrightarrow H_2O + CO_2 \]

VT - Determination

- Protocol Considerations
  - Similar protocols to LT test
  - However, shorter continuous test can be used because of rapid alterations in ventilation
- Three Main Methods
  - Ventilation curve
  - V-slope method
  - Ventilatory equivalents method
VT - Determination

• Ventilation Curve
  – Plot $V_T$ vs. $VO_2$ or Watts or Time
  – The point at which there is a non-linear increase in ventilation

• V-Slope Method
  – Plot $VO_2$ vs. $VCO_2$
  – The point at which the increase in $VCO_2$ is greater than the increase in $VO_2$

• Ventilatory Equivalents Method
  – Plot $V_T/VO_2$ and $V_T/VCO_2$ vs. Watts or time or $VO_2$
  – Point at which $V_T/VO_2$ increases while $V_T/VCO_2$ decreases or stays the same.

VT Determination - VE Curve

[Diagram showing ventilation and lactate thresholds with various points labeled.]
VT - Determination

• Ventilation Curve
  – Plot $V_e$ vs. $VO_2$ or Watts or Time
  – The point at which there is a non-linear increase in ventilation

• V-Slope Method
  – Plot $VO_2$ vs. $VCO_2$
  – The point at which the increase in $VCO_2$ is greater than the increase in $VO_2$

• Ventilatory Equivalents Method
  – Plot $V_e/VO_2$ and $V_e/VCO_2$ vs. Watts or time or $VO_2$
  – Point at which $V_e/VO_2$ increases while $V_e/VCO_2$ decreases or stays the same.

VT Determination - V Slope Method

VT Breakpoint
**VT - Determination**

- **Ventilation Curve**
  - Plot $V_e$ vs. $VO_2$ or Watts or Time
  - The point at which there is a non-linear increase in ventilation

- **V-Slope Method**
  - Plot $VO_2$ vs. $VCO_2$
  - The point at which the increase in $VCO_2$ in greater than the increase in $VO_2$

- **Ventilatory Equivalents Method**
  - Plot $V_e/VO_2$ and $V_e/VCO_2$ vs. Watts or time or $VO_2$
  - Point at which $V_e/VO_2$ increases while $V_e/VCO_2$ decreases or stays the same.

**VT - Ventilatory Equivalents Plot**

VT Breakpoint
How is LT/VT Expressed?

- VO₂ at LT/VT
- Percentage of VO₂max at LT/VT
- Workload/Exercise intensity at LT/VT

LT/VT and Performance

- Farrell et al. (1979)
  - LT was significantly correlated with performance time during long distance running (3.2km to marathon)
    - \( r > 0.91 \) (VO₂max \( r > 0.83 \))

- Kumagai et al. (1982)
  - Correlated performance time in 5km, 10km, and 10 mile runs with LT
    - LT: \( 5km \ r = 0.945 \) \( 10km \ r = 0.839 \) \( 10m \ r = 0.835 \)
    - VO₂max: \( 5km \ r = 0.645 \) \( 10km \ r = 0.674 \) \( 10m \ r = 0.574 \)

- Powers et al. (1983)
  - Correlated VO₂max, running economy and VT to performance time in 10km road race
    - VT: \( r = 0.94 \) \( \text{RE: } r = 0.51 \) \( \text{VO₂max: } r = 0.38 \)
Mechanism for LT/VT Affecting Performance

- Lactic acid accumulation contributes to muscular fatigue
  - $H^+$ ion interferes with $Ca^{2+}$ binding to troponin-C
  - Lactate ion may also interfere with this binding
  - Alteration in fiber type utilization
  - Alterations in substrate utilization

Class Project

- We will perform one maximal graded exercise test on a cycle ergometer to determine the LT/VT.
- Student will use a variety of analysis techniques to identify the LT/VT.