KINS-153 Cardiovascular Testing and Exercise Prescription

The Lactate and Ventilatory Thresholds

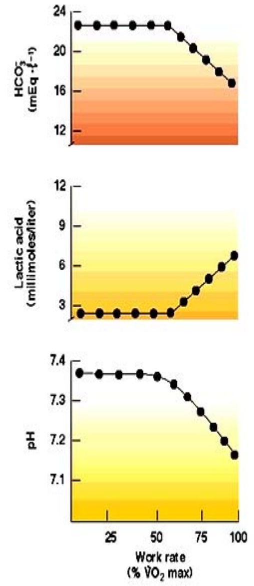
Introduction

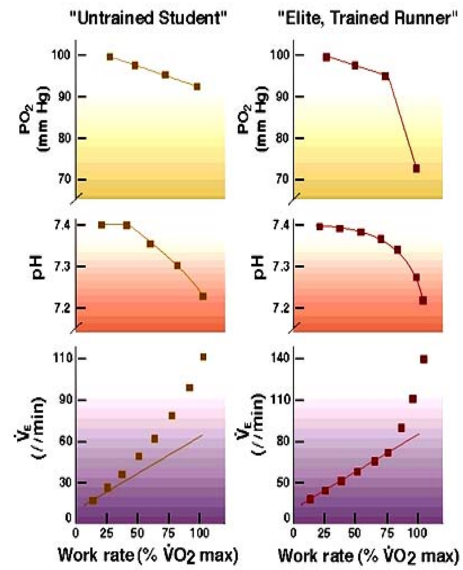
The lactate threshold represents the maximal steady state exercise intensity that can be maintained without an increase in lactate concentration in the blood. The lactate threshold is a useful marker of exercise performance for elite/competitive athletes and serves to help guide training intensity. Clinically, the measurement of the lactate threshold aids in the assessment of cardiovascular fitness. Lactate threshold represents an exercise intensity of approximately 60-85% VO2 max. It is an exercise intensity that can be maintained approximately for a marathon (running) or a century (cycling).

Lactate threshold (LT_1) represents the initial net increase in blood lactate and is determined by several factors. An increase in blood lactate is related to net release of lactate into the blood stream. It depends on the rate of release of lactate by the active muscle and uptake by the tissues (liver, type I fibers, heart). The rate of release of lactate is believed to be correlated with the recruited of type II fibers during exercise. The increase in lactate also coincides with increases in hormones mostly epinephrine and norepinephrine. At intensities above lactate threshold the ability to continue endurance exercise is severely diminished. Eventually, if exercise intensities are increased above the lactate threshold, there is a second break in the lactate curve and this second lactate threshold represents exponential rise in lactate in regards to VO2 (LT_2). At intensities above these lactate thresholds, the increasing energy demands and stimulation of glycolytic enzymes results in an increased glycolytic flux, rapid reduction in muscle glycogen stores, and elevation of blood lactate and acidity, and eventually fatigue!

The determination of lactate threshold requires arterial or venous blood sampling every few minutes and limits it usefulness except when testing a competitive athlete. A more practical noninvasive technique to measure the lactate threshold is the analysis of ventilation parameters during an incremental VO2 max exercise test. The noninvasive determination of lactate threshold by ventilation response to exercise is termed the ventilation threshold ($V_{Threshold}$). The $V_{Threshold1}$ is determined by the disproportionate increase in VE in relation to VO2 consumption. At low exercise intensities VE increase linearly with VO2 and the resultant ventilatory equivalent of oxygen (VE/VO2) stays constant. However, at moderate to high intensities the increase in VE is more abrupt than the increase in VO2 and VE/VO2 increases. The increase in VE in proportion to VCO2 is delayed due to the non-metabolic production of CO2 caused by the buffering of acidity by blood HCO3. However, after blood HCO3 is exhausted there is a second abrupt rise in VE/VCO2 termed $V_{Threshold2}$ or RCP. The difference between the increase in the VE/VO2 and the VE/VCO2 is often termed isocapnic buffering due to the increase buffering of H+ by HCO3 and the resultant liberation of CO2. The initial increase in VE/VO2 is the $V_{Threshold}$. The diagram below relates the increase in VE, HCO3, lactate, and H+. Beware that there is about an 8% variation between the lactate and $V_{Threshold}$ thresholds (Gladden, 1985).

Physiological Response to Increasing Exercise Intensities





Description of the Five Training Zones to Improve Endurance Performance

Scientific Term	**Recovery**	**Aerobic**	**Lactate Threshold**	**Maximal Lactate Steady State & VO2max**	**Anaerobic**
Coaching Term	***"Easy"***	***"Aerobic Base"***	***"Tempo"***	***"High Intensity"***	***"Sprint"***
Performance Variable	**Recovery**	**Endurance**	**Speed Endurance**	**Sustainable Speed**	**Explosive Speed & Acceleration**

The purpose of the laboratory will be to determine the onset of lactate accumulation by directly by the measurement of blood lactate and indirectly by the $V_{Threshold}$ technique. The identification of these threshold will be used to set up training zones for an exercise prescription.

Procedures (Follow ACSM exercise test requirements then these additional procedures)

1) Prepare three subjects for a cycle ergometry VO2 max test.
2) Calibrate the metabolic cart and prepare cycle ergometers
3) Determine the predictive VO2 max workload for your subject. Then divide the workload by 4 to determine the appropriate 3-minute workload increments.
4) Prepare an area for blood collection. Sterile area with gloves, clean lancets, alcohol swabs capillary tubes and cotton gauge.
5) Prepare an area for the mixing of blood with ice-cold reagent and/or instrumentation for blood lactate analysis.
6) Practice drawing water in capillary tubes with no air bubbles.
7) Practice pipetting a sample from a capillary tube.
8) Adjust the seat height of the bike for the subject so the leg has a slight bend at the 6 o'clock pedal position
9) Prepare the two-way valve, headgear and gas tubing for the subject. Adjust so the headgear/breathing valve/tubing apparatus is comfortable for the subject
10) Once ready begin exercise with a 3 minute-rest period followed by the exercise protocol.
11) At 1:30 min of each stage clean fingertip with alcohol and prick subject with lancet at 2:30. Quickly as possible wipe first drop away with cotton gauge and take sample with lactate strip.
12) Every three minutes record BP/ECG Workload
13) At end of test collect an immediate post-exercise sample

Data Analysis

1) Determine whether this was a VO2 max test: RER > 1.15, VO2 < 0.15L min increase, RPE>17, La- > 8mmol, no increase in HR with increased workload
2) Plot the lactate vs VO2 (ml/kg/min)
3) Plot the VE/VO2, VE/VCO2 vs VO2 (ml/kg/min)
4) Determine the LT and $V_{Threshold}$ from graphs
5) Express the LT1&2 and $V_{Threshold\ 1\ \&2}$ as a percentage of %VO2max
6) Plot the HR, RPE, vs %VO2max

7) Fill in the Tables Below:

Training Zones Based on VO_{2max} & Ventilation Threshold Testing

Zone	HR	RPE	Power RPM	Feeling	Time
Recovery	≤	≤	<	Easy	Unlimited
Aerobic - Endurance				Comfortable	> 4 hrs
Lactate Threshold (VT1)				Uncomfortable	>1.5 hr
Maximal Steady State Lactate (VT2)				Stressful	~1.0 hr
VO2max				Very Stressful	~2 to 6 min
Explosive Speed	**	>	>	Maximal	< 1 min

Discussion

1) To determine the physiological training zones based on La-/$V_{Threshold}$ 1 & 2 and VO_{2max}?

2) When prescribing exercise the proper exercise intensity recommended by ACSM is as follows:

Apparently healthy individuals: 50-85% of **VO_{2max}**

Sedentary, at risk, w/symptoms, or w/disease: < 50% of **VO_{2max}**

Why are the above exercise intensities prescribed and how do they relate to physiological markers of La-/$V_{Threshold}$ 1 & 2 and VO_{2max}?

3) The ACSM "equivalent" HR and RPE corresponding to 50-85 % of **VO_{2max}** is the following:

A) 74%-94% of HR max or predicted HR max (or for low fit 64-94%)

B) 50%-85% of HRR or VO2R

(Karvonen Formula = [(HRmax – HR rest) x % Intensity] + HR (or for low fit 40-85%)

(VO2Reserve = [(VO_{2max} – VO2 rest) x % Intensity] + VO2 rest (or for low fit 40-85%)

C) 12-16 RPE

How does your subjects' HR and RPE response at 50-85% of **VO_{2max}** and the training zones in questions#1 compare to the prescribe ACSM Formulas?

3) What **exercise intensity method** would you use to prescribe exercise in these scenarios - field, fitness, or clinical setting?

4) What does the term VO2R stand for and how is it used to prescribe exercise? What limitations are there when you prescribed exercise based on VO2 or METS?

5) If a cardiac patient was on Esidrix, Hydralazine, and Verapamil, how would if effect the HR vs %VO_{2max} relationship? What HR method would you use to calculate the correct exercise %$VO_{2\ max}$?

Human Performance Research Laboratory

EXERCISE DATA COLLECTION SHEET

Name____________________ Age___________ Gender___________ Date_________

Ht__________ cm Wt___________ kg Predicted MaxHR____________ Treadmill_____ Cycle Ergometer______

Stage	Duration	Time	Speed/RPM/Power	Grade/KP	Heart Rate	RPE	La-/BP
REST	0	0	0	0	________	_______	_____
_	__min	_____	_____	_____	________	_______	_____
_	__min	_____	_____	_____	________	_______	_____
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EXERCISE TEST EVENTS SIGNS/SYMPTOMS____

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COMMENTS____

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