Physiology 2
Redwood High School

Measuring Personal VO$_2$ Maximum – The Rockport Walk Test

Background

The ability to exercise for extended time periods (i.e. endurance) is largely dependent on an individual's ability to efficiently utilize oxygen. Exercise, a form of work, is produced by the activity of skeletal muscle cells converting chemical energy, from food, into the kinetic energy of movement. The correlation between endurance and oxygen usage is, therefore, a product of the biochemical pathways that permit this energy conversion. The most efficient pathway for energy conversion involves the breakdown of glucose in the presence of oxygen. This is called 'aerobic metabolism' or 'aerobic respiration' and is summarized by the chemical equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + \text{energy}$$

If an individual can be more efficient in using oxygen, she can be more efficient in converting food into movement and, consequently, should be able to exercise for longer periods of time.

A standard measure/assessment of endurance (or aerobic capacity) is the maximum amount of oxygen which a person can process in a given time period. In order to provide an effective comparison between individuals this quantity must also be corrected for body weight. This measure is termed "VO$_2$ max" (i.e. volume of oxygen utilized at maximum heart rate), and is typically expressed as milliliters of O$_2$/kilogram body weight/minute (mL/kg/min).

VO$_2$ max can be measured in a number of ways. The most direct and accurate involves the actual measurement of inhaled and exhaled gas volumes. This, however, involves expensive equipment and difficult testing protocols. An easier, less expensive technique involves the measurement of pulse rate (beats/min), which indirectly provides a measure of oxygen volumes being delivered to muscle tissue. A direct measure of VO$_2$ max also requires the test subject to be working at maximal capacity, also a difficult test procedure in all but the most physically fit subjects. Consequently, the standard protocol for the general population is a sub-maximal graded exercise test, where heart rate is monitored over gradually increasing workloads but not up to maximal capacity. The oxygen consumption is then extrapolated from sub-maximal to maximal values. This is the technique we will use in calculating VO$_2$ max values for our test subjects – utilizing the ‘Rockport Test.’ This activity is designed to provide some practice in the calculation and interpretation of VO$_2$ max values. As a follow-up, you will watch a demonstration of a maximal test for VO$_2$ max, the ‘Bleep Test.’

Focus Questions

- How can data from a sub-maximal exercise test be used to calculate VO$_2$ max?
- What is the relationship between VO$_2$ max and aerobic fitness?

Procedure

1. Perform an easy aerobic warm-up for (3) minutes. Follow this with a minute of stretching.

2. Walk (1) mile, (4) laps around the track, as fast as possible. Time your walk to the nearest second. Record your data. You will receive a participation grade based on your compliance with this instruction. Extra credit points will be awarded for those students who finish with times in the top 1/3 and the second 1/3 of the class.

3. As soon as you finish your walk, take a (30) second radial pulse count. Convert this data to heart rate in beats/minute. Record this data.
4. Complete the remainder of the data table.

5. Calculate your personal VO2 maximum using the following formula:

\[ \text{VO2 Max} = \frac{\text{Weight} \times \text{Age} \times (M=1; F=0) \times \text{Walk Time} \times \text{Heart Rate}}{\text{Comparison Rating}} \]

Note: Weight should be in pounds. Age is in years. Sex is scored as male =1 and female =0. Time is expressed in minutes to the nearest 1/100 minute. Heart rate is in beats/minute.

6. Re-calculate your VO2 max by changing the following parameters. Record your results in Data Table B.
   a) Using your original walk time: 1) increase heart rate by 15 beats/ min and 2) decrease heart rate by 15 beats/ min.
   b) Using your original heart rate: 1) increase your walk time by 2.00 minutes and 2) decrease your walk time by 2.00 minutes.

Data
Data Table A.

<table>
<thead>
<tr>
<th>Weight (lb)</th>
<th>Age</th>
<th>Sex (M=1; F=0)</th>
<th>Walk Time (.01 min)</th>
<th>Heart Rate (beats/min)</th>
<th>VO2 Max (ml/kg/min)</th>
<th>Comparison Rating</th>
</tr>
</thead>
</table>

Data Table B.

<table>
<thead>
<tr>
<th>Original VO2 max</th>
<th>+ 15 beats/min</th>
<th>− 15 beats/min</th>
<th>+ 2.00 min</th>
<th>− 2.00 min</th>
</tr>
</thead>
</table>

Analysis and Conclusions

1. Using population reference values available in class or on-line, what is your rating based on the value you calculated for VO2 max from this lab. Do you agree or disagree on your level of fitness relative to the general population?

2. Why did the VO2 max values change when you added and subtracted beats? Why did the values change when you added and subtracted time?

3. What does VO2 max mean? Explain how and why a higher VO2 Max value should indicate greater endurance (ability to work over time).

4. What are the physiological differences between a person with a VO2 max value of 52.0 and one with a value of 32.0?