BSL PRO Lesson H05: Wingate Anaerobic Test (WAnT)

A $50.00 modification of an old ergometer collecting dust in a storeroom, coupled with the pull down menus, dialog boxes, and measurement tools of the BSL PRO data acquisition and post-acquisition capabilities provide a precise technique for determining pedal revolutions and the administration of the Wingate Anaerobic Power Test.

This PRO lesson describes hardware and software setup of the BSL PRO System to record the Wingate Anaerobic Test, explains the Transform menu commands to use for meaningful analysis, and details a complete Wingate Test calculation. In this lesson, the WAnT is performed on a modified, plate loaded, Monark 818E work ergometer. All data collection and analysis is done via the BIOPAC MP30 data acquisition unit and the Biopac Student Lab PRO software.

Abstract

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Anaerobic power is believed to be an important component in the overall physical fitness of an individual. The Wingate Anaerobic Test (WAnT), introduced in the mid-1970s, is the most widely used test to assess peak muscle power, local muscle endurance, and fatigability. It has also been used to analyze physiologic and cognitive responses to supramaximal exercise. Various laboratories have evaluated and confirmed its high reliability, sensitivity and validity.

The WAnT consists of 30 s of exhaustive cycling (or cranking) exercise against a resistance (or braking force) determined according to the body weight of the subject. An integral component of the WAnT is the counting of pedal revolutions. In its simplest form, the pedal revolutions can be counted by visual observation. Automation of the counting (i.e., electromagnets or photoelectric cells attached to the ergometer), however, can increase the precision of the count and thus the accuracy of the test. The more sophisticated methods now use electromagnets or photoelectric cells attached to the ergometer. The signal generated by the electromagnets or photoelectric cells is fed into a computer for analysis. The sophistication of the BSL PRO software lends itself very well to this task.

References


Objectives

1. To describe the use of the BSL PRO to count and collect ergometer flywheel revolutions (pedal revolutions).
2. To describe the analysis of post-acquisition data using the BSL PRO transformation options.
3. To illustrate a complete WAnT calculation.

Equipment

- Computer running Windows
- BIOPAC Data Acquisition Unit
- Biopac Student Lab PRO Software
- BIOPAC transducer interface kit (SS-KIT)
- Modified, plate loaded, Monark 818E work ergometer
- Silicone pin photodiode (designed for detection of infrared radiation)
  - The photodiode (TOX 9100) was obtained from Texas Optoelectronics, Inc. in Garland, Texas.
- 3M reflector disc (4.13 cm)
- Contact cement
Ergometer Modification

The Monark 818E work ergometer was customized to permit instantaneous application of resistance. (Figure 2).*

* All modifications were done by Audris Zidermanis.

Note: other ergometers (i.e., ergometer for the upper-limb version of the Wingate Test) can be altered for the purpose of determining anaerobic power indices. The author's choice of the 818E was simply due the availability of it in the physiology lab. The modification does not alter the basic integrity of the 818E and thus allows, if one desires at a latter date, to re-convert the ergometer back to its original configuration. The cost of the entire modification is approximately $50.00.

1. Attach a single 3M reflector disc (4.13 cm) to the flywheel with contact cement.
2. Mount a silicon PIN photodiode on the front portion of the frame that supports the flywheel (Figure 3).

3. Use the SS-KIT to create a 9 pin D male connector for the photodiode (TOX9100).(Figure 4)
   - Connect the anode of the diode directly to pin 2 (Vin+).
   - Connect the cathode of the diode directly to pin 4 (Vin-).

The SS-KIT interface does not require soldering the circuit board to the 9 Pin D Male connector.
**Setup**

**Hardware**

1. Connect the photodiode lead from the modified Monark 818E ergometer to CH 1 (channel one) on the MP unit.
2. Turn the MP unit ON.

**Software**

1. Launch the BSL PRO software on the host computer.
   - The program should create a new "Untitled1" window.
2. Click the MP menu and select **Setup Channels**.
   - Check the following for CH 1 (analog channel one): Acquire, Plot, Values
   - Open the **Channel Setup** dialog.
   - Click the Presets button and choose PPG from pop-up menu
   - Set the Gain to 200.
3. Click the MP menu and select **Setup Acquisition**.
   - Set **Acquisition length** to one minute.
   - Set **Sample Rate** at 500 samples/second.

**Performing the WaNT**

1. Click **Start** to begin recording.
2. Ask the subject to pedal full-force (crank) for 30 seconds.
3. Click **Stop** after 30 seconds.

The reflective (analog) signal thus generated is recorded as a pulse pattern and transformed into a line plot with the use of various options found under the **PRO Transform** menu. Additional analysis of the line plot is accomplished by the measurement tools and commands found on the toolbar display.

**Analysis**

The BSL PRO offers a wide array of measurement and analysis tools to provide a precise technique for determining pedal revolutions during the administration of the WAnT. Two analysis options follow.

**Post-acquisition analysis of the pulse pattern**

1. Click the **Transform** menu and select **Find Rate**
   - Click the Function menu and select **Rate (BPM)**
   - Deselect **Auto threshold detect**
   - Set Noise rejection at 5 mV
   - Select **Find rate of entire wave**
   - Click **OK**
2. Click the **new rate waveform** to activate that channel
3. Click the Transform menu and select Smoothing

- Set the Smoothing factor at 300
- Click OK

4. Click the Display menu and select Autoscale waveform (or use Toolbar icon)
5. Click the Display menu and select Autoscale horizontal (or use Toolbar icon)
6. Double-click the "BPM" channel label to generate the label dialog
   - Type "RPM" (revolutions per minute) as the new label
   - Click OK

Determining Pedal RPMs From the Waveform Data

1. Use the pull-down measurement options to set CH 2 rpm (derived waveform) to display delta T, Mean, Min., and Max.
2. Click the Marker icon from the Toolbar.
3. Use the I-beam to highlight a peak of the derived waveform.
4. Click the Find Peak icon on the Toolbar.
   - Set first cursor to "Peak" in Peak Detector dialog box
   - Click OK
5. Insert a marker at the peak (PC=Esc; Mac=F9)
6. Label the marker "Load Applied" (insert the cursor in the marker region and type)
7. Insert Markers at 5-second intervals from the first one (use the delta T measurement).
9. Use the I beam to highlight the first interval (from Load Applied to 5 sec markers)
10. Note the Mean measurement.
11. Calculate pedal rpm / 5 s as follows:
   \[ \text{rpm} = \frac{\text{Mean (measurement result)}}{4} \]
   \[ \text{Pedal RPMs} = \left[\frac{(\text{rpm}/4)}{60 \text{ s}}\right] \times 5 \text{ s} \]

![A typical pulse plot generated during a WAnT, and a derived line plot generated via BSL PRO Transform menu commands. Full flywheel resistance load engagement and the six 5 s segments are identified.](www.biopac.com)
Wingate Test Calculation
The following is an example of a complete Wingate Test calculation using the rpm's obtained from the Figure 1 line plot.

- **Weight of Subject** = 165.0 lbs. (74.25 kg)
- **Force setting used to calculate optimal load** = 0.100 kg . kg\(^{-1}\)
- **Flywheel Resistance Load** = 74.25 kg \times 0.100 kg . kg\(^{-1}\)
- **Flywheel Resistance Load** = 7.43 kg

**Calculating Anaerobic Power per 5 s**
Work for each 5 s interval of the 30 s test is calculated and expressed in Kilogram-meter per minute (kg-m . min\(^{-1}\)) or watts (1 watt = 6.12 kg-m . min\(^{-1}\)).

- \(6m\) = the distance the ergometer flywheel travels during one pedal revolution.
- Work (kg-m . min\(^{-1}\)) = pedal rpm \times 6m \times resistance load (kg)
- 6.12 = conversion from kg-m . min\(^{-1}\) to watts
- Work (watts) = (kg-m . min\(^{-1}\))/6.12

**NOTE:** Typically the highest mechanical power elicited throughout the test occurs during the first few seconds, i.e. first 5 s, and can therefore also be expressed as **Peak Power**.

**Calculating Anaerobic Capacity per 30 s**
Anaerobic Capacity (also referred to as **Mean Power**) is the sum total of the work performed for each 5 s work interval combined, and is typically expressed in kilojoules (kJ). In this regard, 1 kg-m is equal to 9.804 joules (J) and is subsequently converted to kJ by multiplying each joule value by 0.001.

- **KJ** = kg-m . min\(^{-1}\) \times 9.804 \times 0.001

**NOTE:** Anaerobic Power and Anaerobic Capacity can both also be expressed in absolute values relative to body mass (watts . kg\(^{-1}\)) or to lean body mass (watts . kgLBM\(^{-1}\)).

**Calculating Rate of Fatigue (Fatigue Index)**
Rate of Fatigue is defined as the degree of power drop-off during the 30 s test, and can be calculated as a percentage of peak Anaerobic Power in the following manner:

- \(A\) = Peak anaerobic power
- \(B\) = Lowest anaerobic power

Rate of fatigue (Fatigue Index) = \([(A - B)100]/A\)

<table>
<thead>
<tr>
<th>Time Interval (s)</th>
<th>rpm</th>
<th>kg-m-min(^{-1})</th>
<th>Watts</th>
<th>kJ</th>
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<tbody>
<tr>
<td>0-5</td>
<td>8.49</td>
<td>378.62</td>
<td>63.08</td>
<td>3.71</td>
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<tr>
<td>6-10</td>
<td>6.06</td>
<td>269.94</td>
<td>44.99</td>
<td>2.65</td>
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<tr>
<td>11-15</td>
<td>5.10</td>
<td>227.37</td>
<td>37.90</td>
<td>2.23</td>
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<td>16-20</td>
<td>4.65</td>
<td>207.22</td>
<td>34.54</td>
<td>2.03</td>
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<tr>
<td>21-25</td>
<td>4.18</td>
<td>186.28</td>
<td>31.05</td>
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<tr>
<td>26-30</td>
<td>3.87</td>
<td>172.70</td>
<td>28.78</td>
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<tr>
<td><strong>Totals</strong></td>
<td>32.35</td>
<td>1442.13</td>
<td>240.34</td>
<td>14.14</td>
</tr>
</tbody>
</table>

**FATIGUE INDEX = 54.39**