Investigation of Methods to Determine Individualized Thresholds for Moderate and Vigorous Intensity from Accelerometer Measurements

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Abstract
Accelerometers are being widely used to quantify individuals’ physical activity (PA) profiles. An important component of the PA assessment is the quantification of time spent in moderate-intensity or higher PA. This is typically performed with the use of absolute intensity thresholds. PURPOSE: The primary purpose of this study was to determine the actual relative PA intensity, as a percentage of oxygen uptake reserve (VO2R), while meeting the absolute thresholds of 1952 activity counts/minute for moderate- and 5725 activity counts/minute for vigorous-intensity. This study also evaluated how much activity counts/minute variability existed between subjects at a VO2R of 40% and 60%.

METHODS: Twenty-eight individuals, 13 men (22.7±2.5 years), and 15 women (23.2±2.8 years), completed a maximal exercise test to determine their maximal heart rate (HRmax) and VO2. Six men and 4 women had VO2max considered high fit (≥20th%ile for age and gender) and 3 men and 5 women were considered low fit (≤20th%ile). On a separate day, subjects completed a submaximal exercise session, which was terminated when he/she reached 85% of HRmax. This exercise session included up to ten 5-minute stages, beginning at 1.5 mph followed by 2.0, 2.5, 3.0, 3.5, 4.0, 5.0, 6.0, 7.0 and 8.0 mph. Subjects’ VO2, HR, and activity counts/minute (measured using ActiGraph GT1M; ActiGraph, Pensacola, FL) were recorded every minute during the exercise session. RESULTS: Subjects’ actual relative intensity at the absolute moderate- and vigorous-intensity thresholds of 1952 and 5725 activity counts/minute were 15±6% and 45±12% VO2R, respectively. The activity counts/minute ranged from 3340 to 8250 and from 5250 to 12364 when subjects achieved 40% and 60% VO2R, respectively. Intraclass correlations (ICC) between activity counts/minute determined by both VO2R and age-predicted HRR were significant (p<0.05) at both moderate-intensity (ICC=0.77) and at vigorous-intensity (ICC=0.85). CONCLUSION: The absolute intensity thresholds do not accurately represent the actual relative intensity for most individuals. Results emphasize the need for establishing a relative activity counts/minute threshold when using accelerometers to accurately determine an individual’s ‘time spent in moderate-intensity or higher PA’.

Introduction
Accelerometers are often used to classify intensity levels of individuals, however, the identification of moderate and vigorous intensity is based on absolute activity count levels (1952 and 5725), respectively. (1)

• As recent AHA scientific statement stated: “Vigorous exercise is usually defined as an absolute exercise work rate of at least 6 metabolic equivalents (METs), which is historically assumed to equal a VO2 of 21 mL·kg−1·min−1”. Six METs approximates the energy requirements of activities such as jogging. Six METs is an arbitrary threshold and does not account for the fact that the myocardial oxygen demands of any physical activity are more closely related to the VO2 requirements relative to the metabolic capacity than to the absolute work rate per se. Consequently, exercise work rates <6 METs may still place considerable stress on the cardiovascular systems of unfit and older individuals.” (2)

• The Objective Measurement of Physical Activity Conference stated: “First, and perhaps most importantly, investigators need to describe the type and intensity of the most prevalent physical activities …” and “ Another high priority is developing prediction equations and activity count thresholds (or cut points) for situations or populations in which levels of physical activity include the full range of intensities, from very light to very vigorous.” (3)

Results

Day one: Familiarization and body composition measurements

Day Two: Maximal exercise test (BSU/Bruce Ramp protocol [4]) with measured VO2max and HRmax

Subject Characteristics (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 13)</th>
<th>Women (n = 15)</th>
<th>All subjects (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>22.7 ± 2.5</td>
<td>23.2 ± 2.8</td>
<td>23.0 ± 2.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>80.2 ± 17.1</td>
<td>65.4 ± 11.9</td>
<td>72.3 ± 16.1</td>
</tr>
<tr>
<td>Body Mass Index (kg/m^2)</td>
<td>25.4 ± 5.1</td>
<td>23.8 ± 4.9</td>
<td>24.5 ± 5.0</td>
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<tr>
<td>Waist Circumference (cm)</td>
<td>82.6 ± 12.5</td>
<td>71.9 ± 8.2</td>
<td>76.9 ± 11.6</td>
</tr>
<tr>
<td>VO2max (ml/kg/min)</td>
<td>49.3 ± 8.6</td>
<td>40.6 ± 6.7</td>
<td>44.6 ± 8.7</td>
</tr>
<tr>
<td>Maximal Heart Rate (bpm)</td>
<td>188.3 ± 7.4</td>
<td>189.0 ± 8.1</td>
<td>188.7 ± 7.6</td>
</tr>
</tbody>
</table>

Day three:
• Submaximal exercise trial with 5-minute stages: beginning at 1.5 miles per hour (mph), increasing to 2.0 mph, 2.5 mph; 3.0 mph, 3.5 mph, 4.0 mph, 5.0 mph, 6.0 mph, and potentially 7.0 mph or 8.0 mph (no rest periods between stages); ended when subject reached 85% of HRmax.
• VO2, HR, RPE, and activity counts measured (used data from the last 2 minutes of each stage).
• Developed regression equations for each subject between activity counts for both VO2R and HRR (age-predicted HRmax).

Summary and Conclusions
• Absolute intensity classifications have merit for epidemiological purposes and for comparability across different research studies.
• However, the findings from this study suggest that the accelerometer-determined absolute intensity thresholds of 1952 and 5725 counts/minute are not accurate indicators of the actual relative intensities for most subjects.
• Relative measures for moderate and vigorous intensity thresholds are needed to accurately determine an individual’s PA intensity level.
• A potential method of collecting submaximal data, using HRR with age-predicted HRmax could provide a reasonable estimate of individualized activity count thresholds for both moderate and vigorous intensity.

References