Cardiopulmonary Measures for Submaximal Arm and Leg Ergometer Tests

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INTRODUCTION

Arm ergometry (Figure 1) is an important training method for people who do not have function in their legs or athletes who primarily use their upper body in sports such as rowing (Brooks, Fahey & Baldwin, 2005). Leg ergometry (Figure 2) places a considerable load on the quadriceps depending on the wattage and revolutions per minute (RPM) that the individual is performing the exercise. It has been affirmed by studies that both ergometry tests are accurate and reliable representations of physical fitness (Eston & Brodie, 1986; Vander, Franklin, & Wisler, 2015). Oxygen consumption (VO2) reveals the cardiovascular system’s ability to deliver oxygenated blood to exercising skeletal muscles and the capacity to extract oxygen from capillaries for the mitochondria to make adenosine triphosphate (ATP) for energy (Porcari, Bryant, & Comana, 2015). Heart rate (HR) is the times a person’s heart beats per minute (bpm), which is dependent on exercise intensity and duration (McArdle, Katch & Katch, 2015). Rate of perceived exertion (RPE) is a subjective measure to identify the intensity level of the exercise (Brooks, Fahey & Baldwin, 2005).

The submaximal exercise tests served as the study’s independent variable. The alternate test and subjects were debriefed on lab procedures. The Hans Rudolph mask was built and the 2400 Metabolic Measurement System was warmed up 30 minutes prior to exercise testing, ergometry.

METHODS

The wattage remained consistent for the 10 minute steady-state exercise within ±5 beats for submaximal heart rate. Participants were asked for RPE during the 10 minute steady-state. The Borg’s RPE scale of 6-20 was used. For both tests, subjects were instructed to stay between 60 and 90 revolutions per minute (RPM) during the entirety of the tests. Following the 10-minute steady-state exercise, the participants began a 5-minute cool down. At this point, wattage was lowered to 0 W for the arm ergometer and 20 for the leg ergometer.

Following the exercise, the subjects were monitored for 5 minutes. The metabolic cart data was collected for each subject. Heart rate (HR), relative oxygen consumption (VO2) and RPE were analyzed and compared between the arm and leg ergometry tests for each subject. Equipment was cleaned to rid it of any germs or potential biohazards. The process was repeated for each subject.

The VO2 results for each subject during the 10-minute period of steady rate exercise is displayed in Figure 2. The first 7 minutes of the test, which included the 2-minute warm-up and 5 minutes of exercise to achieve target HR, were disregarded because the data collected during this time span did not reflect VO2 at the target HR. In the figure, the significant difference in VO2 during the leg ergometer test in Subject 2 are compared to the other subjects is quite evident.

RESULTS

In Table 1, the mean, standard deviation, and range for relative VO2, HR, and RPE are displayed. Subject 2 exhibited the highest VO2 for both tests, with an average of 13.73 ml/kg/min and 22.52 ml/kg/min for arm and leg ergometer tests, respectively. Subject 1 had the lowest VO2 for both tests, with an average of 7.34 ml/kg/min for arm exercise and 3.73 ml/kg/min for leg exercise. Heart rate averages remained between 130 and 140 BPM except for Subject’s 4 arm ergometer HR average of 113 BPM. The correlations between all subjects’ HR and VO2 for arm and leg ergometry was -0.18 and 0.28, respectively.

Table 1. Arm and Cycle Ergometry Descriptive Statistics

<table>
<thead>
<tr>
<th>Subject</th>
<th>Arm Ergometer</th>
<th>Leg Ergometer</th>
<th>Arm Ergometer</th>
<th>Leg Ergometer</th>
<th>Arm Ergometer</th>
<th>Leg Ergometer</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.74</td>
<td>3.73</td>
<td>13.73</td>
<td>22.52</td>
<td>10.44</td>
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<td>SD</td>
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<td>1.26</td>
<td>1.01</td>
<td>1.07</td>
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<tr>
<td>HR (BPM)</td>
<td>134–135</td>
<td>133–133</td>
<td>143–143</td>
<td>131–131</td>
<td>132–131</td>
<td>113–137</td>
</tr>
<tr>
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<td>134</td>
<td>133</td>
<td>131</td>
<td>132</td>
<td>113</td>
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<tr>
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<td>Mean</td>
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<td>0.60</td>
<td>2.16</td>
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<tr>
<td>SD</td>
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<td>12–12</td>
<td>12–12</td>
<td>12–12</td>
<td>11–12</td>
<td>15–10</td>
</tr>
</tbody>
</table>

Figure 1. Subject performing arm ergometer test

Figure 2. Subject performing leg ergometer test

DISCUSSION

The purpose of this study was to determine the difference in oxygen uptake between arm and leg ergometry. According to Bennett and authors (2015), submaximal testing is a valid means of assessing oxygen uptake. Oxygen consumption is defined as the amount of oxygen consumed by the tissues of the body (Thompson, 2010). At rest, the norm value of oxygen consumption is 3.5 ml/kg/min, or 1 MET (Thompson, 2010). Relative VO2 is a better representation of true oxygen consumption because it accounts for an individual’s body composition (Bennett, 2013). VO2 (in ml/kg/min) is the subject’s RPE that could support this study’s hypothesis. Equipment difficulties, the small sample size of four subjects, and the fact that the participants only completed one trial per test might have limited the study’s results.

The study has multiple real-life applications. In sports medicine, assessing the functional capacity of the cardiovascular system is essential (Sartor, Vernillo, Moretti, Bonomi, Torre, Kubis, & Veicsteinas, 2013). Since this test directly measures oxygen consumption, the aerobic endurance capacity of each subject can be measured via arm ergometry or leg ergometry. Further, the study can be applied to clinical populations, such as patients with heart failure or coronary artery disease, or even asymptomatic adults. The calculated VO2max from submaximal tests can be used for diagnostic and prognostic purposes (Sartor et al., 2013).

CONCLUSION

The data did not support the hypothesis of arm ergometry providing a higher VO2, HR, and RPE than leg ergometry. Only one of the four subjects exhibited an average VO2 and HR that could support this study’s hypothesis. In this study, HR and VO2 were shown to have a weak correlation for both arm and leg ergometry. The study was limited to one trial per subject. If the participants performed additional tests, the data may more closely reflect the hypothesis. Additionally, the study was limited to four female participants. In order to improve the experiment, a greater number of subjects and an increased number of trials could be employed to provide additional data points.

REFERENCES