Comparative analysis of two different methods of anaerobic capacity assessment in sedentary young men

Komparativna analiza dva različita načina određivanja anaerobne sposobnosti kod mladih nesportista

Aleksandar Klašnja*, Miodrag Drapšin*, Damir Lukač*, Patrik Drid†,
Slavko Obadov†, Nikola Grujić*

University of Novi Sad, *School of Medicine, Department of Physiology,
†School of Sport and Physical Education, Novi Sad, Serbia

Abstract

Background/Aim. The Wingate anaerobic test is a valid and reliable method of measuring anaerobic capacity. The aim of this study was to determine whether other modified test can be used instead of the Wingate test. Methods. A group of 30 sedentary young men were first tested with a cycle ergometer (classic Wingate test), and then with a dynamometer during 30 s of “all out” leg extension exercise (modified Wingate test; WAnTe) in order to test anaerobic capacity. Subsequent correlations between these tests were made. Results. Peak power, mean power on cycling ergometer in absolute and relative values were 463 ± 105 W, 316.7 ± 63.8 W, 5.68 ± 1.17 W/kg, 3.68 ± 0.78 W/kg, respectively. On a dynamometer absolute and relative values of maximal and mean load in kg and power in Watts were 136.54 ± 21.3 kg, 1.67 ± 0.26, 128.65 ± 19.93 kg, 1.57 ± 0.24 kg, 657 ± 125.87 W, and 8 ± 1.54 W/kg, respectively. There was no correlation between 5 s intervals of the classic Wingate test and WAnTe during the first, fourth and fifth intervals, but in the second (r = 0.49, p < 0.05), third (r = 0.38, p < 0.05) and last 5 s intervals (r = 0.39, p < 0.05), and also in peak power and mean power (r = 0.42, p < 0.05 and r = 0.45, p < 0.05 respectively), a significant positive correlation was detected. Conclusion. A modified Wingate test of leg extension on a dynamometer in sedentary young men shows a correlation with the classic Wingate test only in parameters of peak power, and mean power and the second, the third and the last 5 s intervals. Because of that it should only be used for orientation, whereas for precise measurements of anaerobic capacity the classic Wingate test should be used.

Key words: physical endurance; exercise tests; sensitivity and specificity; adolescent.
Introduction

It has become common knowledge that exercise is good for health. Yet, only a small percentage of population exercises regularly enough to reap the benefits of an active lifestyle, such as greatly reduced risk of chronic diseases such as heart disease and type 2 diabetes and reducing obesity.

During rest muscles use only a small percent of energy (under 20% of the whole energy). In physical activity, the situation is quite different. Depending on the intensity and duration of physical activity, energy demands can increase over one hundred times. Short-lasting and high-intensity activities such as running 100 m dash and weight lifting, need instant release of energy. That energy is gained from phosphates (adenosine triphosphate – ATP, creatine phosphate – PCr) found in muscle tissue. For long-lasting activities, ATP must be regenerated from metabolism of carbohydrates, fats and proteins.

Quantity and speed of energy release and renewal depend on the type of physical activity. This is essentially regarded as the energy capacity of humans. Size of energy capacity and the level of its use differentiate one person from another, which is very important for achieving good sport results. Human energy capacity is divided into two parts, aerobic and anaerobic part, and the division is made upon the biochemical processes in the cells. Both of these capacities can be measured experimentally.

The purpose of measuring anaerobic capacity is to determine the capability of the human body to activate fast-releasing and short-lasting energy systems during maximal physical work. There are different ways of measuring anaerobic capacity. Assessments of motor abilities are usually used, oxygen debt and deficit, as well as muscle biopsies. Muscle biopsy is not suitable for testing outside of laboratory, thus other tests are usually applied.

The Wingate anaerobic test (WAnT) is based on a 30 s “all out” exercise on a cycle ergometer which was proposed by Cumming. A prototype of the test was made during the 1970s in Israel. Today this test is used in laboratories all over the world. The test is simple to use, economic, safe, objective and reproducible.

It has already been speculated that the Wingate test is a valid and reliable method of measuring anaerobic capacity during short, maximal cycling. However, a special cycling ergometer is not always accessible to non-sportsmen in regular gyms. Also, the test is originally made for cycling, hence its modification may be needed in order to meet individual demands.

The purpose of this investigation was to compare the classic Wingate test with dynamometric measurements of leg extension as a measure of anaerobic capacity.

Methods

A group of 30 sedentary young men participated in this study. All the subjects were healthy and none was under pharmacological treatments or special diets. Informed consent was obtained from all the subjects after explanation of the nature and risks involved in the research.

For each participant a protocol with the results, time of examination, anthropometric parameters (body mass, body height) was made. Body height was measured with the Martin anthropometry with 0.1 cm the precision, and for body mass decimal medical scale with precision of 0.1 kg was used.

All tests were done in the laboratory for functional testing at the School of Medicine, University of Novi Sad, Serbia. Tests were done with the mechanically braked cycle ergometer under identical microclimate conditions. Power output data were recorded using a computer with specially designed software. Generally accepted anaerobic performances were measured (peak power, mean power and fatigue index).

All subjects were familiarized with the test procedures on the ergometer to minimize learning effects. Each test started with a 10-min warm-up, after which subjects performed the test itself.

The test and recording started with a sound signal. The subjects cycled at maximal power for 30 s. Seat height was adjusted for every person and conventional length of pedal was 16.5 cm. In our laboratory, like in many other studies, this length was used for all subjects, regardless of their height and foot length.

Dynamometric measurements of the thigh strength were done on the isometric apparatus Concept 2 DYN0 (USA).

Prior to the testing, all subjects were familiarized with the test procedures, performed the same warm-up, and had strictly defined joint angles of the lower extremities.

As a part of strength testing of knee extensors, there were three trial contractions, followed by consecutive maximal contractions at maximal speed against the preset resistance for 30 s.

The results were processed in the apparatus' software system and were displayed as isotonic muscle strength (maximal load against defined resistance in kg), strength (Watt) and velocity of contraction (mm/s). The number of contractions was calculated, and the mean value for each period of 5 s was taken for further calculation with the total of six values for a 30 s period.

Dynamometric measurements were done on the separate day than the measurements on cycling ergometer, under the same microclimates conditions and at the same part of the day like the first test.

The descriptive results were reported as mean values and standard deviations (SD). The differences between the groups were analyzed using the t-test for independent samples. For all statistics the significance level was set at \( p < 0.05 \). For analyzing data the software system Statistics 6.0 was used.

Results

The sample comprised 30 sedentary young men (mean ± SD: age 21.32 ± 0.86 years, body height 183.14 ± 6.08 cm and body weight 81.93 ± 9.98 kg).
Peak power (PP), mean power (MP), in absolute and relative values on a cycle ergometer were 463 ± 105 W, 316.7 ± 63.8 W, 5.68 ± 1.17 W/kg, and 3.68 ± 0.78 W/kg, respectively (Table 1).

During the Wingate test on a cycling ergometer the best values were achieved in the third 5 s interval, while on a dynamometer the best results were achieved in the first, after which there was a decrease in power. Loads during 5 s intervals on a cycling ergometer and dynamometer are showed in Figures 1 and 2.

A significant positive correlation was found in parameters PP and MP on a cycling ergometer and dynamometer (\( r = 0.42, p < 0.05 \) and \( r = 0.45, p < 0.05 \)) (Table 3).

Testing of subjects on dynamometer values of load in kg and power in Watt were obtained. Parameter load (A) was 128.65 ± 19.93 kg in absolute values and 1.57 ± 0.24 kg in relative values. Power (P) was 657 ± 125.87 W, while power per kilogram of body mass was 8 ± 1.54 W/kg (Table 2).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>x</th>
<th>SD</th>
<th>CV</th>
<th>MIN</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power (W)</td>
<td>463</td>
<td>105</td>
<td>23</td>
<td>294</td>
<td>689</td>
</tr>
<tr>
<td>Peak power/Body mass (W/kg)</td>
<td>5.68</td>
<td>1.17</td>
<td>21</td>
<td>3.89</td>
<td>7.80</td>
</tr>
<tr>
<td>Mean power (W)</td>
<td>316.7</td>
<td>63.8</td>
<td>20</td>
<td>214.8</td>
<td>434.7</td>
</tr>
<tr>
<td>Mean power/Body mass (W/kg)</td>
<td>3.86</td>
<td>0.78</td>
<td>19</td>
<td>2.62</td>
<td>5.3</td>
</tr>
</tbody>
</table>

\( x \) – mean value; SD – standard deviation; CV – coefficient of correlation; MIN – minimal value; MAX – maximal value

Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>x</th>
<th>SD</th>
<th>CV</th>
<th>MIN</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power (kg)</td>
<td>136.54</td>
<td>21.3</td>
<td>16</td>
<td>115</td>
<td>154</td>
</tr>
<tr>
<td>Peak power/Body mass (kg/kg)</td>
<td>1.67</td>
<td>0.26</td>
<td>16</td>
<td>1.4</td>
<td>1.88</td>
</tr>
<tr>
<td>Mean power (kg)</td>
<td>128.65</td>
<td>19.93</td>
<td>15</td>
<td>97</td>
<td>148</td>
</tr>
<tr>
<td>Mean power/Body mass (kg/kg)</td>
<td>1.57</td>
<td>0.24</td>
<td>15</td>
<td>1.18</td>
<td>1.80</td>
</tr>
<tr>
<td>Power – (W)</td>
<td>657</td>
<td>125.87</td>
<td>19</td>
<td>462</td>
<td>945</td>
</tr>
<tr>
<td>Power/Body mass (W/kg)</td>
<td>8</td>
<td>1.54</td>
<td>19</td>
<td>5.63</td>
<td>11.5</td>
</tr>
</tbody>
</table>

\( x \) – mean value; SD – standard deviation; CV – coefficient of correlation; MIN – minimal value; MAX – maximal value

Table 2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>WAnT</th>
<th>WAnTe</th>
<th>Pearson’s coefficient of correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power</td>
<td>0.42*</td>
<td>0.45*</td>
<td></td>
</tr>
<tr>
<td>Mean Power</td>
<td>0.33</td>
<td>0.49*</td>
<td></td>
</tr>
<tr>
<td>5s</td>
<td>0.38*</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>10s</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15s</td>
<td>0.39*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant positive correlation value

Table 3
There was no significant correlation between 5 s intervals of the classic Wingate test and Wingate test of extension of legs (WAnTe) in the first, fourth and fifth interval, but in the second ($r = 0.49, p < 0.05$), third ($r = 0.38, p < 0.05$) and the last ($r = 0.39, p < 0.05$) interval, significant positive correlation was detected (Table 3).

Discussion

The anaerobic 30 s Wingate test performed on a cycle ergometer is a reliable and valid method of testing anaerobic performance. It has been used for assessment of anaerobic power in different sport disciplines and for all ages and genders. This test is performed on a cycle ergometer, and the most common parameters obtained are PP, MP and index of fatigue (IF). Peak power represents the highest value of mechanical power obtained during the test in all five–second intervals. Index of fatigue is the amount of power depletion during the test and is represented as a percentage of peak power.

The Wingate test is performed traditionally on the mechanically braked cycle ergometer, although some research was done with an electromagnet wheel cycle ergometer controlled by the computer. The data obtained in these studies showed no significant difference between the two methods in values of PP and MP. Different testing modalities were also put to the test. The original Wingate test was performed with a subject in the seated position to enable reproducibility and comparability of the test data. But it was observed that the subjects were prone to stand up during the test and sprint in stand up position, especially professional bikers. This observation put up the question if the stand-up position during the test enables better results, and in more recent studies it was proved that there is a difference in two types of cycling. As a conclusion in these studies the authors suggested that the standing position is better for determining the real anaerobic capacity.

Macintosh et al. tried to find out if there was a difference in test results, when subjects were starting the test from the stationary position or having a flying start. In four trials the subjects started from the seated position, while three times they fly-started. It was found that better results were obtained from the stationary position. According to this results, in our research stationary starting position was used.

There were many trials in the past to bring to correlation different field tests, laboratory tests with the parameters of the Wingate test (PP and MP), to check for its validity and also relative contributions of anaerobic and aerobic capacity.

Estimation of anaerobic state based on the Wingate test gives valid information about the current state and also about getting better during training process.

Although many different tests show a significant correlation with the classic Wingate anaerobic test, the results of our study with modified Wintage test of leg extension on a dynamometer machine showed a significant correlation only in some parameters.

A possible explanation for non-correlation in the first 5-second interval could be the presence of a certain amount of inertia during the classic WAnT on a cycle ergometer. The existence of a significant correlation in the 2nd and 3rd five-second intervals comes out directly from overcoming of initial inertia and reaching the maximal values of load. After a period of almost identical shape of the test curve, in the last 5-second interval a dissociation was evident, most likely due to faster fatiguing of the working muscles on a dynamometer machine. Further proof of such a suggestion was the maximal load reached in the first 5-second interval on a dynamometer machine faster as compared to the classic WAnT performed on a cycle ergometer.

Also, a significant correlation in important anaerobic parameters (PP and MP) shows that a test on dynamometer also provides a useful information about individual anaerobic status, and that is important in achieving recommendations of the American College of Sport Medicine (ACSM). ACSM recommends that people not involved in a professional sport should also be physically active and that physical activity should be part of everyday life. But, no every exercise is a beneficial one. Performing a very difficult exercise before the body is sufficiently conditioned may actually cause an injury. That is why it is very important to adapt physical activity to individual fitness. A test on dynamometer can be used for monitoring of non-athletes during conditioning and goal achieving during training for health. The results of our study are in accordance with other authors concerning sedentary individuals.

Conclusion

A modified Wingate test of leg extension on a dynamometer in sedentary young men shows a correlation with the classic Wingate test only in some parameters, so the Wingate test on a dynamometer should only be used for orientation, while for precise measurements of anaerobic capacity the classic Wingate test should be used.

REFERENCES


The paper received on March 3, 2009. Accepted on August 7, 2009.