The Wingate Anaerobic Test (WAnT) has been established as an effective tool in measuring both muscular power and anaerobic capacity in a 30-second time period; however there are no published normative tables by which to compare WAnT performance in male and female collegiate athletics. The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for male and female NCAA Division I college athletes using the WAnT. One thousand three hundred and seventy four male and female tests were conducted on athletes ranging from the ages of 18 to 25 using the WAnT. Absolute and relative peak power and anaerobic capacity data were recorded. One-half standard deviations were used to set up a seven-tier classification system (poor to elite) for these assessments. These classifications can be used by athletes, coaches, and practitioners to evaluate anaerobic peak power and anaerobic capacity in their athletes.
WINGATE ANAEROBIC TEST PEAK POWER AND ANAEROBIC CAPACITY CLASSIFICATIONS FOR MEN AND WOMEN INTERCOLLEGIATE ATHLETES

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ABSTRACT

Zupan, MF, Arata, AW, Dawson, LH, Wile, AL, Payn, TL, and Hannon, ME. Wingate Anaerobic Test peak power and anaerobic capacity classifications for men and women intercollegiate athletes. J Strength Cond Res 23(9): 2598–2604, 2009—The Wingate Anaerobic Test (WAnT) has been established as an effective tool in measuring both muscular power and anaerobic capacity in a 30-second time period; however, there are no published normative tables by which to compare WAnT performance in men and women intercollegiate athletics. The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for men and women National Collegiate Athletic Association (NCAA) Division I college athletes using the WAnT. A total of 1,585 (1,374 men and 211 women) tests were conducted on athletes ranging from the ages of 18 to 25 years using the WAnT. Absolute and relative peak power and anaerobic capacity data were recorded. One-half standard deviations were used to set up a 7-tier classification system (poor to elite) for these assessments. These classifications can be used by athletes, coaches, and practitioners to evaluate anaerobic peak power and anaerobic capacity in their athletes.

KEY WORDS muscular power, fatigue index, absolute power, relative power, physical fitness

INTRODUCTION

Physical fitness can be assessed through 5 major components: cardiorespiratory endurance, muscular power/strength, muscular endurance, flexibility, and body composition. An anaerobic activity is defined as energy expenditure that uses anaerobic metabolism (without the use of oxygen) that lasts less than 90 seconds, utilizing an exhaustive effort (25). Two major energy sources are required during the WAnT. The first is the adenosine triphosphate-phosphocreatine (ATP-PCr) system, which lasts for 3 to 15 seconds during maximum effort (25). The second system is anaerobic glycolysis, which can be sustained for the remainder of the all-out effort (25). Therefore, the WAnT measures the muscles’ ability to work using both the ATP-PCr and glycolytic systems. Many sports—including football, sprinting, soccer, baseball, lacrosse, and gymnastics—use anaerobic metabolism extensively during competition. This study examines the aspect of lower-body peak power and anaerobic capacity using the 30-second exhaustive Wingate Anaerobic Test (WAnT).

Several tests can assess an athlete’s peak power (a measure of muscular strength and speed), anaerobic capacity, or both. These tests include the vertical jump test, standing long jump test, Bosco repeated jumps (18), and WAnT (3,6,11). The WAnT measures lower-body peak power; anaerobic capacity; and the reduction of power, known as fatigue index (FI) (3,7). The WAnT is a 30-second all-out exhaustive ergometry test where the athlete pedals against a resistance that is set at a certain percentage of his or her body weight. The power output is measured throughout the test by the number of revolutions the athlete can achieve on the ergometer during those 30 seconds. The peak power recorded is the maximal power output achieved for 5 seconds of the test, usually the first 5 seconds. The anaerobic capacity, or average power, is recorded and averaged over the entire 30 seconds of the test. The lowest power output is an average of the lowest 5 seconds seen during the test, usually the last 5 seconds. Finally, the difference in power output from highest to lowest is recorded as the FI. The ability to evaluate these
measurements makes the WAnT a valuable test for coaches, athletes, and research scientists.

Many researchers and coaches measure muscular strength with a 1-repetition maximum (IRM) lift (11). They also measure muscular endurance via repetition lifts (to include bench press at a percent of the athlete's body weight, push-ups, sit-ups, or pull-ups) until exhaustion. These measurements allow a coach to observe individual improvements; however, it is difficult to truly compare one athlete's data to another's in a lifting exercise unless the exact distance of the lift or weight (in the case of push-ups or pull-ups) is equal. Comparing an athlete's data to a set standard is important for athletes and coaches of sports that require both muscular power and anaerobic capacity. Until this study, there has not been a compilation of data to compute normative tables by which athletes could compare their Wingate scores.

**METHODS**

**Experimental Approach to the Problem**

The purpose of this study was to develop a classification system for anaerobic peak power and anaerobic capacity for men and women college-age athletic populations.

**Subjects**

National Collegiate Athletic Association (NCAA) Division I athletes from the U.S. Air Force Academy between the ages of 18 and 25 years participated in this study (Table 1). The athletes came from sports that require short bursts of peak power and a high anaerobic capacity during competition to include lacrosse, gymnastics, sprint cycling, football, baseball, tennis, and track. A total of 1,585 WAnTs (1,374 men and 211 women) were administered to 521 Division I athletes (457 men, 64 women). These data were preexisting data from the quarterly, semi-annual, or annual testing that these teams perform for training purposes; thus no informed consent documents (ICDs) were obtained.

**Procedures**

Prior to testing, body weight was collected using a Detecto electronic scale. The athletes were then fitted for their optimal seat height on a Monark 8248 or 874E weight ergometer. These ergometers were specially designed WAnTerometers, with instantaneous load and braking systems. The seat height was adjusted so that no more than 5 degrees of knee flexion was present when the leg was fully extended. Each subject was then given a 3 to 5 minute warm-up period on a Monark 868 cycle ergometer, striving to achieve a warm-up heart rate of 130 to 140 beats per minutes (bpm). Athletes who had not previously taken the WAnT were required to perform 2 or 3, 5-second high revolution spins during their warm-up. This was completed to acquaint the athletes with the pedaling speed requirements of the WAnT.

The resistance load was set at 7.50% of the subject's body weight within a 0.1-kg resolution of resistance range. This load was used for tests in both men and women. Prior to getting on the ergometer for the test, a Polar Vantage NV heart rate monitor transmitter was placed around the athletes'
### Table 3. Wingate Anaerobic Test power comparisons for men.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Sample size (n)</th>
<th>Subject type</th>
<th>Peak power (W)</th>
<th>Relative peak power (W/kg⁻¹)</th>
<th>Average power (W)</th>
<th>Average power (W/kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>2008</td>
<td>1,374</td>
<td>18–25-year-old intercollegiate athletes</td>
<td>951</td>
<td>11.65</td>
<td>686</td>
<td>8.47</td>
</tr>
<tr>
<td>Al-Hazzaa et al. (1)</td>
<td>2001</td>
<td>23</td>
<td>25-year-old elite soccer players</td>
<td>873</td>
<td>11.88</td>
<td>587</td>
<td>8.02</td>
</tr>
<tr>
<td>Apostolidis et al. (2)</td>
<td>2004</td>
<td>13</td>
<td>Junior Basketball League (age: 18.5 years)</td>
<td>–</td>
<td>10.70</td>
<td>–</td>
<td>8.00</td>
</tr>
<tr>
<td>Barfield et al. (4)</td>
<td>2002</td>
<td>25</td>
<td>20 years old</td>
<td>868</td>
<td></td>
<td>634</td>
<td></td>
</tr>
<tr>
<td>Bell and Cobner (5)</td>
<td>2007</td>
<td>41</td>
<td>21-year-old rugby players</td>
<td>1,154</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heller et al. (9)</td>
<td>1998</td>
<td>11</td>
<td>Taekwondo national team</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kocak and Kari</td>
<td>2003</td>
<td>20</td>
<td>International-level wrestlers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mangine et al. (13)</td>
<td>1989</td>
<td>83</td>
<td>National soccer players</td>
<td>538</td>
<td>6.10</td>
<td></td>
<td>8.12</td>
</tr>
<tr>
<td>Maud and Shultz</td>
<td>1995</td>
<td>20</td>
<td>18–22 years old</td>
<td>700</td>
<td>9.18</td>
<td>563</td>
<td>7.28</td>
</tr>
<tr>
<td>Nindl et al. (15)</td>
<td>1995</td>
<td>20</td>
<td>High school athletes</td>
<td>694</td>
<td>9.10</td>
<td>548</td>
<td>7.20</td>
</tr>
<tr>
<td>Patton et al.</td>
<td>1985</td>
<td>10</td>
<td>Olympic biathletes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peveler et al.</td>
<td>2007</td>
<td>9</td>
<td>Trained cyclists</td>
<td>1,248</td>
<td></td>
<td>648</td>
<td></td>
</tr>
<tr>
<td>Ponorac et al. (17)</td>
<td>2007</td>
<td>95</td>
<td>Judo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sbriccoli et al.</td>
<td>2007</td>
<td>6</td>
<td>Olympic-level judokas</td>
<td>1,236</td>
<td>12.10</td>
<td>557</td>
<td>5.40</td>
</tr>
<tr>
<td>Starling et al. (20)</td>
<td>1996</td>
<td>10</td>
<td>Competitive cyclists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watson and Sargeant (22)</td>
<td>1986</td>
<td>24</td>
<td>University hockey players (age = 20 years)</td>
<td></td>
<td>10.10</td>
<td></td>
<td>7.70</td>
</tr>
<tr>
<td>Weber et al. (23)</td>
<td>2006</td>
<td>10</td>
<td>Active males</td>
<td>1,055</td>
<td>13.30</td>
<td>766</td>
<td>9.70</td>
</tr>
<tr>
<td>Wiegman et al. (24)</td>
<td>1995</td>
<td>10</td>
<td>25-year-old athletes</td>
<td>850</td>
<td>10.35</td>
<td>620</td>
<td>7.55</td>
</tr>
</tbody>
</table>
### Table 4. Wingate Anaerobic Test power comparisons for women.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Sample size (n)</th>
<th>Subject type</th>
<th>Peak power (W)</th>
<th>Relative peak power (W/kg⁻¹)</th>
<th>Average power (W)</th>
<th>Average power (W/kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>2008</td>
<td>211</td>
<td>18–25-year-old intercollegiate athletes</td>
<td>598</td>
<td>9.59</td>
<td>445</td>
<td>7.16</td>
</tr>
<tr>
<td>Findley et al.</td>
<td>2002</td>
<td>10</td>
<td>Female firefighters</td>
<td>451</td>
<td>-</td>
<td>314</td>
<td>-</td>
</tr>
<tr>
<td>Heller et al.</td>
<td>1998</td>
<td>12</td>
<td>Tae kwon do national team</td>
<td>-</td>
<td>10.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jacob et al.</td>
<td>2002</td>
<td>19</td>
<td>Endurance trained (ET)</td>
<td>508</td>
<td>9.50</td>
<td>409</td>
<td>7.70</td>
</tr>
<tr>
<td>Maud and Shultz</td>
<td>1989</td>
<td>60</td>
<td>18–28 years old</td>
<td>710</td>
<td>12.60</td>
<td>510</td>
<td>9.00</td>
</tr>
<tr>
<td>Nindl et al.</td>
<td>1995</td>
<td>20</td>
<td>High school athletes</td>
<td>442</td>
<td>7.50</td>
<td>307</td>
<td>5.30</td>
</tr>
<tr>
<td>Sbriccoli et al.</td>
<td>2007</td>
<td>5</td>
<td>Olympic-level judokas</td>
<td>418</td>
<td>9.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Thorland et al.</td>
<td>1986</td>
<td>31</td>
<td>Junior-level sprint/mid-distance runners</td>
<td>725</td>
<td>11.40</td>
<td>518</td>
<td>8.10</td>
</tr>
<tr>
<td>Weber et al.</td>
<td>2006</td>
<td>10</td>
<td>Active female</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Woolstenhulme et al.</td>
<td>2004</td>
<td>18</td>
<td>Division I basketball players</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5. Wingate Anaerobic Test classification of peak power (W, W/kg⁻¹) and anaerobic capacity (W, W/kg⁻¹) for men.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Peak power (W)</th>
<th>Peak power (W/kg⁻¹)</th>
<th>Anaerobic capacity (W)</th>
<th>Anaerobic capacity (W/kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite</td>
<td>&gt;1,163</td>
<td>&gt;13.74</td>
<td>&gt;823</td>
<td>&gt;9.79</td>
</tr>
<tr>
<td>Excellent</td>
<td>1,092–1,163</td>
<td>13.04–13.74</td>
<td>778–823</td>
<td>9.35–9.79</td>
</tr>
<tr>
<td>Above average</td>
<td>1,021–1,091</td>
<td>12.35–13.03</td>
<td>732–777</td>
<td>8.91–9.34</td>
</tr>
<tr>
<td>Average</td>
<td>880–1,020</td>
<td>11.65–12.34</td>
<td>640–731</td>
<td>8.02–8.90</td>
</tr>
<tr>
<td>Below average</td>
<td>809–879</td>
<td>10.96–11.64</td>
<td>595–639</td>
<td>7.58–8.01</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt;739</td>
<td>&lt;9.57</td>
<td>&lt;549</td>
<td>&lt;7.14</td>
</tr>
</tbody>
</table>
WAnT classifications

Table 6. Wingate Anaerobic Test classification of peak power (W, W/kg⁻¹) and anaerobic capacity (W, W/kg⁻¹) for women.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Peak power (W)</th>
<th>Peak Power (W/kg⁻¹)</th>
<th>Anaerobic capacity (W)</th>
<th>Anaerobic capacity (W/kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite</td>
<td>&gt;730</td>
<td>&gt;11.07</td>
<td>&gt;541</td>
<td>&gt;8.22</td>
</tr>
<tr>
<td>Below average</td>
<td>510–553</td>
<td>8.60–9.09</td>
<td>382–413</td>
<td>6.45–6.80</td>
</tr>
<tr>
<td>Fair</td>
<td>467–509</td>
<td>8.11–8.59</td>
<td>351–381</td>
<td>6.10–6.44</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt;467</td>
<td>&lt;8.11</td>
<td>&lt;351</td>
<td>&lt;6.10</td>
</tr>
</tbody>
</table>

Success in many sports requires high leg power and anaerobic capacities. Some sports require absolute power, or the highest power output possible, independent of body size, such as football linemen, power lifters, or hammer throwers. If 2 players' skill level or technique are equal, then the more powerful athlete will usually outperform the less powerful opponent. Other sports, where the athlete must move his or her body across a field or ice rink with a quick burst of energy, require a high relative peak power and anaerobic capacity. Up until now, WAnT studies with a large sample size have not been completed on well-trained college-age athletes and thus there has been no classification system developed for coaches to interpret test results. The purpose of this study was to develop a classification system for absolute and relative peak power and anaerobic capacity for men and women college-age athletic populations. In doing this, any athlete can perform the WAnT and compare themselves to other athletes on a scale from “poor” to “elite.”

Our data closely reflect the data on various research projects with small sample sizes. Studies investigatingpower or training effects related to power are summarized for men (Table 3) and women (Table 4). These tables reflect the peak power and anaerobic capacities reported and are compared to the means of this study. When comparing the data, it is important to recognize the differing subject samples. Studies that used college-age elite athletes are most comparable to the present study (1,12), whereas older and younger subject studies, and studies completed on standard 868 ergometers, may not be as relevant. Before 1999 the automatic weight basket system had not been used extensively in most human performance laboratories. All but a few labs had to manually crank the load adjustment knob to quickly add the load. With this in mind, the delay time to reach maximum resistance was most likely 2 to 4 seconds, reducing the peak power and
possibly the anaerobic capacity because the 30 seconds usually did not start until the final load was reached. Today's ergometers allow for instantaneous loading and recording so the athlete receives credit for the initial seconds of the test. Most studies performed prior to 1999, with the exception of 1 (16), report substantially lower peak power and anaerobic capacities than the present study.

The study performed by Maud and Shultz (14) is the only other known study that has attempted to set normative tables by which to compare WAnT performance. This study consisted of 186 subjects (112 men and 74 women) from club and varsity sports, physical education majors, and physical education students. They established a percentile ranking in men and women for peak power (W, W/kg -1 and W/kgLB M -1 ), mean power (W, W/kg -1 and W/kgLB M -1 ), and fatigue index (%). Testing for this study was performed with manual counting on a standard 818 ergometer and may have resulted in human error at the higher revolutions. The authors also reported a 2- to 3-second delay in reaching the required load (14); thus the athletes were working at maximal effort without receiving credit for this work. These 2 limitations, along with the fact that our subjects were all intercollegiate athletes, may account for the significantly higher averages in all WAnT categories seen in this study.

A 7-bin category structure was formed from the data collected. Tables 5 (men) and 6 (women) contain the category tier of peak power and anaerobic capacity (W and W/kg -1 ) for intercollegiate athletes. It is common to find 5 categories of evaluation to categorize many different levels of fitness for the average person (14). Most times these are simply broken up into percentiles, 0 to 20% being the lowest and so on. Sometimes 6 categories have been used. It was decided in this study to use a one half standard deviation to differentiate the categories and, in doing so, have 3 categories on either side of average. This 7-category system allows for a more accurate evaluation of the individual athlete and provides the clinician, coach, and athlete with a better understanding of the interpretation of the test results. No classification system was set up for fatigue index or heart rates. The athletes were asked to bring their heart rates up to around 140 bpm during warm-up and to perform an active recovery following the WAnT until their heart rates returned close to 120 bpm. It was found that the FI was inversely related to peak power. Having a high or low FI does not directly indicate an athlete's ability, but if there are 2 equally powerful athletes and I has a lower FI, then, physiologically speaking, that athlete will probably be the better athlete on the field. By itself, however, no value was found in setting up a classification system for the FI.

**Practical Applications**

The purpose of this study was to establish set standards for intercollegiate athletes in lower-body peak power and anaerobic capacities from the Wingate Anaerobic Test. Although there have been multiple studies done involving the WAnT, none have been able to work with such a high number of well-trained athletes. The classification categories formulated will allow coaches, clinicians, and athletes to use these charts as tools to evaluate power output and provide comparisons from a set of reliable standards. This information should begin to create a framework by which athletes can compare their performance on the Wingate Anaerobic Test.

**References**


Athlete WAnT Classifications


