Reliability of Wingate Testing in Adolescents With Down Syndrome

Myriam Guerra, Maria Giné-Garriga, and Bo Fernhall

The Wingate anaerobic test (WAnT) has not been used to assess individuals with Down syndrome (DS) and it is unknown if it is reliable in this population. We investigated the reliability of the WAnT in 19 adolescents with DS (age = 14.8 yrs; weight = 52.7 kg; height = 146.3 cm). Participants completed, on separate days, two standards WAnT using a resistance of 0.7 Nm × body weight (kg) in individuals ≥ 14 years old, and 0.5 Nm × body weight (kg) in participants < 14 years of age. Data were analyzed using intraclass correlation coefficient (ICC), dependent t tests and Bland-Altman plots. There was a significant difference between days for peak power (210.37 W vs. 236.26 W; ICC = 0.93), but not for mean power (158.72 vs. 168.71 W; ICC = 0.86), time to peak power (6.67 vs. 6.28 s; ICC = 0.69), or the fatigue index (9.33 vs. 5.43 W/sec; ICC = 0.09). Adolescents with DS exhibit low WAnT performance compared with previously published data on adolescents without DS and the reliability of WAnT is questionable in this population.

Tests of aerobic power are valid and reliable in children with mental retardation (MR), including children with Down syndrome (DS; 10). Children and adolescents with DS have consistently been shown low levels of aerobic power (12,17), but little is known about anaerobic power in this population. However, individuals with DS have very low levels of muscle strength (16,22) suggesting that they may also exhibit low levels of anaerobic power.

Anaerobic power may be of considerable importance in children, as physical activity patterns of children are characterized by short bursts of activity interspersed with short rest periods (14). Thus, the natural patterns of children’s physical activity are similar to anaerobic activities. However, Bailey et al. (2) showed that these activities were of low intensity and may actually be protective of anaerobic energy production, suggesting more work is required to evaluate the anaerobic contribution to the normal activity patterns of children. Since anaerobic function is dependent on muscle performance and neurological control (19,20) it is of special interest in children with DS, because this population has low levels of muscle strength and often exhibit poor neuromuscular coordination (12,16).

The 30 s Wingate cycle ergometer anaerobic test (WAnT) is a popular method developed to evaluate anaerobic power in several populations (5,18). This test

Guerra and Giné-Garriga are with the Dept. of Physical Activity and Sports Sciences, FPCEE-Blanquerna, University Ramon Llull, Barcelona, Spain. Fernhall is with the Dept. of Kinesiology and Community Health, University of Illinois, Urbana-Champaign, IL 61820.
involves pedaling for 30 s at supramaximal effort, at a constant applied force using commonly available cycle ergometers and yields data on muscle power, muscle endurance and fatigability (18). Peak power reflects the ability to produce high mechanical power in a short time, whereas mean power represents local muscle endurance (26). The 30 s Wingate test is highly reliable in nondisabled children, with test-retest coefficients ranging from 0.89 to 0.97 (3,4).

Despite its popularity as an exercise test among populations with special needs, the WAnT has not been used to assess people with DS. Chia, Lee, and Teo-Koh (6) found the WAnT was reliable for boys with intellectual disabilities without DS. However, performance was significantly more variable and boys with intellectual disabilities had much lower levels of anaerobic power than boys without intellectual disabilities, similar to findings of aerobic performance of children with intellectual disabilities (11,13,17). Other tests of anaerobic power have also been shown to be reliable in populations with intellectual disabilities (with and without DS; 15), but it is unknown if the WAnT is a reliable test in children with DS. Therefore, the purpose of this study was to evaluate the reliability of the Wingate test in adolescents with DS.

**Methods**

**Participants**

Nineteen participants were recruited from a special education school for children and adolescents with developmental disabilities. All of them were adolescents with mild mental retardation and were diagnosed with DS (12 males and 7 females). Participants lived at home or with their legal guardian. All the participants were prescreened for any medical contraindications to exercise, including congenital heart defects, medications affecting heart functions, and any motor problems that would prevent them from cycling. Descriptive characteristics of the subjects are shown in Table 1. Before participation, informed consent was obtained from the subjects’ parents or legal guardians and participants gave oral assent to participate. The study was approved by the University Institutional Review Board.

**Familiarization**

Participants were tested previous laboratory familiarization. The importance of familiarization sessions for this population has been previously explained (21,24).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>14.84 ± 3.01</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>52.70 ± 13.81</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>146.33 ± 9.11</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.96 ± 5.26</td>
</tr>
</tbody>
</table>

**Table 1  Descriptive Characteristics of the Sample (n = 19)**
Participants were familiarized with instrumentation, staff and how to perform the tests. All familiarization sessions were repeated 2–3 times or until the participants could comfortably perform each test.

**Wingate Testing**

Participants completed two Wingate 30-s tests, in the morning and on separate days. Testing was performed on an electromagnetic cycle ergometer (LODE Excalibur). On test days, participants warmed up for three minutes with sprints of 2–3 s interspersed between constant pedal rates of 60 rpm. They were then asked to complete, immediately following warm-up, a standard WAnT (18,4). The resistance was set at a torque of $N = 0.7 \times \text{body mass (kg)}$ in individuals $\geq 14$ years old, and a torque of $N = 0.5 \times \text{body mass (kg)}$ in subjects $< 14$ years of age.

The cool down consisted on 2–3 min of pedaling against a light resistance immediately following the testing (18). The cycle ergometer was interfaced with a computer and all data were collected on-line, in real time, and then analyzed off-line following the test.

The variables of interest obtained were mean power, peak power, and fatigue index. Mean power is the average power sustained throughout the 30s period, peak power is the highest mechanical power elicited during the test, which typically occurs in the first few seconds and the fatigue index is the rate of peak power decrease throughout the 30 s test period (18).

**Statistical Analysis**

Statistical procedures were performed using SPSS version 13.1 for Windows. Descriptive statistics were calculated for all variables. To determine the reliability of the test results, intraclass correlation coefficient (ICC) was calculated over the two test sessions. Dependent sample T-tests were used to evaluate potential differences between test days, and statistical significance was set at $p < .05$. To evaluate the limits of agreements between tests we also constructed Bland-Altman plots.

**Results**

Data are reported in means and standard deviation (SD), respectively (Table 2). Mean anaerobic power was $158.72 \text{ W} \pm 84.98 (3.35 \text{ W/kg})$ and $168.71 \text{ W} \pm 75.18 (3.5 \text{ W/kg})$ on the first and second test respectively, with an ICC of $r = .86 (p < .05)$. Peak power was $210.37 \text{ W} \pm 105.86$ and $236.26 \text{ W} \pm 98.29$ on the first and

**Table 2 Results From the Wingate Anaerobic Tests**

<table>
<thead>
<tr>
<th></th>
<th>Test 1 (Mean ± SD)</th>
<th>Test 2 (Mean ± SD)</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean power (w)</td>
<td>158.72 ± 84.98</td>
<td>168.71 ± 75.18*</td>
<td>0.86</td>
</tr>
<tr>
<td>Peak power (w)</td>
<td>210.37 ± 105.86</td>
<td>236.26 ± 98.29</td>
<td>0.93</td>
</tr>
<tr>
<td>Fatigue index (w/sec)</td>
<td>9.33 ± 11.33</td>
<td>5.43 ± 3.01</td>
<td>0.09</td>
</tr>
</tbody>
</table>

*significant difference between tests $p < .05$
second test, respectively, with an ICC of $r = .93$ ($p < .05$). There was a significant difference in peak power between tests ($p < .05$). The time to peak power was 6.67 s and 6.28 s on the first and second test respectively, with an ICC of $r = .69$ ($p < .05$). There was no significant difference between the two tests for the time to peak power, nor for the fatigue index (9.33 W/sec ± 11.33 and 5.43 W/sec ± 3.01 for test 1 and 2, respectively) with a lower ICC ($r = .09; p < .05$). The Bland-Altman plots are presented in Figure 1. Although the bias was small for mean power, the rate of fatigue and time to peak power, the limits of agreements were large. The bias was also large for peak power.

**Discussion**

The main findings of this study were that anaerobic performance is poor in children with DS and the W AnT has questionable reliability in this population. The reliability coefficients of peak and mean power, 0.93 and 0.86 respectively, were similar to those reported for children without disabilities (18). Our data are also consistent with previous reliability studies done in children with intellectual disabilities without DS, which showed ICC of 0.93 and 0.95 for peak power and mean power, respectively (6). Thus, we found similar ICC for the WAnT in children with DS as in children with mental retardation without DS and children without disabilities, even though performance levels are lower in this population. Although the reliability coefficients were reasonable in this group of children with DS, peak power was significantly different between tests suggesting poor precision of this measurement. Mean power was also slightly higher on the second test, but this difference was not significantly different. The fatigue index was also not significantly different between tests, but the ICC for the fatigue index was very low and not significant, showing this variable was not reliably measured in children with DS. Furthermore, the Bland-Altman plots show that the limits of agreement is large even in the presence of a small bias, suggesting that individual variability between tests is large in this group of adolescents with DS.

These data clearly suggest that the WAnT has questionable reliability in adolescents with DS, at least when two measurements are used. Since the second test yielded higher peak power (statistically significant) and mean power (not statistically significant) our data suggest that more than two tests may be needed to obtain reliable data in children with DS. However, considering the extensive familiarizations session, our participants completed at least three tests, but we did not collect any data during familiarization. Doré et al. (7) showed that three tests were needed for reliable data in children, although their participants were much younger than our participants (9.8 vs. 14.8 years). Since we only conducted two measured tests, this needs to be addressed in future studies in participants with DS.

Children with DS exhibit low physical fitness and aerobic power levels (12,17). The present data show that children with DS also exhibit low levels of anaerobic power compared with previously published data of their nondisabled peers (4). Inbar et al. (18) found that boys 12–14 years old had a mean power of 335.79 ± 58.52 W and peak power of 407.00 ± 71.43 W, whereas girls had mean power values of 259.7 ± 62.2 W and a peak power of 331.3 ± 85.9 W. Our data
Figure 1 — Bland-Altman plots of mean power, peak power, and rate of fatigue. The solid lines denote the bias (mean difference) and the broken lines denote the limits of agreement.
show that children with DS exhibit approximately 50% of the expected anaerobic power of children without disabilities. This appears to be a greater reduction than previously observed in aerobic performance (8,17). The results are consistent with previous studies done with populations with mental retardation, including DS, where peak power was $219 \pm 87$ W and mean power was $155 \pm 74$ W (6).

It is difficult to speculate on the reason for the poor reliability of WAnT performance in children with DS. Our population of adolescents has similar characteristics of adolescents with intellectual disabilities with or without DS, included in other studies measuring both aerobic and anaerobic power (6,8,17), thus it is unlikely that cognitive impairments per se can explain our results. Furthermore, the adolescents in our study underwent a familiarization process as suggested by several authors (21,24), and it has been successfully used this type of familiarization protocol in previous studies to produce reliable test results of aerobic power (9,23). Nevertheless, it is possible that the nature of all effort for 30s is difficult for adolescents with DS, thus more practice or more tests may be needed to yield reliable data. It is also possible that leg strength may influence WAnT performance in children with DS. Muscle strength is directly related to WAnT performance and thus might influence the results (25,1). Individuals with DS have consistently been shown to exhibit poor levels of muscle strength (16,22), which might be related to the poor reliability of WAnT testing in the current study. However, this needs further investigation, since we did not measure strength in the current study.

This study has several limitations. First, the age range and range in body mass were fairly large. It is possible that reliability of the Wingate test be different between participants of different ages and body mass. Second, we used standardized breaking forces based on age, and it is possible that this may have influenced our results. Finally, although the cycle ergometer was factory calibrated, we were unable to check the calibration of the ergometer before each test.

**Conclusion**

Adolescents with DS exhibit low levels of WAnT power. The reliability of WAnT testing in this population is questionable and needs further investigation to examine the influence of number test used and the possible influence of muscle strength.

**References**


