Validity of a Wheelchair Perceived Exertion Scale (WHEEL Scale) for Arm Ergometry Exercise in People with Spina Bifida

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Disclosures:

• Does not intend to discuss commercial products or services.
• Does not intend to discuss non-FDA approved uses of products/providers of services.
• Received the Spina Bifida Young Investigators Award from the Spina Bifida Association/Ashley Rose Foundation
More than 166,000 individuals currently live with spina bifida (SB) (Spina Bifida Association).

Risk factors for cardiovascular disease (42%) and metabolic syndrome (32.4%) are prevalent in people with SB (Buffart et al. 2008, Nelson et al. 2007).

Arm ergometry exercise improves muscle strength and aerobic fitness and enhances overall health and quality of life in people with mobility disabilities (Hicks et al., 2003, Widman et al., 2006).
INTRODUCTION

Rating of perceived exertion (RPE)

• Low cost subjective means of quantifying the physiological and psychological strain during exercise stress test or submaximal exercise program (Borg, 1982, Robertson, 2001)

Concurrent and construct validity of the perceptual metrics are prerequisites to such scale applications (Robertson, 2004)
### Borg 6-20 Perceived Exertion Scale

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion at all</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard (heavy)</td>
</tr>
<tr>
<td>12</td>
<td>Very hard</td>
</tr>
<tr>
<td>13</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>14</td>
<td>Maximal exertion</td>
</tr>
</tbody>
</table>

**Figure 1.1** Fifteen-category Borg Perceived Exertion Scale.

INTRODUCTION

Concurrent validity of Borg 6-20 scale

- Significant strong (0.80 to 0.90) positive and linear relation to HR, V02, and blood lactate across incrementally increasing work rate during a graded maximal exercise stress test in non-disabled populations (Borg, 1982; Borg, Hassmen, Lagerstrom 1987; Noble & Robertson 1996)

Borg Scale often used as criterion reference metric when testing the construct validity of other RPE scales for able-bodied adults.

Borg RPE scale has been used to control exercise intensity in people with spinal cord injury. (Gooseny-Tolfrey et al., 2010, Grange et al., 2002)
OMNI Scale for Children developed by Dr. Robert J. Robertson in response to lack of valid RPE scales for children.

Pictorial representation of the exertion levels can be chosen if:

• unable to read the verbal descriptors

• does not understand the numeric scale
OMNI Scale of Perceived Exertion: Adult, Cycle Format

Figure 2.1 OMNI Picture System of Perceived Exertion for adult bicycle exercise.

INTRODUCTION

Limitation of RPE scales in people with childhood disabilities who are lifelong users of assistive devices:

• may have limited/no experience riding bicycle, walking or stepping

• may be unable to relate personal feelings of exertion to an able-bodied person pictured on a RPE scale who is exercising on equipment that is designed for persons without lower extremity disabilities

• people with mild impairments in cognition or perception may be unable to relate their subjective feelings of exertion to the numerical Borg Scale
INTRODUCTION

WHEEL Scale (Crytzer et al 2015) created in response lack to the lack of RPE scales for people with lower extremity disabilities who may also have mild cognitive or perceptual impairments

WHEEL Scale (Crytzer et al. 2015) adapted from the OMNI Child Cycling RPE scale (Robertson 2004) and portrays color photos of a person in a wheelchair
WHEEL Scale

0 not tired at all
1 a little tired
2 getting more tired
3 tired
4 really tired
5 very, very tired
Aim: To investigate the construct and concurrent validity of the WHEEL Scale

Hypotheses:

1a. Positive correlation will be seen between Borg Scale RPE and oxygen uptake (VO$_2$) and heart rate (HR)
1b. Positive correlation seen between the WHEEL Scale RPE and VO$_2$ and HR
1c. Positive correlation seen between the Borg Scale and the WHEEL Scale RPE’s
Recruitment:

- Spina Bifida Clinics, Center for Assistive Technology, local community organizations

Inclusion criteria:

- Having spina bifida
- Having scoliosis
- Inability to pedal a standard (two-wheel) bicycle
- Age 13-80 years
Exclusion Criteria:

- History of coronary artery disease, coronary bypass surgery, other cardiopulmonary events
- Upper extremity (UE) injuries or range of motion limitation that would prevent performing arm ergometry
- UE or thoracic surgery in the last six months
- Other medical conditions for which the subject’s primary care physician determined was a contraindication to arm ergometry exercise testing
Protocol for Exercise Stress Test

- Administered by exercise physiologist and PT in laboratory
- HR, RER, VO$_2$, VCO$_2$ recorded by a metabolic cart
- One minute warm-up at 10 Watts (W)
- Participants maintained 70 RPM during test with verbal/visual cues while the work rate increased by 10 W each minute
- Participants asked to rate their perceived exertion using Borg and WHEEL Scales during last 15 sec. of each minute
ANALYSIS

Scatter plots created to assess outliers and determine if a linear trend occurred between power output and:

- Relative HR
- Relative VO2
- RPE from the Borg Scale
- RPE from the WHEEL Scale

Correlation analyses using Kendall’s tau (τ) to determine whether physiological variables (HR, VO2) increased linearly and positively as workload increased.

Correlation between RPE derived from the Borg and WHEEL Scales calculated.
## Results: Socio-demographic Data

<table>
<thead>
<tr>
<th></th>
<th>Total (N = 24)</th>
<th>Male (n = 12)</th>
<th>Female (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><strong>Race, n</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>21</td>
<td>87.5</td>
<td>11</td>
</tr>
<tr>
<td>Black or African-American</td>
<td>2</td>
<td>8.3</td>
<td>1</td>
</tr>
<tr>
<td>Other (Unknown)</td>
<td>1</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Primary assistive device, n</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual wheelchair</td>
<td>16</td>
<td>66.7</td>
<td>7</td>
</tr>
<tr>
<td>Power wheelchair</td>
<td>2</td>
<td>8.3</td>
<td>1</td>
</tr>
<tr>
<td>Crutches/Cane/Walker</td>
<td>4</td>
<td>16.7</td>
<td>3</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td>8.3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Level of lesion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic</td>
<td>14</td>
<td>58.3</td>
<td>7</td>
</tr>
<tr>
<td>Lumbar</td>
<td>10</td>
<td>41.7</td>
<td>5</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age, yr.</strong></td>
<td>32.08</td>
<td>12.98</td>
<td>34.33</td>
</tr>
<tr>
<td><strong>Body Mass Index based on arm span</strong></td>
<td>24.23</td>
<td>7.81</td>
<td>22.31</td>
</tr>
<tr>
<td><strong>PASIPD score (METS hr./day)</strong></td>
<td>14.73</td>
<td>11.10</td>
<td>12.26</td>
</tr>
<tr>
<td><strong>Self-reported exercise (hr.)</strong></td>
<td>2.36</td>
<td>2.85</td>
<td>1.42</td>
</tr>
<tr>
<td><strong>Peak oxygen uptake (liters/min)</strong></td>
<td>1.24</td>
<td>0.63</td>
<td>1.43</td>
</tr>
<tr>
<td><strong>(milliliters/kg/min)</strong></td>
<td>18.95</td>
<td>6.90</td>
<td>21.08</td>
</tr>
<tr>
<td><strong>Heart ratio, (beats/min).</strong>*</td>
<td>148.13</td>
<td>28.08</td>
<td>148.82</td>
</tr>
<tr>
<td><strong>Respiratory exchange rate</strong></td>
<td>1.06</td>
<td>0.19</td>
<td>1.11</td>
</tr>
</tbody>
</table>
RESULTS

Kendall’s Correlation Coefficients ($\tau$) for the relation between power output and physiologic and perceptual variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Relative HR</td>
<td>.55</td>
<td>.41</td>
<td>.44</td>
<td>.32</td>
</tr>
<tr>
<td>2. Relative VO$_2$peak</td>
<td>.46</td>
<td>.47</td>
<td>.48</td>
<td></td>
</tr>
<tr>
<td>3. Borg Scale</td>
<td></td>
<td>.70</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>4. WHEEL Scale</td>
<td></td>
<td></td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>5. Power Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All correlations were significant at the 0.05 level (2-tailed)

Key: HR = Heart Rate, VO$_2$peak = oxygen consumption, RPE = rating of perceived exertion
DISCUSSION

For hypothesis 1 and hypothesis 2:

• Modest positive correlations between physiological variables and both RPE Scales.

• Correlation coefficients for physiologic variables modest compared to previous studies (VO₂-Borg $r^2=0.23$; HR-Borg $r^2=0.21$; VO₂-WHEEL $r^2=0.29$; HR-WHEEL $r^2=0.22$)

For hypothesis 3:

• The Borg Scale and WHEEL Scale were highly correlated ($r^2=0.72$, $p<0.0001$)
DISCUSSION

Significant positive linear association between workload and HR ($t=0.45$); Borg found higher correlation ($1.00$) in non-disabled adults using arm ergometry stress testing.

- Reasons for low HR in presence of high power output include
  - Medications to lower HR
  - Highly conditioned athlete

Significant positive associations and linear association between workload and VO2 ($t=0.54$); Pelletier et al (2013) found higher correlations in people with spinal cord injury in rehab.

- Retain pre-injury physical fitness in SCI

Significant positive correlation between VO2/HR and WHEEL and Borg

- physical deconditioning (PASIPD 14.73 METS hr/day; SD = 11) was lower than reported by Washburn et al (2002)
- May have reached VO2 peak at lower intensities leading to test termination sooner than expected (15/24 achieved a max test)
- Lack of familiarity with the scales
- Pressor response arm ergometry
DISCUSSION

Weaknesses

• Small sample size
• Variability in participants’ exercise tolerance

Strengths

• Administration of test in laboratory setting by qualified personnel provided environmental control to reduce measurement error
• The WHEEL Scale is an easy to use and low cost tool for clinicians to monitor exercise intensity of client’s with SB
Significant positive correlations were found between HR, VO$_2$ and RPE derived from the Borg and the WHEEL Scales.

The WHEEL Scale is a useful tool for clinicians prescribing and regulating exercise intensity for people with SB.
ACKNOWLEDGEMENTS

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  • Exercise Physiology Lab in the Endocrinology and Metabolism Research Center
  • Department of Health and Physical Activity

UPMC Mercy Hospital Adult Spina Bifida Clinic

UPMC Children’s Hospital Spina Bifida Clinic
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