Use of Rating of Perceived Exertion (RPE) to Prescribe Exercise Intensity for Wheelchair-Bound Children and Adults

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Seventeen individuals (ages 11–30 years), all wheelchair users, were classified as active or sedentary. Peak mechanical power, heart rate (HR), and rating of perceived exertion (RPE) were determined during continuous, incremental all-out arm ergometry. Subjects were asked to wheel on an oval track at prescribed speeds, and one month later they repeated this task. All subjects could distinguish among prescriptions, as judged from HR and wheeling velocities. However, the active subjects chose higher speeds (by 0.8–1.3 m/s), a wider range of speeds, and could better distinguish among sequential RPE levels than did the sedentary subjects. All subjects chose wheeling velocities higher than expected from their originally established HR-on-RPE regression. One-month retention was high and similar between groups. Individuals who use wheelchairs can discriminate among wheeling intensities as prescribed using the RPE scale and have excellent retention for at least one month.

Self-estimation of exertion using some type of rating scale has been employed for many years as supplementary information to data obtained during graded exercise testing (2, 8). Recently, subjective rating scales such as Borg’s 6–20 category rating of perceived exertion (RPE) scale (7) have been used as a method of prescribing intensity (see Birk and Birk [6] for review). Based on a diagnostic fitness evaluation, a “window” of RPE numbers (e.g., 12–15) is prescribed as the target intensity level, and the individual attempts to maintain exercise within this range. The use of RPE to gauge exercise intensity has been recognized by the American College of Sports Medicine (ACSM) as a useful technique, particularly when used in conjunction with heart rate (1).

Research studies on the effectiveness of RPE as a tool to gauge exercise intensity generally have used adults (9, 12, 13, 16) or able-bodied children (17, 18, 19). There is no information to date on whether a disabled population,
specifically the wheelchair-bound, can employ RPE effectively for exercise training. Thus, it was the purpose of this study to determine if children and adults who use wheelchairs can accurately pace their wheeling around a track using intensities prescribed to them as numbers on the Borg RPE category scale. An additional purpose was to determine whether this ability differs between active and inactive individuals, and whether it is retained one month later.

**Methods**

**Subjects**

Seventeen volunteers, ages 11–30 years, were recruited from organizations for the disabled or sports clubs, qualified for participation, and were subsequently divided into groups based on physical activity status. Activity status was determined by questionnaire (modified from Bar-Or and Ward [3], pp. 151-168). An active subject was defined as one who participated in exercise workouts more than three to four times per week and that lasted 15–20 min per session. Sedentary subjects were those whose activity patterns occurred less than three times per week and that lasted less than 20 min per session. Most subjects in the active category were involved in some form of regular sport competition. All subjects had disabilities requiring use of a wheelchair. Disabilities included spina bifida, cerebral palsy, and traumatic paraplegia. Level of spinal lesion was of no consequence in subject selection as long as the individual could wheel his or her own nonpower chair.

**Design and Procedures**

**Session 1.** This session was devoted to orientation and collection of baseline information. Arm span was taken to reflect body height using a measuring tape permanently affixed to a length of wood. Skinfold thickness (mean of three trials) was measured with Harpenden calipers at four sites: biceps, triceps, subscapular, and suprailiac (11). Body weight was measured with a Mott electronic scale accurate to 20 g (Model LC2424).

Following the anthropometric measurements, the RPE 6–20 scale was introduced and then used within a progressive, continuous, maximal arm ergometer test as described by Bar-Or and Zwiren (4). Briefly, subjects were seated in their chair with the arm ergometer (Fleisch or Monarch) positioned so that the axle of the pedal was at shoulder height. Subjects cranked at 50 RPM for 2-min intervals with increments that would elicit a total test duration of 6–12 min. Test termination occurred when subjects were unable to maintain the cranking cadence. Other variables monitored during the test were heart rate (HR) and mechanical power. HR (bipolar ECG or Sports Tester PE 3000) and RPE were determined during the last 15 s of each load.

**Session 2.** At least 2 days later, subjects returned to the lab and were acquainted with their full range of physical efforts. “Anchoring” of the extremes of this range was done by repeated 3-min arm cranking bouts at intensities corresponding to each subject’s predetermined lower extreme (RPE 7) and upper extreme (RPE 19) of the RPE scale. Each of these intensities was performed three times using a randomized sequence. The subjects rested between bouts
until their HR recovered to below 100 beats·min⁻¹. Individuals were taught to “feel” the particular intensity and to recognize it as either the 7 or 19 level. The same ergometer used for Session 1 was used in Session 2.

**Session 3.** The following week, subjects reported to the track for the first prescription session and were instructed to wheel at an even speed for 400 m, using either a 200-m indoor or a 400-m outdoor track (one subject from each group). Intensities were prescribed as RPE numbers. Subjects performed 4 bouts, one each for RPE 7, 10, 13, and 16. RPE 7 was always prescribed first to allow for subject warm-up, but was included in the statistical analysis. The other three tasks were prescribed in a random order. Sufficient rest periods were given to allow HR to return to <100 beats·min⁻¹. HR was monitored using the Sports Tester monitor, with values stored in memory for later recording. A digital stopwatch was used to record split times at 100-m intervals. Total time was later used to calculate wheeling speed over the 400-m distance. Subjects used their own personal wheelchairs, but many of the active subjects had access to specialized “racing” chairs.

**Session 4.** Session 4 was intended to assess retention and was conducted 1 month later. Subjects returned to the track and followed a protocol identical to that of Session 3.

**Data Analysis**

Differences in subject characteristics between the activity groups were assessed using a Student’s t test. To determine how accurately a subject executed the prescribed wheeling intensities, individual HR-on-RPE regression lines were plotted for Session 1 (“criterion session” = C) and for the two prescription sessions (P1 and P2). Group means allowed comparisons of slopes and intercepts of the three lines by activity status. Data were analyzed using a two-way ANOVA model, with a Student Neuman-Keuls post hoc test employed whenever F ratio was significant.

Wheeling velocities and HRs were compared at each of the four prescription levels (RPE 7, 10, 13, and 16). Two-way ANOVA with repeated measures (group and time) was used to analyze retention ability. Tukey’s post hoc test was used to compare group means. An alpha level of .05 was used to determine level of significance.

**Results**

Subject characteristics are presented in Table 1. The two groups were similar in age and weight, but the active group was taller (estimated by arm span) and had a higher peak aerobic power (per kilogram of body weight) than the sedentary group (p < .05).

**HR on RPE**

As a general pattern, HR of all subjects (see Figure 1), irrespective of activity status, increased consistently with increasing RPE number (p < .0001, F = 23.1, df = 3). Based on the HR-on-RPE regression lines in sessions C, P1, and P2, subjects overestimated the choice of wheeling intensities, particularly at the low
Table 1  Subject Characteristics by Groups

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Weight (kg)</th>
<th>Arm span (cm)</th>
<th>( \Sigma ) skinfolds (mm)</th>
<th>Peak aerobic power (Watt/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
</tr>
<tr>
<td>Active (( n = 10 ))</td>
<td>18.8</td>
<td>6.9</td>
<td>55.1</td>
<td>13.3</td>
<td>164.0*</td>
</tr>
<tr>
<td>Sedentary (( n = 7 ))</td>
<td>17.7</td>
<td>7.8</td>
<td>51.8</td>
<td>17.2</td>
<td>151.0</td>
</tr>
</tbody>
</table>

*\( p < .05 \).

Figure 1 — Heart rate (HR) at each of the four RPE prescriptions presented as means ± SEM. Each RPE prescription level is significantly higher than the preceding one (\( p < .0001 \)). P1 denotes the first prescription session and P2 the session 1 month later.
Rating of Perceived Exertion

Figure 2 — Comparison of all subjects’ HR-on-RPE regression lines for the criterion session and the two prescription sessions (P1 and P2). Both P1 and P2 are significantly different from the criterion session (C) \( (p < .05) \).

Efforts. This is displayed in Figure 2, which includes group regression lines for all subjects combined. The slopes and intercepts for the two prescription tasks (P1 and P2) were significantly different \( (p < .05) \) from the criterion \( (F_{\text{intercept}} = 4.51, F_{\text{slope}} = 4.51, df = 2) \). There was no difference, however, in the degree of overestimation between the two activity groups. Figure 2 further shows the similarity of the regression lines in sessions P1 and P2, suggesting a high retention of a person’s ability to execute a prescribed task after one month.

Wheeling Velocities

Velocities chosen by sedentary and active subjects in each of the prescribed RPE tasks are summarized in Figure 3. At each RPE level in either session, active subjects chose faster velocities than did sedentary subjects \( (p < .01, F = 14.3, df = 1) \). Furthermore, active subjects could better discriminate among the prescribed tasks by progressively selecting higher speeds with increasing RPE numbers \( (p < .05, F = 3.57, df = 3) \). Although active subjects discriminated successfully between all consecutive RPE prescriptions (7 vs. 10, 10 vs. 13, 13 vs. 16), sedentary subjects could only discriminate RPE 7 from RPE 13 and RPE 16.
Figure 3 — Wheeling speed at each of four RPE prescriptions presented as means ± SEM. P1 denotes the first prescription session, P2 the session 1 month later. Sedentary subjects’ speeds are significantly different from those of the trained subjects (p < .01). Wheeling speeds increased significantly (p < .05) for each consecutive RPE number, except for RPE 10 versus 13 and 13 versus 16 in the sedentary group.

differences were found in either group between the velocities selected 1 month later. The ability to replicate the performance following a month’s interval was particularly apparent at RPE 7 and 10 for both groups and at RPE 16 for the active group.

Discussion

The use of a subjective rating scale for the prescription of exercise intensity has been proposed as an alternative to heart rate counting for use with adults (10, 15, 16). Recent work has established that able-bodied children can discriminate among various RPE intensity levels in the reproduction of exercise (17, 19, 19). However, the usefulness of this approach with special populations, such as the individuals who use wheelchairs, has not been studied.

Data from this study indicate that individuals who use wheelchairs can discriminate among wheeling intensities as prescribed for them by the Borg
category scale, but this ability is improved with exercise training. Furthermore, subjects have displayed an excellent retention of this ability for at least 1 month.

Although subjects could discriminate among RPE prescription levels, HR for a given RPE level was consistently higher in the prescription phases than in the criterion sessions. Explanation for this observation is not straightforward. Arm work uses a smaller muscle mass than does leg or whole body exertion and could be the main source of the overproduction. One of the few studies that compared rating of perceived exertion during upper and lower body exercise found the RPEs were lower for leg than arm exercise (14). However, this study looked only at estimation of exercise intensity, not production, and observed responses to prolonged exercise (10–60 min). Another possible explanation for the overestimation may be related to the use of an arm ergometer for assessing the criterion and the use of the subject’s own wheelchair, freely wheeling, for the prescription sessions.

Studies with overweight children (17) and healthy adults and children (18) observed faster speeds and higher HRs during RPE-prescribed outdoor running when the RPE concept was taught using a cycle ergometer. Ceci and Hassmen (9) found that physically active adult males tended to execute an RPE prescription somewhat differently at the outdoor running track than on a treadmill, suggesting that exercise prescriptions developed from treadmill data be reduced by two RPE units for use in outdoor settings.

Other studies (5, 12, 16) have found the accuracy of RPE for prescription to be better at RPE 13 and 16 than at lower intensities, as was noted in this study. Since this finding was consistent for physical training groups, prescription of mild to moderate exercise intensities should take into account the higher than expected HR, and presumably effort, chosen by the individual. The following is an example of the corrections that one could use in prescribing wheeling efforts to active and less active subjects in order to yield a certain HR:

- To achieve HR equivalent to RPE 10, prescribe RPE 6–7.
- To achieve HR equivalent to RPE 13, prescribe RPE 9–10.
- To achieve HR equivalent to RPE 16, prescribe RPE 14–15.

It was noted (data not included) that younger subjects had greater difficulty at the lower prescription levels.

Individuals who train in athletic events such as distance running, cycling, skating, or wheeling are usually able to gauge their velocity. A common practice in sport training is to describe a certain velocity as a percentage of one’s maximal velocity. It was therefore surprising that the active subjects in this study (those who exercise on a regular basis) did not show much advantage over the sedentary group in the accuracy of producing the prescribed tasks. One reason may be the difference in exercise modality between the practice and the prescription sessions. Another may be that the particular individuals who took part in this study were not using fractions of their maximal speed as a means of gauging their wheeling velocity during training or competition. We are not aware of data on the ability of healthy athletes to use the RPE as a means of prescription of intensity.

Although training status did not affect a subject’s ability to reproduce exercise intensity, it did alter the pace and range of wheeling speeds. Sedentary subjects utilized a narrower range of wheeling speeds (0.2–0.3 m/s) than did the
active subjects (0.6–0.7 m/s). It should be noted that many of the active subjects had access to a different type wheelchair for the prescription sessions. The use of a specialized “racing” chair may have contributed to the faster speeds observed among this group.

The following conclusions can be drawn from this study:

1. Adults and teenagers who rely on a wheelchair as their major means of transportation can be prescribed wheeling intensities using the Borg category RPE scale.
2. When taught the notion of the scale during an arm-cranking exercise, these people select wheeling velocities that are higher than expected, based on their HR-on-RPE regression line as calculated from a maximal ergometer test. Since overestimation is consistent, the prescription should be adjusted so that the required HR can be reached.
3. Trained subjects seem to discriminate better among exercise intensities and utilize a greater range of exercise intensities than do the nonathletes.
4. Such an ability is retained by all subjects, irrespective of activity status, for at least one month after the original prescription.
5. At any RPE level, trained individuals chose wheeling velocities that are higher than those chosen by the untrained. However, the HR at each prescribed RPE does not depend on one’s training status.

References


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