COMPARISON OF THE RATING OF PERCEIVED EXERTION (RPE) AND CATEGORY-RATIO (CR-10) SCALES DURING INCREMENTAL EXERCISE

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Clinical Exercise Physiology

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College of Science and Health
Clinical Exercise Physiology

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COMPARISON OF THE RATING OF PERCEIVED EXERTION (RPE) AND CATEGORY-RATIO (CR-10) SCALES DURING INCREMENTAL EXERCISE.

By Reese Glover

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology.

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ABSTRACT

Glover, R. A. *Comparison of the rating of perceived exertion (rpe) and category-ratio (cr-10) scales during incremental exercise*. MS in Clinical Exercise Physiology, December 2018, 57pp. (C. Foster)

Rating of Perceived Exertion (RPE) and Category-Ratio (CR-10) scales are the most well-known methods for subjectively quantifying intensity during exercise. However, limited data exists comparing intraindividual correlation between RPE and CR-10 scales. Purpose: To evaluate intraindividual variability between RPE and CR-10 scales during maximal incremental exercise. Methods: 14 subjects (21.7±2.73 years) completed two randomly ordered graded exercise tests (GXTs) on a cycle ergometer separated by 48-hours. Heart rate (HR) and oxygen consumption (VO2) were measured. Subjective responses were recorded at the end of each stage using RPE and CR-10 scales. Regression analysis was used to examine the relationship between RPE and CR-10 scales. Results: Maximal values during RPE scale GXT: VO2max = 46.5±8.11 mL/kg/min, HRmax = 188.9±3.99 bpm; PeakPO = 240.6±46.43 watts; RPEmax = 18.7±0.87. Maximal values during CR-10 scale GXT: VO2max = 45.8±7.40 mL/kg/min, HRmax = 187.8±4.74 bpm; PeakPO = 241.9±48.97 watts; CR-10max = 9.3±1.18. The scales were strongly correlated (r=0.94). Conclusion: This study showed that RPE and CR-10 scales correlate on an intraindividual level, suggesting an interchangeable relationship.
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INTRODUCTION

‘Perfecting the art’ of exercise prescription is not an easy task, but the field of exercise physiology has come closer by incorporating the use of subjective tools to aid intensity quantification. Evidence suggests exercise has a dose-response relationship with premature morbidity and mortality and by meeting minimum physical activity recommendations, individuals can also minimize the presence of mood disorders, stress, and anxiety, and significantly reduce risk factors associated with the development of cardiovascular disease (Riebe, Ehrman, Liguori, & Magal, 2017; Arem et al., 2015).

The American College of Sports Medicine (ACSM) provides guidelines for frequency, intensity, duration (time), type, volume, and progression (FITTVP) needed to reach individual fitness goals (Riebe et al., 2017) as well as to provide basic recommendations that are safe for both general and patient populations. Although most aspects of the FITTVP principle are relatively easy to recommend, quantifying and prescribing intensity is more complex.

Typically, defining an appropriate exercise intensity involves conducting a maximal effort graded exercise test (GXT). Although useful to prescribe intensity, this method becomes challenging when there are limited personnel and equipment available. Accordingly, recommendations of appropriate intensity can be troublesome due to variability among individuals. This is especially problematic in patients who are taking
cardioactive medications and/or who have various pathologies. Therefore, it may be more suitable to utilize subjective tools, such as Rating of Perceived Exertion (RPE) and the Talk Test (TT) to monitor exercise intensity.

The RPE is a widely used method to quantify subjective intensity and homeostatic disturbance during exercise (Borg, 1982; Borg, 1998). Additionally, prescribing exercise using RPE as an alternative to previously mentioned measures, may lead to increased exercise adherence (Parfitt, Evans, & Eston, 2012). It has been accepted by the ACSM that the RPE scale, the Category-Ratio (CR-10) scale, the OMNI scale, and the TT, are all valid and effective means to generate the exercise prescription (Riebe et al., 2017).

The RPE and CR-10 scales remain the most widely used of a variety of RPE scales (Figure 1). Many studies have validated the relationship between the RPE scale and physiological variables such as heart rate (HR) and oxygen consumption ($\text{VO}_2$) (Borg, 1998; Noble & Robertson, 1996). Concurrent validity as it relates to blood lactate (BLa) and pulmonary ventilation, has also been established with the CR-10 scale (Borg, 1998; Noble, Borg, Jacobs, Ceci, & Kaiser, 1983; Noble & Robertson, 1996). Furthermore, the RPE and CR-10 scales have been shown to have high construct validity in various studies that have compared the scales on an interindividual level (Borg, 1998; E. Borg, 2001; Borg & Kaijser, 2006; Noble & Robertson, 1996). Although the scales were constructed to accomplish different functions, the high construct validity implies a regular relationship.

To compare the scales, Borg (1998) proposed a transformation table in which ratings could be transformed from the RPE and CR-10 scales. While experimental
evidence has not validated this scale transformation, Borg (2001) provided evidence supporting the proposed relationship between the scales.

A.  

<table>
<thead>
<tr>
<th>No exertion at all</th>
<th>Nothing at all</th>
<th>&quot;No P&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely light</td>
<td>Extremely weak</td>
<td>Just noticeable</td>
</tr>
<tr>
<td>Very light</td>
<td>Very weak</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>Weak</td>
<td>Light</td>
</tr>
<tr>
<td>Somewhat hard</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Hard (heavy)</td>
<td>Strong</td>
<td>Heavy</td>
</tr>
<tr>
<td>Very hard</td>
<td>Very strong</td>
<td></td>
</tr>
<tr>
<td>Extremely hard</td>
<td>Extremely strong</td>
<td>&quot;Max P&quot;</td>
</tr>
<tr>
<td>Maximal exertion</td>
<td>Absolute maximum</td>
<td>Highest possible</td>
</tr>
</tbody>
</table>

Figure 1. A. the RPE scale and B. the CR-10 scale. Adapted RPE scales (Borg, 1998).

It has been recognized that there is lack of agreement among those in the exercise physiology community of which scale and protocol to use to best determine perceptual responses to exercise (Borg & Kaijser, 2006). To refine exercise prescription, there should be a clear understanding of the transformation that can exist between the scales. With high concurrent and construct validity, the RPE and CR-10 scales, along with their verbal anchors, seem to correlate well on an interindividual basis. However, limited data exists directly comparing the intraindividual correlations among the RPE and CR-10 scales. Thus, the primary purpose of this study is to examine the intraindividual equivalence between the RPE and CR-10 scales during maximal incremental exercise.
METHODS

Subjects

The subjects were 14 recreationally active (exercising at least 3 days per week) healthy men and women from a university population (8 men, 6 women). Although participants were physically active, none were currently participating in competitive athletics. After approval from the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects, all subjects provided written informed consent. Prior to testing, subjects completed the American Heart Association (AHA) Health/Fitness Pre-Participation Screening form to determine contraindications or physical limitations that would prevent participation in the study. Subjects were tested >3-hour postprandial, refrained from alcoholic consumption and heavy exercise for 24 hours, and abstained from caffeine consumption 6 hours prior to testing.

All 14 participants successfully completed the testing protocol and were included in the data analysis of the present study. Resting HR, height, and weight were measured at baseline and are presented in Table 1.
Table 1. Descriptive Characteristics of Men and Women (N=14).

<table>
<thead>
<tr>
<th></th>
<th>Male (n=8)</th>
<th>Female (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>21.9±3.52</td>
<td>21.5±1.38</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180.3±5.96*</td>
<td>164.7±8.41</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>80.8±9.18*</td>
<td>63.9±7.75</td>
</tr>
<tr>
<td>VO(_2)max (mL/kg/min)</td>
<td>49.0±7.87</td>
<td>45.0±8.11</td>
</tr>
<tr>
<td>Heart rate max (bpm)</td>
<td>188±4.9</td>
<td>192±2.5</td>
</tr>
<tr>
<td>Peak power output (W)</td>
<td>271.9±31.34*</td>
<td>207.2±44.48</td>
</tr>
<tr>
<td>Max RPE 6-20</td>
<td>18.5±1.04</td>
<td>19.0±0.55</td>
</tr>
<tr>
<td>Max RPE CR-10</td>
<td>9.3±1.11</td>
<td>9.4±1.36</td>
</tr>
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Values represent mean ± SD.  
VO\(_2\), oxygen consumption; RPE, rating of perceived exertion; CR-10, Category-Ratio scale.  
*Significantly different than females (\(p<.05\)).
Experimental Design

Testing consisted of two GXTs conducted on an electronically braked cycle ergometer (Excalibur Sport, Lode, Groningen, Netherlands). The GXTs entailed 2-minute stages beginning at 25W with increments of 25W until volitional fatigue. Subjects were instructed to maintain a pedaling rate of 60-80 rotations per minute. Oxygen consumption was measured using open-circuit spirometry (MOXUS Metabolic Cart, AEI Technologies, Bastrop, TX). Maximal oxygen consumption (VO\textsubscript{2}\text{max}) was defined as the highest continuous VO\textsubscript{2} over a 30-second period. Heart rate was monitored throughout the test using radio-telemetry (Polar Electro Oy, Kempele, Finland).

Although identical in protocol, the order in which the RPE and CR-10 scales were used was randomized. Both tests were conducted within a 5-day period, with at least 48 hours between. Standardized instructions for the scales were read to the subjects prior to beginning each GXT (Borg, 1998). Rating of Perceived Exertion was obtained during the last 10 seconds of every stage of the GXT. Subjects continued cycling at 25-50W for 3-minutes after reaching volitional fatigue. After the 3-minute cool-down period, BLa was measured in a fingertip blood sample using dry chemistry (Lactate Plus, Nova Biomedical, Watham, MA). Maximal effort during the GXT was confirmed by a respiratory exchange ratio of $\geq$1.10, RPE of $\geq$17 (RPE) or $\geq$7 (CR-10), postexercise venous lactate concentration BLa of $\geq$8 mmol/L$^{-1}$, and fatigue. All subjects met all criteria for maximal effort.
**Statistical Analysis**

Standard descriptive statistics were used to describe the subject population. To compare differences between males and females, and independent groups t-test was performed using the Statistical Package for Social Sciences (SPSS) 25.0 software (SPSS Inc., Chicago, IL, USA). The RPE values were plotted against the CR-10 values using Microsoft Excel (2016; Microsoft Windows, Redmond, WA). Regression analysis was completed with a best fit correlation and 95% Coefficient Intervals (95% CI) to examine the relationship between the RPE and CR-10 scales. Concurrent validity was examined using simple linear regression between RPE and relative measures of exercise intensity such as percent heart rate reserve (%HRR) and percent VO$_2$max (%VO$_2$max). Individual %HRR was derived from max and resting HR and compared with both scales using linear regression. An average coefficient across all subjects was obtained using linear regression with both individual %HRR and %VO$_2$max plotted against the scales. A two-tailed Fisher’s r-to-z transformation was used to determine if there were significant differences between correlation coefficients. Alpha was set at .05 to achieve statistical significance.
RESULTS

Males were found to be significantly different than females in height, weight, and peakPO and are presented in Table 1. The RPE and CR-10 scales were found to be strongly correlated when compared at matched workloads (r=0.94). Corresponding RPE data, correlation coefficient, and a regression equation are presented in Figure 2. To compare their relationship, linear regressions of RPE and %HRR are presented in Figure 3 and Figure 4. The RPE and CR-10 scales were found to have a strong correlation with %HRR (r=0.89 and 0.87). The RPE scale and individual %HRR were found to have a high correlation (r=0.97) as an average coefficient across all subjects. Similarly, the CR-10 scale and %HRR were evaluated using linear regression for every subject and was also found to have a high average correlation (r=0.96). To examine RPE and its congruence with %VO2max, linear regressions are presented in Figure 5 and Figure 6. The RPE and CR-10 scales had a strong and high correlation with %VO2max (r=0.88 and 0.90). Rating of Perceived Exertion was also compared with individual %VO2max. Both scales and individual %VO2max were found to have a high correlation (r=0.97) as an average coefficient across all subjects. A two-tailed Fisher’s r-to-z transformation between correlation coefficients of physiological variables revealed no significant differences between the two scales (p>.05).
Figure 2. Comparison of the 6-20 rating of perceived exertion scale (RPE) and Category-Ratio (CR-10) \( (r=0.94) \) at individually matched workloads. A transformation equation derived from regression analysis is provided: \( y = 0.02x^2 + 0.1659x - 1.3221 \). An RPE of 13 (“Somewhat hard”) and RPE of 15 (“Hard (Heavy)”) correspond to an RPE of 4 and 5.5 on the CR-10 scale.
Figure 3. Relationship between %HRR and the 6-20 rating of perceived exertion scale (RPE) scale ($r=0.89$).

Figure 4. Relationship between %HRR and the Category-Ratio (CR-10) scale ($r=0.87$).
Figure 5. Relationship between %VO$_2$max and the 6-20 rating of perceived exertion scale (RPE) scale ($r=0.88$).

Figure 6. Relationship between %VO$_2$max and the Category-Ratio (CR-10) scale ($r=0.90$).
DISCUSSION

The purpose of this study was to investigate the variability among the intraindividual rating behavior of subjects while using the RPE and CR-10 scales during maximal GXTs. Randomly ordered, GXTs were performed using the RPE scale and the CR-10 scale. Accordingly, the study examined the construct variability between the RPE and CR-10 scales. Concurrent variability of the two scales as they related to HR and VO$_2$ was also assessed.

The scales were shown to have a high correlation at matched workloads ($r=0.94$). These findings are consistent with (Borg & Kaijser, 2006) comparing the RPE and CR-10 scale with a mean best-fit correlation of about $r=0.98$. Concurrent variability with the RPE and CR-10 scales and %HRR indicated strong relationships ($r=0.89$ and 0.87), and high average correlations were observed with %HRR ($r=0.97$ and 0.96). Comparable correlation coefficients between the RPE scales and HR were reported by Borg and Kaijser (2006) ($r=0.91-0.99$). Similarly, %VO$_2$max was found to have a strong and high correlation with the RPE and CR-10 scales ($r=0.88$ and 0.90). Several studies that have compared the RPE and CR-10 scales and have also shown high construct and concurrent validity (Borg, 1998; E. Borg, 2001; Noble et al., 1983; Noble & Robertson, 1996). With a highly regular relationship, it implies that the scales can be used interchangeably.
For exercise practitioners, prescribing appropriate intensities can be difficult. As recommended by the ACSM, RPE is useful to refine exercise prescription, but is not suggested to be its *primary* guide (Riebe et al., 2017). However, prescribing exercise using RPE as an alternative may lead to increased exercise adherence. Training at an RPE of 13 has been reported to increase aerobic fitness while giving exercisers a sense of autonomy and enjoyment (Parfitt et al., 2012). In the present study, it was found that an RPE of 13 on the RPE scale equates to an RPE of approximately 4 on the CR-10 scale.

The transformation equation and lines illustrating the relationship of an RPE of 13 (“Somewhat hard”) to an RPE of 4 are found in Figure 2. In agreement with Borg (2001), these findings support a theoretical relationship and if comparisons are of interest, the scales can be transformed with a transformation equation.

The results of the present study are not fully consistent with Borg’s previously postulated transformation table (Borg, 1998). Subjects were instructed to rate above an RPE of 6 on the RPE scale and above 0 on the CR-10 scale as the ratings are associated with no physical exertion at all. When applying the transformation equation to the RPE of 6 on the RPE scale, it is assumed to be equivalent to an RPE of 0 on the CR-10 scale since no physical stimuli is present. Numbers were systematically rounded to the nearest half to allow for easy comparisons between the transformation table presented by Borg (1998) and the transformation table created with data from the present study, see Figure 11.
The common semantic descriptor “Somewhat hard” (RPE of 13), correlates to 50-70% of VO\(_2\)max, which may serve to improve aerobic fitness (Parfitt et al., 2012). When evaluating the transformation table and an RPE of 13, Borg (1998) suggested that an RPE of 3.5 to correspond with an RPE of 13, unlike the findings of the present study in which an RPE of 13 corresponded to an RPE of 4. This perceptual intensity lies between the verbal descriptors of “Moderate” and “Strong” on the CR-10 scale (RPE of 3 and 5). Unlike an RPE of 4 which is positioned along the CR-10 Scale, the RPE of 3.5 is not. Although the CR-10 scale allows users to rate all along its continuum, a visible rating option may simplify exercise prescription as it is helpful for users to see the number on the CR-10 Scale. When examining an RPE of 15 (“Hard (Heavy)” on the RPE scale, the
verbal anchors of the scales would more likely indicate a relationship between an RPE of 15 and an RPE of 5 (“Strong (Heavy)”) on the CR-10 scale. However, in the present study an RPE of 15 corresponds to an RPE of 5.5 on the CR-10 scale. Interestingly, this can be observed in both transformation tables. The infrequency of rating above an RPE of 10 on the CR-10 scale may be attributed to the active subjects who were tested. Collectively, 3 out of 14 subjects rated above an RPE of 10 with a maximal recorded RPE of 11. The physically active subjects who were tested in this study may explain why an RPE of 20 equates to an RPE of 10 on the transformation table of the present study. These individuals could be accustomed to heavy exertion; thus, the stimulus may not have been enough to elicit a rating exceeding 10.

The present study had several limitations. Although the statistical analysis yielded a high correlation between the scales at matched workloads, data was collected from a small sample size (N=14). Therefore, there may not have been enough subjects to truly detect significant differences between rating behaviors while using the two scales. Thus, the findings of the present study will need to be confirmed in a larger study. The replication of this study with a larger sample size and with more heterogenous participants may serve to strengthen the results of the present study (Chen, Fan, & Moe, 2002).

As participants were generally unfamiliar with the scales, standardized instructions were read to subjects prior to beginning each GXT (Borg, 1998). Influences of instruction can play a large role in the understanding of each scale and the subsequent rating behavior. Although the instructions emphasize the use of the verbal anchors, subjects seemed to rate in a linear behavior with both scales. This could be due to an
altered understanding of the scales. Individual differences in working capacity could have contributed to errors in the transformation table, as peak PO ranged from 143.8W to 312.5W across subjects. As intensity increased, physiological and perceptual data available for comparison became limited dependent upon the individual’s maximal capacity.
CONCLUSION

The present study found that subjects rated in a highly relatable fashion when comparing the RPE and CR-10 scales. The results of this study also suggest that to train at an intensity equivalent to an RPE of 13, exercisers should rate an RPE of 4 on the CR-10 scale. Future research should be conducted to confirm the “pleasantness” of training at an RPE of 4 on the CR-10 scale, as there may be implications to review the transformation table presented by Borg (1998). Also, studies may want to focus on subjects with similar or high working capacities. Along these lines, there may be a need to explore the intraindividual variability of the scales in sedentary or older individuals.
REFERENCES


APPENDIX A

INFORMED CONSENT
INFORMED CONSENT FOR “Comparison of Rating of Perceived Exertion (RPE) and Category-Ratio (CR-10) scales during incremental exercise”

Principal Investigator: Reese Glover
UW-La Crosse
738 Hillview Avenue
La Crosse, WI 54601
507-696-5160

1. I, ________________________________, give my informed consent to participate in this study designed to compare two widely used rating of perceived exertion scales for measuring exercise intensity during training. I have been informed that the study is under the overall direction of Carl Foster, Ph.D. who is a professor in the Department of Exercise and Sport Science at the University of Wisconsin-La Crosse. I consent to the presentation, publication and other release of summary data from the study which is not individually identifiable.

2. I have been informed that my participation in this study will require me to:
   a) Perform, on several occasions, workouts on an exercise bicycle from submaximal up to maximal training sessions of ~30 minutes duration, in which interval exercise with varying workloads will be performed
   b) Wear a scuba breathing value that allows the investigators to measure my metabolic rate
   c) Wear a chest strap that transmits my heart rate via radio waves to a specialized wristwatch
   d) Have several small blood samples taken from my finger tip

3. I have been informed that there are no foreseeable risks associated with this study other than the fatigue associated with heavy exercise and the discomfort wearing the breathing value and providing the fingertip blood samples.

4. I have been informed that there are no primary benefits to myself other than knowledge about my fitness. Based on the results of this study, exercise professionals may be able to better guide the training of exercisers.

5. I have been informed that the investigator will answer questions regarding the procedures throughout the course of the study.
6. I have been informed that I am free to decline to participate or to withdraw from the study at any time without penalty.

7. Concerns about any aspect of this study may be referred to Reese Glover at 507-696-5160, the principle investigator, or his advisor Dr. Carl Foster at 608-785-8687. Questions about the protection of human subjects may be addressed to Dr. Bart Vanvoorhis, Chair of the UW-L Institutional Review Board at 608-785-6892.

Investigator: ___________________________ Signature: ___________________________
Date: __________________________

Participant: ___________________________ Signature: ___________________________
Date: __________________________
APPENDIX B

AMERICAN HEART ASSOCIATION HEALTH/FITNESS FACILITY PRE-PARTICIPATION SCREENING
American Heart Association
Health/Fitness Facility Pre-Participation Screening

Assess your health needs by making all TRUE statements.

History

You have had:

☐ A heart attack
☐ Heart surgery
☐ Cardiac catheterization
☐ PTCA
☐ Pacemaker/ICD/rhythm disturbance
☐ Heart valve disease
☐ Heart failure
☐ Heart transplantation

If you have marked any of the statements at the left, you should consult your health care provider before engaging in exercise. You may need to use a facility with medically qualified staff.

Symptoms

You experience:

☐ Chest discomfort with exertion
☐ Unreasonable breathlessness
☐ Dizziness, fainting, blackouts
☐ You take heart medications

CV Risk factors

☐ You are a male and over 45
☐ You are a postmenopausal female not on estrogen therapy
☐ You smoke
☐ You blood pressure is >200
☐ You don’t know your cholesterol
☐ You have a blood relative who has heart problems
☐ You are a diabetic
☐ You are physically inactive
☐ You are more than 20 pounds overweight

If you check two or more of the following, you should consult your health care provider before engaging in exercise. You should probably use a facility with a professionally qualified exercise staff.

Other health issues

☐ You have musculo-skeletal problems
☐ You have concerns about the safety of exercise
☐ You take prescription medication
☐ You are pregnant

☐ None of the above is true

You should be able to exercise safely without needing to consult with your health care provider in almost any facility that meets you exercise program needs.
APPENDIX C

RPE SCALE
6  No exertion at all
7  Extremely light
8  Very light
9  Light
10
11  Somewhat hard
12
13  Hard (heavy)
14
15  Very hard
16
17  Extremely hard
18
19  Maximal exertion
APPENDIX D

RPE SCALE INSTRUCTIONS
RPE Scale Instructions

While exercising we want you to rate your perception of exertion, i.e., how heavy and strenuous the exercise feels to you. The perception of exertion depends mainly on the strain and fatigue in your muscles and on your feeling of breathlessness or aches in the chest.

Look at this rating scale; we want you to use this scale from 6-20, where 6 means “no exertion at all” and 20 means “maximal exertion.”

<table>
<thead>
<tr>
<th></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>15</td>
<td>Hard (heavy)</td>
</tr>
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<td>17</td>
<td>Very hard</td>
</tr>
<tr>
<td>19</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>20</td>
<td>Maximal exertion</td>
</tr>
</tbody>
</table>
corresponds to “very light” exercise. For a normal, healthy person it is like walking slowly at his or her own pace for some minutes on the scale is “somewhat hard” exercise, but it still feels OK to continue. “very hard” is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired. on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Don’t underestimate it, but don’t overestimate it either. It’s your own feeling of effort and exertion that’s important, not how it compares to other people’s. What other people think is not important either. Look at the scale and the expressions and then give a number.

Any questions?
APPENDIX E

CR-10 SCALE
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
<td>“No P”</td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Extremely weak</td>
<td>Just noticeable</td>
</tr>
<tr>
<td>1</td>
<td>Very weak</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Weak</td>
<td>Light</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Strong</td>
<td>Heavy</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very strong</td>
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</tr>
<tr>
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</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Extremely strong</td>
<td>“Max P”</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>~</td>
<td></td>
<td>Absolute maximum</td>
</tr>
<tr>
<td>●</td>
<td>Absolute maximum</td>
<td>Highest possible</td>
</tr>
</tbody>
</table>
APPENDIX F

CR-10 SCALE INSTRUCTIONS
CR-10 Scale Instructions

We want you to rate your perception of exertion, that is, how heavy and strenuous the exercise feels to you. The perception of exertion depends mainly on the strain and fatigue in your muscle and on your feeling of breathlessness or aches in the chest.

We want you to use this scale from 0 to 10 and “•”, where 0 means “no exertion at all” and 10 means “extremely strong – max P”, that is, the maximal exertion you have previously experienced.

1 corresponds to “very light” exercise. For a normal, healthy person it is like walking slowly at his or her own pace for several minutes.

3 on the scale is “moderate” exercise, it is not especially hard, it feels fine, and it is no problem to continue exercising.

5 corresponds to “heavy” exercise; it feels hard and you are tired, but you don’t have any great difficulties in going on.

7 is “very hard” and very strenuous. A healthy person can still go on but he or she has to push him- or herself a lot. It feels very heavy and the person is very tired.

10 on the scale is an extremely strenuous exercise level. It is “max P”. For most people this is an exercise as strenuous as they have ever experienced before in their lives.

• The dot denotes a perceived exertion that is stronger than 10, “extremely strong.” It is your “absolute maximum,” for example, 12, 13, or even higher. It is the highest possible level of exertion.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Don’t underestimate it, but don’t overestimate it either. It’s your own feeling of effort and exertion that’s important, not how it compares to other people’s. What other people think is not important either. Look at the scale and the expressions and then give a number.

What “max exertion” – your “max P” – have you previously experienced in your life? Use that a “10”.

Any further questions?
APPENDIX G

REVIEW OF RELATED LITERATURE
The purpose of the paper is to review the literature surrounding the basis of Rating of Perceived Exertion (RPE), more specifically, the comparison between the 6-20 RPE (RPE scale) and the 0-10 Category-Ratio (CR-10 scale) scales; and the equivalence of the verbal descriptors anchored to the scales.

**Exercise prescription**

Whether in a rehabilitation, fitness, or athletic training program, individuals exercise to look, feel, and perform better. Numerous exercise and training studies have shown the benefits of physical activity (PA) and its impact on health and performance. While evidence suggests that exercise has a dose-response relationship, by simply meeting minimum PA recommendations, individuals can decrease the risk of premature morbidity and mortality, minimize the presence of mood disorders, stress, and anxiety, and attenuate cardiovascular disease (CVD) along with its risk factors (Riebe, Ehrman, Liguori, & Magal, 2017; Arem et al., 2015). Leading a sedentary lifestyle is considered a major risk factor for the development of CVD, and it has been reported that a low aerobic exercise capacity may be a strong predictor of premature mortality (Myers et al., 2002). Guidelines reported by the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) are in place to allow exercise practitioners to provide basic recommendations that are safe for both general and patient populations (Balady et al., 1998).

Within these guidelines, the ACSM recommends frequency, intensity, duration (time), type, volume, and progression (FITTVP) needed to reach individual fitness goals.
(Riebe et al., 2017). The FITTVP principle embodies the elements of exercise prescription, and by incorporating these variables, individuals are likely to obtain the benefits of exercise and PA. Although most aspects of the FITTVP principle are relatively easy to recommend, quantifying and prescribing intensity is more complex.

**Limitations of quantifying intensity.** Intensity of exercise can be quantified mechanically by measuring power, torque, and velocity. Monitoring intensity in this way is highly objective and simple to replicate with the same modality. However, multiple modalities require different units of measure, making replication difficult (Wolff, 2000). Intensity can also be interpreted by absolute or relative percentages (Borg, 1998). During a graded exercise test (GXT), heart rate (HR), oxygen consumption (VO$_2$), metabolic equivalents (METs), heart rate reserve (HRR), oxygen uptake reserve (VO$_2$R), and various other measures are recorded to help determine appropriate exercise intensity (Riebe et al., 2017). The HRR method, developed by Martti Karvonen in 1957, is widely used to prescribe a therapeutic range of intensity during exercise. Although useful to prescribe intensity, relative percentages become challenging to obtain when there are limited personnel and equipment to conduct a maximal effort GXT. Accordingly, recommendations of appropriate intensity can be troublesome due to variability among individuals. This is especially problematic in patients who are taking cardioactive medications and/or who have varying pathologies. ‘Perfecting the art’ of exercise prescription is not an easy task, but the field of exercise physiology has come closer by incorporating the use of subjective tools to quantify intensity.

**Subjective measures.** The field of exercise physiology is becoming more dependent upon subjective measures of intensity to complement objective variables to
monitor intensity during exercise. It has been established by the ACSM that the Borg RPE Scales, OMNI Scales, and the Talk Test, are all valid and effective means to generate the exercise prescription (Riebe et al., 2017). Session rating of perceived exertion (sRPE), developed by Foster et al. (1995), has also been accepted as a method to assess training load and has shown a valid relationship between HR and blood lactate. Evidence also suggests that the use of RPE may contribute to greater exercise adherence.

Interestingly, it has been found that training at a 13 on the RPE scale, equivalent to a “somewhat hard” intensity, is both beneficial and enjoyable (Parfitt, Evans, & Eston, 2012). Simply training at a pleasant, yet challenging, intensity will improve cardiovascular fitness and may lead to long term exercise adherence. This provides evidence suggesting that RPE may be a superior method when prescribing intensity. Gunnar Borg (1998), the founder of RPE, defined perceived exertion as, “the degree of heaviness and strain experienced in physical work as estimated according to a specific rating method” (p. 9).

**Rating of Perceived Exertion**

Rating of perceived exertion is a widely used method to quantify subjective intensity and homeostatic disturbance during exercise (Borg, 1982; Borg, 1998). It is common practice to use RPE in tandem with other physiological variables to monitor exercise training in patients, athletes, and healthy adults. These rating scales have gained popularity in clinical settings, especially in cardiac rehabilitation, where they are commonly used as a supplemental aid while performing GXTs and is a subjective tool in
prescribing an appropriate exercise intensity for clinical populations. It is used to predict exercise capacity, analyze changes in training, and to assess performance in both athletes and healthy individuals.

**Verbal anchors.** The RPE is influenced by an array of physical factors involving muscular and pulmonary fatigue, age, and thirst, and psychological factors such as mood and experience with the exercise task (Chen, Fan, & Moe, 2002; Riebe et al., 2017). This dynamic process of perception is reliant on feedback from the sensory organs communicating with the brain and contributes to the judgement of a given intensity level (G. Borg & E. Borg, 2001). The use of verbal anchors on RPE scales, allows for comparisons between individuals based on an agreed understanding and meaning of the anchors. Language and personal experience play a large role in the position of the verbal descriptors along the scale. Although intensities may be given in numbers, G. Borg and E. Borg (2001) explain the discrepancy between the numbers and verbal anchors along the scale, “There is, however, no direct connection between perceptual intensities and numbers as there is for verbal expressions” (p. 17). Thus, adjectives and adverbs are anchored to numbers to understand a conceived magnitude, based upon similar experiences among individuals to determine intensity. It is critical to maintain “congruence between numbers and anchors” by using the systematic principles involved in category-ratio scales (E. Borg, 2011). Although RPE is a seemingly simple concept, it is molded in the more complex fields of psychology and physiology (Noble & Robertson, 1996).
Historical Grounding

Psychophysics and its subfield of scaling have built the foundation for RPE, as it involves human perceptual responses in the presence of physical stimuli (Borg, 1998). The earliest studies of psychophysics and sensory perception were conducted in the early 1830’s by the German physiologist, Ernst Heinrich Weber, who would later inspire physicist and philosopher, Gustav Theodor Fechner. Subsequent studies would involve sensory perception as it relates to physical stimuli, and Fechner would go on to coin the term of “psychophysics” in the 1860’s. Nearly 100 years later, the concept of RPE would be introduced, in the late 1950’s.

Gunnar Borg, a Swedish psychologist, began to conceptualize the idea of perceptual scaling with his colleague Hans Dahlström during their initial studies involving perceived exertion in heavy physical work in 1958 and 1960 (Borg, 1982; Borg, 1998). Borg’s work was inspired by the ratio scaling methods developed by S.S. Stevens and his collaborators at Harvard. With the use of power functions and scaling, Stevens developed the first method to mathematically describe increases in perception, or magnitude estimation (G. Borg & E. Borg, 2001; Noble & Robertson, 1996). Their work made it possible to adjust the position of verbal anchors to allow scales to grow linearly (G. Borg & E. Borg, 2001). Although, their studies focused mostly on sensory perception rather than fatigue and the sense of perceived exertion. These scaling methods suffered the inability to make intra- or interindividual comparisons, which are of high importance when considering the clinical and research applications of perceptual scaling (Borg, 1982). To correct for this problem, Borg adapted Stevens’ power law and created
a category scale, now referred to as the 6-20 RPE scale (RPE scale). The 1960’s became a pivotal time in the advancement of perceived exertion and exercise science.

At the same time RPE emerged, utilization of treadmills and cycle ergometers for clinical and research use began to expand (Noble & Robertson, 1996). To observe the overall “Gestalt” of perceived exertion during exercise, involving both central factors and local factors, such as the cardiopulmonary and musculoskeletal systems, Borg made his first attempt at a category scale (Borg, 1998; Borg & Kaijser, 2006). He created a 21-grade scale with common verbal descriptions that were specifically assigned to odd numbers on the scale to determine appropriate perceptual responses (Noble & Robertson, 1996). Under the assumption that exertion and physiological strain grows linearly with exercise intensity, the scale was designed to align closely with HR due to its inherent relationship with strain. Behind this concept, HR could be predicted by multiplying RPE by 10. Instead, various studies indicated that there was a nonlinear relationship with HR and ratings as workload increased (Borg, 1998; Noble & Robertson, 1996).

**RPE scale.** Subsequently, Borg developed a 15-grade scale that differed in verbal expressions and grew linearly with workload and HR. This 6-20 scale corresponded to a linear growth function and represented its relationship to HR in its numbering, even though it maintained the previously inaccurate HR prediction assumption as the 21-grade scale (Noble & Robertson, 1996). Borg first presented this scale in 1966 at a clinical physiology seminar in Sweden and, in 1967, would collaborate with researcher Bruce Noble at the University of Pittsburgh. This visit encouraged Noble, who in turn, contributed to the concept’s widespread use for stress testing in the United States. Although Borg would make slight changes to the verbal anchors of the 15-grade scale in
the early 1980’s, this scale has become widely accepted and more commonly known as the RPE scale.

However, the RPE scale has certain drawbacks to its use. As the scale was created to measure whole body perception of exercise, it showed poor correspondence to lactate accumulation and pulmonary ventilation which have a positively accelerating curve when compared to power output (Noble & Robertson, 1996). Additionally, the 6-20 scale denied itself as a true ratio scale due to the absence of an absolute zero as well as issues concerning absolute ceiling effects, all which needed to be addressed (Borg, 1998). To correct for these limitations, Borg began the construction of a category scale with ratio properties in the early 1970’s (Borg, 1998).

**CR-10 scale.** In 1975, Borg presented his initial version of a category-ratio (CR) scale during the first international symposium on perceived exertion held in Stockholm (Borg, 1998). The constructed scale was a 0-20 scale that included the subjective expressions anchored in their correct position along the scale and a known exponent of 1.6 which is commonly found with muscular effort (Borg, 1982; Borg, 1998; Noble & Robertson, 1996). The scale functioned well but there was a need to simplify. Ultimately, the CR-10 scale was created. It used a simple numerical range of 0-10, which encouraged the use of decimals, and allowed for ratings above 10 (Borg, 1982; Borg, 1998). The scale was also associated with a power function, growing with an exponent of 1.6 and has been shown to correlate to “local” factors like blood lactate. Borg (1998) describes administration of CR-10 scale, “It has a great potential for testing not only sensory perceptions, but also attributes of more complex character, such as well-being, discomfort, beauty and utility, and difficulty of daily performances related to risk
assessments” (p. 49). Accordingly, the CR-10 scale has a variety of unique applications but has more traditionally been used as a pain and dyspnea scale. More recently, the CR100 scale (centiMax) was developed with the same CR properties but functions as a fine graded scale (G. Borg & E. Borg, 2001; E Borg & Kajser, 2006). Although, the CR-10 scale continues to be the most popular of the CR scales due to its simplicity.

As the 1960’s served as a time for growth in scientific research surrounding RPE and exercise science, in 1975 a wealth of knowledge was compiled in the first edition of the ACSM Guidelines. Those interested in exercise could use these guidelines as a viable resource, and it paved a path for those entering the field of exercise physiology. Methods of quantifying training load became of interest during the same time, and with nearing technological advances in field equipment in the 1980’s, exercise science was heading towards an exciting place for research. Only 12 years after its implication, RPE was quickly becoming one of the biggest fields within applied psychophysics (Borg, 1998).

**OMNI scale.** Due to high interest in the perceptual responses to exercise, over the years scales have been modified and have taken on many variations. Scales such as the CERT, BABE, CALER, OMNI, and E-P Scale, have been developed for children by simplifying previous RPE scales to either 1-10 or 0-10 scales with wording that is more familiar to younger aged individuals (Eston, 2012). The OMNI scale, termed after the word *omnibus*, has generally been recognized as a popular and valid scale for assessing RPE across a wide range of populations and modalities (Riebe et al., 2017; Haile, Gallagher, & Robertson, 2014; Mays et al., 2010; Utter et al., 2004). In the early 1990’s, the OMNI scale was developed and validated by Robertson and his colleagues, first for children, but more recently for adults across various modes of exercise (Haile, Gallagher,
& Robertson, 2014; Mays et al., 2010; Utter et al., 2004). A more familiar range of 0-10 and simplified semantic descriptors created an easy scale for children to use and was unique in that it followed a picture system of certain modalities of exercise. The scale has been shown to mimic the RPE scale in a positive linear function with metabolic and circulatory responses to exercise (Mays et al., 2010; Utter et al., 2004). Another scale was developed in 1995, modifying the CR-10 scale that would have several implications for training in athletes.

**Session RPE.** Looking back to the 1970’s, Banister developed the concept of training impulse (TRIMP) for training load in attempt to understand the proper intensity and duration of training needed to produce optimal results for athletes (Calvert, Banister, Savage, & Bach, 1976). By combining certain elements of training, it allowed coaches and athletes to view their training load in a single term (Foster et al., 2001). Although the concept involved difficult methods of monitoring and calculating HR along with other variables like duration. Researchers who asked the question, “How was your workout Honey?” would simplify methods of obtaining a TRIMP score (Foster, Daines, Hector, Snyder, & Welsh, 1996). Session RPE was then created to represent an entire training session as a “global rating of intensity” and subsequent studies would show its use as practical tool to monitor training with a wide variety of exercise sessions (Foster, Daines, Hector, Snyder, & Welsh, 1996; Foster et al., 2001; Foster et al., 1995; Foster, Heimann, Esten, Brice, & Porcari, 2001; Foster et al., 2012; Foster, Rodriguez-Marrooyo, & de Koning, 2017).

Foster et al. (1995) modified the verbal anchors of the CR-10 scale to denote simple American English where the verbal expressions “light” became “easy” and
“strong” or “severe” became “hard”. The scale provided relatively the same information as the more complicated TRIMP method for calculating training load and had good correspondence with the behavior of HR and blood lactate transition periods (Foster et al., 1995). Along with sRPE, additional scales have been developed over the past 20 years that have further applications for both athletes and others.

The Estimated Time Limit and the Task Effort and Awareness Scales involve RPE as a feedback mechanism controlled centrally in the brain (Eston, 2012; Foster et al., 2012). By regulating the rate of energy expenditure, humans control the amount of homeostatic disturbance occurring in the body during exercise (Foster et al., 2012a; Foster et al., 2012b). The scales previously mentioned are highly involved in pacing strategies. The concept of a “hazard score”, or the product of RPE and percentage of distance remaining during an activity plays a role in changing velocity, which has been found in both athletes and patients (Eston, 2012; Foster et al., 2012a; Foster et al., 2012b).

**Lack of agreement and standardization.** As research interest has grown, many scales have been developed each with numerous applications. The RPE and CR-10 scales remain to be the most well-known and commonly used rating scales for both clinical use and research questions (Borg & Kaijser, 2006; Eston, 2012). It has been recognized that there is lack of agreement among those in exercise physiology of which scale and protocol to use to accurately determine perceptual responses to exercise (Borg & Kaijser, 2006).
**Concurrent Validity**

Both the RPE scale and CR-10 scale, have their place in practice. The RPE scale is relatively easy to understand and its linear relationship with HR is simple to interpret, but if this relationship is lost the scale loses its advantages (Borg E. & Kaijser, 2006). Their fundamental difference is that the CR-10 scale has a positively accelerating growth function, which has been said to reflect the response to exercise more accurately (Borg, 1998).

**RPE scale: Concurrent validity.** Many studies have validated the concurrent relationship between the RPE scale and physiological variables such as VO$_2$ and HR (Borg, 1998; Noble & Robertson, 1996). The RPE scale is generally accepted as a method to assess sensations of exertion and it can be used to predict a given HR or percentage of VO$_2$. It has been postulated that an estimation-production paradigm can be used to prescribe a RPE that corresponds to a given HR, VO$_2$, or blood lactate value (production mode) reported from a prior GXT (Eston, Faulkner, Mason & Parfitt, 2006). As an example, Noble and Robertson (1996) described a study in which RPE was “clamped” at 13 during a treadmill test and during a separate training session. It was found that HR did not differ between the two tests, thus providing evidence that RPE can be prescribed to regulate intensity. In two studies conducted by Eston, Faulkner, Mason, and Parfitt (2006) and Eston et al. (2012), researchers tested individuals with perceptually regulated exercise tests (PRETs). Instead of a GXT in which subjects have no control of speed or gradient, during PRETs subjects can change speed or gradient until certain RPEs are obtained. Rating of Perceived Exertion was clamped at defined ranges and were extrapolated to estimate VO$_2$ max.
Eston et al. (2006) tested physically active men and women on a cycle ergometer to assess the validity of predicting VO$_2$max with self-regulated incremental exercise tests at given RPE ranges during 2- or 4-minute durations. Different durations were assigned to test the hypothesis that exercise performance is controlled centrally in the brain which is thought to balance homeostasis by calculating the metabolic demands of the exercise task and the duration. Pacing strategy ultimately lead to a lower VO$_2$max prediction in the 4-minute protocol due to subjects choosing to work at a lower rate of work. It was reported that the 2-minute protocol, extrapolated to an RPE of 20 from the 9-15 range was the most accurate in predicting VO$_2$max when compared directly to a GXT.

In a follow up study, Eston et al. (2012) analyzed both sedentary and active individuals on a treadmill using a PRET to test the validity of predicting VO$_2$peak. Ratings of perceived exertion were anchored at their corresponding numbers along the scale. Heart rate, RPE and the VO$_2$ data that were extrapolated from these anchors, were used to estimate VO$_2$peak at an RPE of 19 (commonly reported maximum) and 20 (theoretical maximum). Data that were extrapolated was then compared to a direct measure of VO$_2$peak from a GXT. It was found that VO$_2$peak was most accurately estimated by extrapolating to an RPE of 19 with the perceptual range of 9-15 in individuals of varying fitness levels.

These studies demonstrate the validity of estimating VO$_2$peak with an initial submaximal PRET in both active and sedentary individuals, prior to completing a GXT. Also, concurrent validity was further established with the RPE scale. Various studies have validated the use of RPE in extrapolating to a theoretical end-point and have
suggested that RPE may be more useful than HR when predicting maximal exercise capacity (Eston, 2012).

**CR-10: Concurrent validity.** Concurrent validity as it relates to blood lactate and pulmonary ventilation, has also been established with the CR-10 scale (Borg, 1998; Noble, Borg, Jacobs, Ceci, & Kaiser, 1983; Noble & Robertson, 1996). To assess the relationship between the CR-10 scale, muscular fatigue, blood lactate and HR, Noble, Borg, Jacobs, Ceci, and Kaiser (1983) tested male subjects during a GXT on a cycle ergometer. To examine multiple perceptual factors, leg effort, cardiorespiratory effort, and leg pain, were assessed as three different RPEs during the work test. It was reported that RPE exhibited a positively accelerating curve with power output. While HR was shown to increase in a linear fashion, blood and muscle lactate followed a similar path as RPE and corresponded to the scales original construction with a positively accelerating curve. Similar findings were reported by Borg and Kaijser (2006) in which a combination of HR and blood lactate contributed to ratings on the CR-10 scale.

**Construct Validity**

The RPE and CR-10 scales are different in their construction and are meant to accomplish separate functions, although, Borg (1998) postulates that the two scales can be compared using a rough transformation table. Furthermore, the RPE and CR-10 scales have been shown to have high construct validity in various studies that compare the scales (Borg, 1998; Noble & Robertson, 1996).
In a study involving a comparison between the RPE and CR-10 scales, Borg and Kaijser (2006) tested healthy men and women on a cycle ergometer to assess the construct validity between the scales. Subjects were divided and assigned to a RPE and CR-10 scale group. After data was collected, the RPE and the CR-10 scales were compared using regression analysis. The scales were shown to have a high construct validity with mean individual correlations of $r=0.98$. However, no intraindividual correlations could be obtained because the psychophysical scales separated the groups. Some deviations from linearity were observed when the scales were compared to HR, but this could be due to the short increments that were assigned.

In a related study, Borg (2001) compared the RPE and CR-10 scales during increasing workloads to volitional exhaustion on a cycle ergometer. Subjects including men and women, were divided into four groups in which two used the RPE scale and the remaining two used the CR-10 scale. It was reported that when plotted against each other, the RPE and the CR-10 scale can be expected to have a slightly negatively accelerating function (E. Borg, 2001). This is due to their differences in construction. The scales were shown to correlate and a transformation equation supporting the theoretical relationship between the scales was also determined: $\text{RPE} = 6 + 2.8(\text{CR10} - .03)^{0.79}$. Each scale tends to resonate in its purpose in that they follow the physiological measures intended in their original construction. Although, there is ample evidence to suggest that the RPE and CR-10 scales have a high construct validity and correlate well on an interindividual level.
Summary

Defining an appropriate exercise intensity has traditionally involved costly methods, and variability among individuals, especially clinical patients, makes measurements challenging. Subjective measures, such as the RPE, seem to be a more useful tool for exercise prescription and monitoring intensity. Additionally, prescribing exercise using RPE as an alternative to previously mentioned measures, may lead to increased exercise adherence.

The history of RPE is robust in nature. It has served the field of exercise physiology well as a method to monitor, prescribe, and regulate intensity, and to assess training load. In the presence of various scales, the RPE and CR-10 scales remain the most prevalent of RPE scales. Although, there is a need for standardization and agreement among exercise professionals who are working in rehabilitation or training programs in which utilize RPE. With high concurrent and construct validity, the verbal anchors of the scales seem to correlate well. However, limited data exists that compares the intraindividual correlations among the RPE and CR-10 scales. Thus, there is a need for more research surrounding the equivalence of the RPE and CR-10 scales to determine the intraindividual variability in perceptual rating behavior.
REFERENCES


