Concurrent Validation of OMNI Rate of Perceived Exertion 
Colour-Face Scale in Young Adults- NIEjr01

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ABSTRACT

The OMNI Rate of Perceived Exertion Scales have been validated across different age groups, genders, ethnicities, but it can be revised for greater user inclusivity. **Purpose:**

The aim of this study is to establish the concurrent validation of OMNI Rate of Perceived Exertion Colour-Face Scale on healthy male and female adults. **Methodology:**

20 subjects, 10 males and 10 females, participated in the investigation. The session involved a discontinuous submaximal graded exercise test. The submaximal treadmill test functions on a 4 minutes cycle at 1:1 work rest ratio. The treadmill started at 6km·h⁻¹ and increased at of 0.5km·h⁻¹ per work stage. During the work stage, oxygen uptake was obtained via the metabolic cart. Both heart rate and perceived exertion were recorded and at the last 15 seconds of each work stage. The test was terminated upon volitional exhaustion. **Results:**

Significant positive linear regression was observed between heart rate (r = 0.78, p = 0.00) and oxygen uptake (r = 0.81, p = 0.00) with perceived exertion ratings OMNI Ratings of Perceived Exertion Colour-Face Scale. **Conclusion:**

Concurrent validity is established for OMNI Rate of Perceived Exertion Colour-Face scale on healthy male and female adults.

1 INTRODUCTION

Regular physical activity is vital in the prevention of chronic diseases such as cardiovascular disease, diabetes, cancer, hypertension, depression, obesity and osteoporosis [20]. There are different ways of monitoring exercise intensity such as the use of heart rate (HR) range or perceived exertion scale. The latter is an easier and more accurate option given the extensive validation of the OMNI Rate of Perceived Exertion Scale (RPE) [4]. However, the monochrome scale that is duplicated for different exercise types and age groups (adults and children) can be modified to ensure greater outreach to users of different cognitive abilities. The modified OMNI RPE scale will include colours and use of facial expressions. Colours have been shown to improve learning and memory retention. The use of facial expression is a common feature across pain scales. Both new features have been analysed independently on various perceived exertion scales and the results were promising. Hence, the newly developed OMNI RPE Colour-Face Scale (CFS) that includes both new features will be validated in this study (Figure 1).

The study aims to establish construct validation of the OMNI RPE CFS with healthy male and female adults. This investigation covers the construct validity of the OMNI RPE CFS where the physiological variables, HR and oxygen uptake (VO₂) will be regressed against RPE obtained from the experimental group. The construct validity will be conducted in a laboratory. The result of the study does not represent information for outdoor settings.

Through our investigation, we have made multiple assumptions:

1) Concurrent validity established previously is valid and accurate. Both HR and VO₂ shares a positive linear regression with RPE
2) The modified features of the OMNI RPE
CFS will still be a valid tool for users to identify their perceived exertion during exercise in an indoor setting.

In addition to the assumptions listed, there are certain limitations in this experiment that we had to account for. First, our chosen subjects were over the age of 21 years old. Although the use of OMNI RPE CFS is meant to be applied across all age groups including children, the investigation does not cover the validity of the OMNI RPE CFS on subjects below the age of 21. Hence, future study can look into the effectiveness of the OMNI RPE CFS on subjects not in this age group.

Second, all participants also have to participate in moderate physical activities (PA) at least 3 times a week, as well as have a Body Mass Index (BMI) that falls within the range of 18.5 to 30 kg·m⁻². Participants are to be physically fit for the investigation, and there is no significant difference in the fitness levels of each participant. Consequently, the investigation does not validate the OMNI RPE CFS scale on those of lower fitness levels.

2 AIMS / OBJECTIVES

Our aim of this investigation is mainly to establish the concurrent validity of the OMNI RPE CFS on healthy male and female adults.

3 LITERATURE REVIEW

Self-regulation is a method recognized by the American College of sports medicine to measure an individual’s exercise intensity. The first perceived exertion scale was created by Gunnar Borg.

Borg RPE Scale

The Borg scale, developed by Gunnar Borg, the creator of Rate of Perceived Exertion scales, measures one's exertion rating based on a 6 to 20 perceived exertion scale [16]. Borg's RPE scale is used frequently in clinical settings due to its simple features [22].

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
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<tbody>
<tr>
<td>0</td>
<td>Not tired at all</td>
</tr>
<tr>
<td>1</td>
<td>A little tired</td>
</tr>
<tr>
<td>2</td>
<td>Getting more tired</td>
</tr>
<tr>
<td>3</td>
<td>Tired</td>
</tr>
<tr>
<td>4</td>
<td>Tired</td>
</tr>
<tr>
<td>5</td>
<td>Light</td>
</tr>
<tr>
<td>6</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>7</td>
<td>Very light</td>
</tr>
<tr>
<td>8</td>
<td>Extremely light</td>
</tr>
<tr>
<td>9</td>
<td>Hard (heavy)</td>
</tr>
<tr>
<td>10</td>
<td>Very hard</td>
</tr>
<tr>
<td>11</td>
<td>Extremely hard</td>
</tr>
</tbody>
</table>

Figure 2: Rating of Perceived Exertion Scale

However, one issue with the original Borg RPE Scale was that it was unable to facilitate comparisons between different individuals due to individual perceptual differences (Figure 2). [23]. This makes the scale ineffective to a certain level. The Borg scale also functioned on the assumption that all users regardless of language ability could read and understand wordings on the scale and are thus able to follow the instructions of the tester to estimate or reproduce RPE values using the scale. As
such, this engendered concerns regarding the reliability of the scale when used with younger children who may lack the reading abilities, experience and conceptual understanding to properly utilise the scale [12]. Further investigations which incorporated symbols and graphics which emulate categories of effort and fatigue into paediatric versions of the RPE scale also recognised the need for verbal descriptors, terminology and graphics which were more pertinent to children’s cognitive development, age and reading ability [12]. The first such published investigation involved the replacement of verbal indicators in the Borg scale with stick figures depicting different stages of fatigue and this adapted scale was tested with a group of 10 to 12-year-old asthmatic children (Figure 3) [19]. However, the children still faced difficulties interpreting the scale.

Evidence of the validity of this scale was obtained according to Williams et al, 1994 and others provided data that supported its validity [14,15] but the scale still incorporated only numbers and words and was not validated against VO2 [8]. Moreover, the CERT did not meet the validation criterion based on the basic principles of Borg’s Model of the Three Effort Continua [16] — positive RPE response linearity.

1. VERY, VERY EASY
2. VERY EASY
3. EASY
4. JUST FEELING A STRAIN
5. STARTING TO GET HARD
6. GETTING QUITE HARD
7. HARD
8. VERY HARD
9. VERY, VERY HARD
10. SO HARD I’M GOING TO STOP

Figure 4: CERT

Subsequently, Yelling et al. [17] created the Pictorial Children’s. Effort Rating Table (PCERT) which, in addition to the verbal descriptors in the CERT, had illustrations to depict the levels of physical effort conveyed by the descriptors (Figure 5). The PCERT was validated against HR by Yelling et al [17] and against HR and VO2 by Roemmich et al. [18].

A later investigation saw the development of the Children’s Effort Rating Table (CERT) [21] which was a 1-10 RPE Scale as opposed to Borg’s 6-20 scale (Figure 4). Evidence of the
Robertson et al. [8] also developed the OMNI RPE scale which was a 0-10 scale containing verbal descriptors as well as pictorial ones depicting a child on a bicycle (Figure 6).

![Figure 6: OMNI RPE scale (cycling)](image)

Ever since, the scale has been developed and adapted to different exercises. Concurrent validations around aerobic (e.g., running, cycling, stepping) and resistance exercise intensity have surfaced (Figure 7).

![Figure 7: OMNI RPE scale (walking/running)](image)

In those interventions, the stimulus variables are correlated with the response variable. Results of positive correlation between the two variables indicate concurrent validity of the scale.

The concurrent validity of the OMNI RPE scale has been established using blood lactate (BlA), VO₂, and HR from individuals of various characteristics – age group, gender, nationality and health statuses [8][7][6][5]. In aerobic studies conducted on adults by Robertson et al [3], Utter et al. [2], Mays et al. [1], and Krause et al. [4] showed high correlation coefficient in both males and females when HR and VO₂ were separately regressed against RPE. The coefficient ranges between 0.77-0.83 in females and 0.75-0.96 in males. For VO₂, the coefficient ranged between 0.85-0.96 in females and 0.86-0.95 in males. Supported by many literatures and results of those from the OMNI RPE scale, the scale can be considered a valid tool for assessing perceived exertion and prescribing intensity for aerobic exercises.

The OMNI RPE CFS

In the interest of a more inclusive and ‘all-in-one’ OMNI RPE scale, i.e., one scale for users of both age group (i.e., adults and children) and covers all exercise modalities (aerobic and resistance exercises), the OMNI RPE CFS was developed. The OMNI RPE CFS consist of a 4-colour gradient bar imposed on a 0 – 10 range scale; children verbal descriptors adopted from Robertson's OMNI RPE Children run/ walk scale were placed on RPE 2, 4, 6, 8 and 10; and four facial expressions with varying degree of exercise intensity were placed alongside the colour bar at RPE 0, 3, 6 and 9. Research done by Dzulkifli & Mustafar [9] explains the effects of colour on the brain and how coloured material boosts arousal and memory, aiding the encoding and retrieval phases of memory. In addition, Murray & Jeffrey's [10] research paper identified the effect of colour-coded drafts triggering higher-order thinking and metacognition. During their investigation, a teacher tasked his students with colour-coding their assignments and observed an improvement in the clarity and depth of their understanding. Huang et al. [11] studied facial expressions during incremental cycling exercise. His study supports the use of facial expression alone in reporting perceived exertion during exercise. Concurrent validity was established by correlating the HR and VO₂ with RPE of the OMNI RPE CFS. Results indicated positive linearity in both regression analysis with r at 0.86 and 0.79 respectively.

Concurrent validity of the OMNI RPE CFS has not been examined. The study will establish concurrent validity by regressing against the OMNI RPE Adult Walk/ run Scale as it was the scale used for the measurement of concurrent validity. Secondly, the scale is widely known and accepted as a valid measurement tool.
4 METHODOLOGY / MATERIALS

Subjects

20 healthy subjects (10 males and 10 females) were recruited for the study. All subjects were above the age of 21 years old whose BMI fell within the range of 18.5 to 30 kg·m⁻². Subjects were free of musculoskeletal injury (i.e., sprain, strains and fracture), illness or disease, were non-smokers and were without colour-blindness of any type (red-green, blue-yellow or total colour blindness). They also participated in moderate physical activities (PA) at least 3 times a week, totalling longer than 150 minutes of total moderate exercise per week and were experienced in playing soccer. Prior to the sessions, subjects completed an informed consent form, medical indemnity form (PAR-Q+), and the global physical activity questionnaire. Participants were randomly assigned to the control or experimental group. Each group used the OMNI RPE Adult Walk/ run scale and OMNI RPE CFS respectively. Both groups had equal gender distribution.

Experimental design

All subjects went through an orientation process to familiarise them with the use of the OMNI RPE Adult Walk/ run scale or OMNI RPE CFS, use of HR monitor, respiratory metabolic system and the discontinuous graded treadmill exercise (GXT) protocol. Anthropometric measurements were also taken for all subjects. All participants started with a warm up followed by the GXT. Details of the warm up and GXT are as described below.

6 RESULTS

<table>
<thead>
<tr>
<th>Table 1. Descriptive Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
</tr>
<tr>
<td>%BF (%)</td>
</tr>
</tbody>
</table>

(a) Warm up: First, subjects took part in the warm up exercise, where they ran on a treadmill for 8 minutes. Each subject ran at a speed of 6km·h⁻¹ for the first 3 minutes, 7km·h⁻¹ from the fourth to fifth minute and 8km·h⁻¹ from the sixth to eighth minute. Treadmill gradient was maintained at 0% throughout.

(b) Discontinuous submaximal GXT test: Subjects started on the treadmill at 6km·h⁻¹ with speed increment of 0.5km·h⁻¹ per stage. Each work and rest stage is at 4-minutes. VO₂ was obtained via the metabolic cart. At the last 15 seconds of the work stage, subjects were asked to rate their perceived exertion using their assigned scale - "on a scale of 0 - 10, can you tell me how tired you are feeling overall?". The HR was also recorded. The test was stopped when 2 of 3 maximal oxygen uptake (VO₂max) criteria were met. The criteria were 1) A plateau in VO₂ is observed on the VO₂ measurement graphs. 2) Subject's HR is ± 10 bpm or 95% of their maximal heart rate for their age. 3) The subject's respiratory exchange ratio (RER) is greater than 1.15.

5 DATA ANALYSIS

Evidence for response validity was determined using correlation and simple linear regression analysis. These analyses separately regressed VO₂ and HR against RPE using data obtained during the final 2 minutes of each work stage. ANOVAs were performed separately for the data sets.
Table 2. Regression analysis of OMNI RPE CFS express as a function of OMNI RPE by cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>RPE Predictor</th>
<th>Slope</th>
<th>Intercept</th>
<th>SEE</th>
<th>r</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂</td>
<td>Overall</td>
<td>0.16</td>
<td>1.12</td>
<td>0.31</td>
<td>0.81</td>
<td>0.66</td>
</tr>
<tr>
<td>HR</td>
<td>Overall</td>
<td>7.37</td>
<td>110.58</td>
<td>16.67</td>
<td>0.78</td>
<td>0.61</td>
</tr>
</tbody>
</table>

VO₂: oxygen uptake; HR: heart rate, SEE: standard error

RPE: Positive Linearity Regression

Pearson correlation coefficients (r-value) showed a high positive relation of RPE with VO₂ and HR. A significant positive linearity regression was observed between VO₂ and RPE, \( F = (1, 256), r = 0.81, p = 0.00 \). Similarly, a significant positive linearity regression was exhibited between HR and RPE, \( F = (1, 214), r = 0.78, p = 0.00 \).

**7 DISCUSSION**

**OMNI CFS RPE response**

RPE responses derived from the OMNI RPE CFS in this investigation distributed as a positive linear function of oxygen uptake (VO₂ ml·kg⁻¹·min⁻¹) and heart rate (HR, beats·min⁻¹) for the submaximal power outputs that were utilised in the treadmill exercise test. A positive correlation for RPE was evident from the results. The validity coefficient derived from the regression analyses was \( r = 0.81 \) for the positive linear function of RPE against VO₂ (p<0.01) and \( r = 0.78 \) (p<0.01) for the positive linear function of RPE against HR.

These findings are consistent with previous studies. One such study is one which examined the RPE responses of adults performing walk/run and cycle modes and using the Adult OMNI Walk/run and Cycle formatted scales, respectively. The study also reported validity coefficients from \( r = 0.67 \) to 0.88 (walk/run protocol) and \( r = 0.81 \) to 0.95 (cycle protocol) [3][2]. The investigation results also remain consistent with other studies like one validating the adult RPE scale for elliptical ergometry which produced correlational values ranging from \( r = 0.94 \) to 0.96 in the male cohort and \( r = 0.93 \) to 0.97 in the female cohort for the function of RPE against physiological variables like HR and VO₂ [1], and another study validating the adult OMNI RPE scale for the cycle ergometer exercise which gave validity coefficients ranging from \( r = 0.81 \) to 0.95 for a similar function.

The use of positive RPE response linearity as an applied validation criterion is based on the basic principles of Borg’s Model of the Three Effort Continua [16]. The Model states that as exercise performance increases along an intensity dependent continuum, the corresponding physiological (i.e., VO₂, HR) and perceptual responses (i.e., RPE) also increase similarly, and these interdependent variables show a positive relation. This relation between perceptual and physiological responses during exercise is essential when using RPE to determine optimal exercise intensity for people [8]. The positive linear relation in the investigation between OMNI CFS RPE and the selected physiological variables, VO₂ and HR, satisfies the application outcomes derived from the Three Effort Continua Model. Colours have been shown to improve learning and memory retention, and establishing the OMNI RPE CFS would be the key to improve the efficacy of the existing perceived exertion construct among individuals whose meta-cognition and memory are enhanced by colour. With the OMNI CFS validated, the OMNI CFS can be applied in exercise, sports pedagogical etc. contexts in Singapore for adults over the age of 21.
8 LIMITATIONS AND RECOMMENDATIONS

There are however certain limitations in this experiment that we had to account for. Firstly, our chosen subjects were over the age of 21 years old. Although the use of OMNI RPE CFS is meant to be applied across all age groups including children, the investigation does not cover the validity of the OMNI RPE CFS on subjects below the age of 21. Hence, future studies can look into the effectiveness of the OMNI RPE CFS on subjects not in this age group. Second, all participants also have to participate in moderate physical activities (PA) at least 3 times a week, as well as have a BMI that falls within the range of 18.5 to 30 kg·m⁻². Participants are to be physically fit for the investigation, and there is no significant difference in the fitness levels of each participant. Consequently, the investigation does not validate the OMNI RPE CFS scale on those of lower fitness levels.

9 CONCLUSION

RPE is a very useful and convenient tool for gauging exercise intensity. It is undisruptive to exercise, can be estimated at any instant and requires no equipment. However, the monochromatic scale is not as effective as it could be for those whose meta-cognition and memory are enhanced by colour since colours can be used for learning and meta-memory in a deliberate or natural way. As such, the OMNI CFS has an edge over the original RPE. The present findings provide evidence supporting the ability of adults in relating verbal descriptors and facial illustrations to colour gradient bar scale. With the evidence for the validity of OMNI RPE CFS perceived exertion scale obtained for adults aged 21 years and above, it is now possible to teach adults of this population to use the OMNI RPE CFS to gauge their exercise intensity. With proper anchoring, using standard anchoring instructions by Robertson et al., adults can be taught to identify moderate exercise intensities that are suitable for them. Some adults may steer away from exercise which they perceive to be too tiring or intense for them. As such, using the OMNI RPE CFS to determine their perceived exertion can more effectively help adults, especially those whose learning is better achieved with the use of colour. Numerous research has shown the association between metacognition and memory, where the results support the use of colour to enhance learning. In this context, the use of OMNI RPE CFS allows users to select exercise intensities at which they can maintain comfortably while still receiving health benefits. Conversely, such adults who tend to overexert and thus harm their health may use the OMNI RPE CFS to bring them to healthy exertion levels while still improving their fitness. Thus, with the validation of the OMNI RPE CFS, a wider range of adults, especially those whose metacognition and memory are enhanced by colour, can now utilise the CFS to customise their workouts for maximum health benefits at healthy exertion levels.

10 ACKNOWLEDGEMENTS

We thank our supervisors, Dr Govindasamy Balasekaran (Associate professor at Nanyang Technological University) and Ms Peggy Boey for guiding and mentoring us through the course of this project. We also thank Mr Lim Lee, our school coordinator for assisting us throughout the project. Special thanks to Nanyang Technological University for giving us this opportunity to be working with our supervisors.

11 REFERENCES


