Concurrent Validation of OMNI Rate of Perceived Exertion Colour-Face Scale in Female Adults (NIE03)

Huang Shi Rui
Dunman High School

Associate Professor Govindasamy
Balasekaran
National Institute of Education

Abstract

Background: The OMNI Rate of Perceived Exertion scale has been widely validated but it can be better revised to cater for users of different age group during different exercise.

Aim: To examine and establish the concurrent validity of the OMNI Rate of Perceived Exertion Colour-Face Scale on female adults in Singapore.

Method: Ten clinically normal females participated in the study. Participants were involved in a discontinuous submaximal graded treadmill exercise test. The protocol functions on a 1:1 work rest ratio. Each work and rest stage is 4 minutes. The treadmill started at 6km.h\(^{-1}\) and increased at 0.5km.h\(^{-1}\) per work stage. Gas exchange variables were obtained via the metabolic cart; heart rate measurements were taken via a heart rate transmitter; and RPE was recorded at the last 15 seconds of each work stage.

Results: Regression analysis indicated that RPE distributed as a positive linear function for both HR (r = 0.80, p = 0.00) and VO\(_2\) (r = 0.87, p = 0.00).

Conclusion: Concurrent evidence supports the use of OMNI Rate of Perceived Exertion Color-Face Scale by female adults to effectively self-regulate exercise intensity.

Keywords: Rate of Perceived Exertion, Adults, Concurrent validity, OMNI Rate of Perceived Exertion Colour-Face Scale

1 INTRODUCTION

With an increase in physical activities (PA) among the general public, the guidelines for health and safety during exercise should be followed more closely to prevent injuries, especially when individuals are constantly training and performing exercises at high intensity. High intensity exercises when conducted during specific training phases on conditioned athletes has its benefits such as, gain in strength, reduction in body mass and percentage body fat. However, unconditioned athletes when exposed to frequent high intensity exercises would have negative impacts on both mental and physical states. Hence, to ensure safety during exercise, it is recommended to use non-invasive measures such as the widely validated OMNI rate of perceived exertion (RPE) scale.

RPE is a tool for measuring an individual’s effort, breathlessness and fatigue during physical work and is highly relevant for clinical and regular exercise regimes [1]. It can also be used to determine the optimum level of exercise to improve cardiovascular fitness.

Since the measure of RPE is non-invasive and easier to carry out than the measurements of oxygen uptake (VO\(_2\)), heart rate (HR), or blood lactate (BLa) during exercise, as the former does not require any additional devices, it is a convenient tool for exercise prescription and can be conveniently used for the regulation of exercise intensity.

OMNI RPE scales are fitted for users of different age groups and are used in a wide range of exercise modalities. Hence, each different age group and exercise modality has its own set of scales, while retaining the primary features of the OMNI RPE scale.
To improve the usability of the scale, the OMNI RPE Colour-Face Scale (CFS) should have the ability to be applied to a variety of exercise modalities, and can be used across different demographics of individuals, including people belonging to different age groups, educational or cultural backgrounds, and so on. This supports the main aim of the scale being ‘OMNI’.

As shown below in Figure 1, the newly developed OMNI RPE CFS is a vertical scale which contains both numeric and verbal descriptors, a four-colour gradient bar and pictorial descriptors in the form of frontal facial illustrations representing varying degrees of physical exertion.

Since participants were narrowed to only non-obese and clinically normal female adults, it excludes other key demographics, such as individuals with cardiovascular or respiratory illness. Since the protocol used in this study is not suitable for those with cardiorespiratory illness, this study may not guarantee similar results for those with chronic diseases, which presents as a limitation in this study.

2 OBJECTIVES

The aim of this study is to establish the concurrent validity of OMNI RPE CFS in female adults through the extent of association between physiological markers of exercise intensity (VO₂ and HR) with the OMNI RPE CFS.

3 LITERATURE REVIEW

Engagement in exercise has been known to bring about holistic benefits to the individual regardless of age, gender or health status [2]. Many research studies since the early period supports and promotes the importance of exercise for cardiovascular and mental health [3]. Healthy individuals and those with medical conditions have different exercise guidelines to ensure sustained or improved well-being. According to the American College of Sports Medicine (ACSM), individuals should participate in at least 150 minutes of aerobic exercise at moderate intensity per week, for healthy living [4]. The proposed guideline is also echoed by the Singapore Health Promotion Board. Encouragement of regular participation in exercise or PA can be seen through the efforts of the local government [5] [6]. The latest data from the local government revealed a 17% increment of female participation in PA from the 50% in 2015. Compared to males who were generally more active, regardless of age group, the increment for females is higher [7] [8].

According to the annual fitness trend conducted by the ACSM, the top fitness trend of 2021 ranks ‘online training’, ‘wearable technology’, ‘body weight training’ and ‘high intensity interval training (HIIT)’ as the first, second, third and fourth respectively [9]. The four identified PA operate on a generic exercise protocol, with little to no on-site supervision from health professionals.

Translating it to health and safety during exercise, there is little regard on the concept of ‘safe exercise’ especially when one does not have the knowledge of sports science, except for the declaration of health concern prior to the engagement of the physical activity, i.e. PAR-Q+. Exercise conducted at high intensity for prolong duration and frequency is detrimental to the body [10] [11] [12]. In cases of clinical studies, exertional rhabdomyolysis had been identified to be caused by personal trainers [13].
Without physiological knowledge of how the human body improves, an individual is often blinded by the quick gains from such intensive workouts even with the supervision of a practitioner.

Although safe exercise guidelines are mentioned, the emphasis on its importance is still lacking. This could be attributed to the reliance on coaches and fitness programs for improved fitness, and the ignorance of possible modes of measures other than palpating for HR and wearable technology. The latter prescribes exercise routines, training load and measures exercise intensity zones from the collective measure of performance from previous and current activity status. An alternative approach to using HR for exercise prescription and exercise intensity is the use of perceived exertion scale.

There are many formats of perceived exertion scale and the OMNI RPE scale is a renowned one. It has been widely validated across age groups, exercise modalities, nationalities and health statuses [14] [15] [16]. It has also been validated against VO₂ and HR. Simply put, perceived exertion is a valid and accurate tool for exercise prescription and self-regulation of exercise intensity as it shares a positive linear relationship with both HR and VO₂ [17]. Several research have shown moderate to strong correlational coefficients between HR and VO₂ with RPE [18] [19] [20] [21] [22] [23] [24]. As exercise intensity increases, so does VO₂ and HR. The VO₂ is derived from the product of cardiac output and arterial-venous difference. Furthermore, cardiac output is the product of HR and stroke volume. Therefore, the apparent result for the increment in VO₂ can be attributed to increased HR. The strong positive association of the two physiological variables with RPE establishes the concurrent validity of the RPE scale.

Although many users of this century rely heavily on the use of health gadgets, such as fitness watches, the accuracy of HR training zones are determined by the inputs of the user. Hence, without accurate measures of resting and maximum HR, exercising according to the algorithm of the watch’s training zone is dangerously erroneous [25]. Using electronic gadgets for exercise prescription is therefore inaccurate and unsafe, especially for long term training. On the other hand, RPE, which is a subjective measure of perceived exertion during exercise, is fluid to the changes from environmental elements, as well as changes in an individual’s mental and physiological state [19]. The complex understanding of how perceived exertion is derived from a collective measure of physiological and mental state had been identified by Noble and Robertson, through their ‘global exploratory model of perceived exertion’ [24]. Indisputable, the OMNI RPE scale has withstood the test of time but the primary aim of it being ‘OMNI’ is challenged as the scale is replicated for age group (i.e. adult and children) and exercise modality (e.g. running, resistance training, stepping, etc.).

Therefore, to create a more inclusive scale, a multi-facet chart should not be limited by age group nor exercise modality.

The OMNI RPE CFS makes use of verbal descriptors from the children’s walk/run OMNI RPE scale [26] instead of the adult verbal descriptors [15]. This enables each pictorial descriptor to be consonant with its respective verbal descriptor, as the children’s scale has readings ranging from ‘not tired at all’ to ‘very, very tired’. This mirrors the facial expressions used in the OMNI RPE CFS, providing a clearer indication of the level of perceived exertion experienced during exercise. Using children’s verbal descriptors allow users of both higher and lower English language ability to use the scale.

The use of colours has been proven effective at deriving exercise intensity [27] as colours can be universally understood, due to its strong instinctual association with emotions [28]. Red is often associated with anger, hence signifying high intensity while blue is commonly referred to as calm, which corresponds to low intensity. This can be applied to represent the intensity of exercise and perceived exertion. The use of colours can also enhance the way in which individuals perceive and recognise objects in everyday life [29]. Furthermore, relying solely on verbal and pictorial descriptors can compromise an individual’s interpretation of RPE if they have visual or cognitive impairments [30]. Therefore, since the use of colour does not discriminate between different demographics of people, and this supports its incorporation into the OMNI RPE CFS.

Facial images are used instead of full body images as full body images should be appropriately used to assess different modalities of exercise [31] since they depict individuals cycling, running or weightlifting. Thus, the use of facial images is much more versatile across a wide variety of exercise types than full body descriptors. Using full body images will hence challenge the aim of the scale being ‘OMNI’ due to its limited ability to be applied across different exercise modalities. Scales with facial expressions have also been developed and validated, and have been proven effective at monitoring RPE [28] [32]. They are also widely used in clinical settings, especially for pain management [33] [34].

These evidences support the use of adult verbal descriptors, colours and facial expressions at determining perceived exertion during exercise. Hence, this study aims to put these aspects onto a scale for study.
3 METHODOLOGY

3.1 SUBJECTS

A total of 10 clinically normal, non-obese female adults, ranging in ages from 21 to 45 years participated in this study. Subjects did not present clinical, neuromotor, or cognitive contraindications to exercise testing. All reported regular participation in recreational health-fitness activities, at least 3 times a week, and were non-smokers. Subjects were also not affected by colour-blindness of any type.

All subjects were informed of the risks and benefits of the study, and gave their written consent to participate.

The investigation was approved by the Ethical Review Board of the Physical Education and Sports Science academic group of the National Institute of Education, Nanyang Technological University, Singapore (IRB-2020-05-037).

3.2 EXPERIMENTAL DESIGN

These testing procedures were based on the experimental protocol developed by Robertson et al. [14]. Subjects were randomly assigned to either experimental (EG) or control group (CG). The EG and CG uses the OMNI RPE CFS and the OMNI adult walk/run scale respectively.

Subjects were briefed on the research study and experimental procedures, followed by the completion of the informed consent form, medical indemnity form (PAR-Q+) and the global physical activity questionnaire. Subjects were anchored on the use of the respective OMNI RPE scale prior to the exercise test. Anthropometric measurements and body fat percentage (%BF) were recorded. Subjects were reminded not to consume heavy meals at least two hours before each exercise test.

Discontinuous submaximal graded treadmill exercise test (GXT) was used. The GXT is an exercise test with speed increments and was terminated upon volitional exhaustion.

3.3 EXPERIMENTAL VARIABLE

The experimental variables for this investigation were RPE, VO₂ (L·min⁻¹), and HR (beats·min⁻¹). Descriptive variables for each cohort were age (years), height (cm), body mass (kg), (%BF) (%), and body mass index (BMI) (kg·m⁻²).

3.4 ANTHROPOMETRIC MEASURES

Height of subjects was determined using a stadiometer. Body mass was measured using a digital scale and BMI was calculated through dividing the body mass by the square of the height. Age was recorded down during the pre-test assessment. Total %BF was determined using the InBody 520 scale.

3.5 PROCEDURE

Subjects were familiarized with the perceived exertion rating scale (either the OMNI Colour Face Scale or the OMNI adult walk/run scale, depending on their assigned group), and the GXT protocol.

A standardized instructional set regarding the use of the OMNI RPE CFS and OMNI RPE adult walk/run scale was explained to the subjects while they visually examined the scale [25]. The scale’s instructions specifically described exertional rating procedures for the overall body. Procedures to establish the low and high perceptual anchors of the OMNI Scale were based on a visually interfaced cognitive procedure as reported by Robertson et al. [14]. Scale anchoring procedures were standardized for all subjects and conformed to Borg’s range model for rating interindividual differences in perceptual responsiveness [24].

Subjects started with a warm up on the treadmill at 6km·h⁻¹ for the first three minutes. For the next two minutes, speed was increased at 1km·h⁻¹ every minute until 8km·h⁻¹. To establish concurrent validation of the OMNI RPE CFS, subjects ran a discontinuous GXT. The GXT functions on a 1:1 work rest ratio protocol. Work and rest stages were alternated at every 4 minutes. Subjects started at a speed of 6km·h⁻¹ with speed increment of 0.5km·h⁻¹ per work stage. Gradient was maintained at 1% throughout. At the last 15 and 10 seconds of each work stage, RPE and HR were recorded respectively. The test terminated upon volitional exhaustion when two of the three VO₂max criteria were met: a) when a plateau in VO₂ was reached, b) when HR (± 10 bpm) was at 95% of maximum HR, and c) when the respiratory exchange ratio (RER), which is the ratio of CO₂ production to O₂ uptake, was greater than 1.15 [35].

3.6 HEART RATE AND OXYGEN CONSUMPTION

Each participant was given a HR transmitter (Polar Monitory System) which was connected to a watch or linked to the Polar application on a phone. HR was measured at every last 10 seconds of each work stage.

A metabolic cart was used to measure a subject’s carbon dioxide production and VO₂, in order to determine the respiratory gas exchanges during the laboratory exercise session.
3.7 DATA ANALYSIS

Descriptive data for perceptual and physiological variables were calculated as mean ± standard deviation (SD). Raw data obtained were analyzed by averaging the last two minutes of each of the work stages. Separate linear regressions of VO\textsubscript{2} and HR against RPE were carried out.

4 RESULTS

Regression analysis indicated that RPE among females was distributed as positive linear functions for both VO\textsubscript{2} and HR.

Listed in Table 1 are the descriptive characteristics of participants, including the means and standard deviations.

Table 1: Descriptive Characteristics

<table>
<thead>
<tr>
<th>Females</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>24.00 ± 3.41</td>
</tr>
<tr>
<td>Height (m)</td>
<td>158.20 ± 7.07</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>54.36 ± 7.56</td>
</tr>
<tr>
<td>BMI (kg·m\textsuperscript{-2})</td>
<td>21.64 ± 2.00</td>
</tr>
<tr>
<td>%BF (%)</td>
<td>21.07 ± 7.66</td>
</tr>
</tbody>
</table>

m: meters, kg: kilograms, kg·m\textsuperscript{-2}: kilograms per meter squared, %: percentage.

Listed in Table 2 below are the first-order correlation coefficients and linear regression equations for these functions.

A significant positive linearity regression was observed between VO\textsubscript{2} and RPE, \( F = 1, 109, r = 0.87, p = 0.00 \). A significant positive linearity regression was observed between HR and RPE, \( F = 1, 92, r = 0.80, p = 0.00 \).

4.1 DISCUSSION

The OMNI RPE CFS was validated using concurrent validity for female adults. RPE responses derived from the OMNI CFS scale in this study distributed as positive linear functions for VO\textsubscript{2} (L·min\textsuperscript{-1}) and HR (beats·min\textsuperscript{-1}).

The validity coefficients were \( r = 0.87 \) and \( r = 0.80 \) for VO\textsubscript{2} and HR respectively. Evidence of concurrent validity was taken as a positive correlation between the criterion variables (VO\textsubscript{2} and HR) and the concurrent variables (RPE) examined over the full perceptual-physiological range. This is consistent with previous investigations that have used concurrent validity, including the Borg 6-20 Scale [36] [37] and Borg CR-10 Scale [38]. Furthermore, studies on RPE responses of adults performing walk/run mode and using the Adult OMNI Walk/Run formatted scales have also reported validity coefficients ranging from \( r = 0.67 \) to 0.88 [39], which is similar to that observed in this study. These previous experiments employed the same physiological (VO\textsubscript{2} and HR) validation criterion with similar experimental designs.

The use of positive RPE response linearity as a concurrent validation criterion is based on the principles of Borg’s Model of the Three Effort Continua [40]. It states that as exercise performance increases along an intensity dependent continuum, the corresponding physiological (VO\textsubscript{2}, HR) and perceptual responses (RPE) will respond in a similar way. Corresponding and interdependent perceptual-physiological responsiveness during exercise is essential when using RPE to prescribe exercise intensity [41]. Such application is greatly facilitated if perceptual and physiological measures exhibit positive linear response characteristics.

The positive linear relation obtained in this study between the OMNI RPE CFS and the physiological criteria satisfies the application outcomes derived from the Three Effort Continua Model. OMNI RPE CFS can therefore be applied as a non-invasive intensity monitoring instrument either independently or in conjunction with physiological responses during self-regulated exercise, to improve cardiovascular fitness and prevent injuries among female adults.

5 CONCLUSION

The OMNI CFS has distinct measurement properties because it has a format that uses numeric, verbal, pictorial and colour descriptors.

The present findings provide evidence supporting the application of the OMNI CFS to assess undifferentiated RPE (RPE Overall) during exercise in female adults aged 21 to 45 years.

Differentiation of RPE into RPE-Overall, RPE-Legs and RPE-Chest should be explored so individuals can use the OMNI RPE CFS to monitor their training intensity more accurately, by not solely using an overall feeling of exertion.
The undifferentiated response (RPE-Overall) is also somewhat less anatomically precise than the differentiated rating, which would also be dependent on the mode of exercise [42].

Further experimentation should also consider the application of the OMNI RPE CFS to a wider group of users, including clinically (obese and normal weight) and culturally different cohorts of children, adolescents and adults (male and female) using concurrent and construct validity.

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