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Concurrent Validity of Borg's Rating of Perceived Exertion in African-American Young Adults, Employing Heart Rate as the Standard

Spiridon G. Karavatas, PT, DPT, MS, GCS[1]
Kamran Tavakol, PT, PhD[2]

1. Associate Professor, Department of Physical Therapy, Howard University
2. Assistant Professor, Department of Physical Therapy, Howard University

United States

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ABSTRACT
Borg's Rating of Perceived Exertion (RPE) is a simple and convenient method of monitoring exercise intensity; however, the correlation between RPE and heart rate (HR) is not always consistent. This pilot study examined the criterion-based validity of RPE versus heart rate. Twelve fasting, healthy African-American volunteers at ages of 21-41 years performed a supervised, 45-minute brisk walk test on a treadmill over three consecutive days. Throughout the test, each subject was asked the RPE every five minutes. The subjects' heart rates were monitored continuously and recorded every minute. The overall correlation coefficient, r, between RPE and HR for all data sets (N=360) was 0.58. The "r" values for males and females were 0.60 and 0.56, respectively. The analysis revealed that the correlation between RPE and HR was not as strong as previously reported, and that gender influenced the correlation. Also, RPE may be safely used to assess the exercise intensity in healthy subjects.

INTRODUCTION

Borg's Rating of Perceived Exertion (RPE) [1] is based on a subjective feeling of exertion and fatigue during exercise, and it is used to assess and regulate exercise intensity.[2] The theoretical premise of RPE is that a person will give a numerical value on a scale from 6 to 20, representing a verbal expression of effort during exercise[1.]

It is a widespread method of regulating exercise in physical rehabilitation and exercise prescription, because it provides exercising persons of all fitness levels with simple guidelines regarding intensity of exercise. Additionally, it does not involve complex technical measurements as other exercise monitoring methods, e.g. heart rate (HR) or oxygen uptake (VO_2). The American College of Sports Medicine (ACSM) has recommended RPE since 1986 for both fitness and Cardiac rehabilitation purposes[2.] ACSM's guidelines recommend a RPE range of 12 to 16 as the perceived exertion range associated with a cardiovascular training effect;[3] roughly corresponding to 60%-85% of the Maximal Heart Rate (HRmax).[3,4] Heart rate is used as the silver standard to set exercise intensity, because of the relatively linear relationship between HR and $\%VO_2max$,[3] which is considered as the gold standard.

A review of recent literature suggests inconsistencies in the strength of correlation between RPE and HR. The purpose of this pilot study was to determine the overall criterion-based validity of RPE during exercise, using HR as the criterion measure.

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REVIEW OF THE LITERATURE

Ueda & Kurokawa studied the relationship between RPE and HR in tethered swimming. Seventeen subjects, seven males and ten females, swam at sub maximal intensities.[5] The relationship between HR and RPE were linear with a level of correlation (r = 0.989-0.999) for both males and females. One can speculate that such an unusually high level of correlation could be specific to the exercise modality. The conclusion was that RPE was an effective measure of exercise intensity and could be used for exercise prescription in practical swimming.

Travlos & Marisi[6] conducted a study to investigate the influence of fitness level and gradually increased amounts of exercise on individuals' ratings of RPE and HR. Twenty men served as subjects. They were divided into groups of high and low fitness according to their maximal oxygen uptake (VO_2max). Participants were required to pedal on a cycle ergometer at a progressively increased workload (every 10 min.) corresponding to 40%, 50%, 60%, 70%, and 80% of individual VO_2max values. Heart rates and RPE were recorded every 5 minutes. Analysis of the results indicated that highly fit individuals perceived themselves under less exertion than did the group low in fitness, and that there was a stronger correlation between RPE and heart rate for the highly fit individuals than that for the less fit.

A study by Dunbar et al,. investigated the validity of regulating exercise intensity by RPE. The RPE equivalent to 50% and 70% VO_2max was estimated by using standard clinical protocols on a treadmill and cycle ergometer.[7] The subjects then produced the target RPEs on these modalities. Physiological validity of RPE-regulated exercise intensity was determined by comparing heart rate and VO_2 at the same relative intensity. RPE was found to be a valid means of regulating exercise intensity at 50% and 70% VO_2max with one exception. RPE regulation of treadmill exercise was not valid at 70% VO2max in that both VO_2 and heart rate were significantly lower during production than estimation. The results also indicated that that RPE during cycle ergometer exercise was more accurate for regulating exercise intensity than the RPE during treadmill exercise.

Eston & Williams assessed the reliability RPE for the prescription of exercise intensity during cycling. Sixteen healthy subjects, 10 men and 6 women (21 to 62 years) participated four times, 5 to 7 days apart. They cycled at constant work rates based on their RPE 9, 13 and 17 of the Borg 6-20 scale by adjusting the resistance of the ergometer. Analysis of variance did not reveal significant between-trial differences with regard to heart rate for men or women. The relative exercise intensities corresponding to the three ratings of exertion did not differ between men and women.[8]

Pfeiffer et al, studied the reliability and validity of RPE in adolescent girls (age = 15.3+/-1.5 yr) during sub maximal treadmill exercise. HR was measured continuously during exercise. The validity coefficient was 0.66, using Pearson Product Moment correlations, with % HRmax as criterion measure. Reliability of the RPE scales was assessed using intraclass and single-trial measures of 0.78 and 0.64 respectively.[9]

Schaeffer-Gerschutz et al, studied RPE and the physiological responses during four aerobic dance steps in 25 trained female dancers. They concluded that RPE did not significantly correlate with HR or VO_2 for any of the four dance steps; however, for all steps together all RPE were significantly correlated (.40-.62) with VO_2.[10]

A study by Perez-Landaluce et al, compared the physiological characteristics versus RPE in 72 high level road cyclists of three different categories (24 professionals, mean age 26 years, 22 amateurs, 22 years and 26 juniors, 18 years), during a progressive test to exhaustion, using a cycloergometer. The results indicated that RPE and HR were significantly different between professionals and juniors, and that RPE and %HRmax were significantly different with low loads, but no with high loads.[11]

Whaley et al, examined the validity of the generalized RPE recommendations in apparently healthy adults (N = 463) and cardiac patients (N = 217) who presented for a sign-symptom limited maximal graded exercise test. Ratings of perceived exertion associated with relative exercise intensities of 60 and 80% of maximal heart rate reserve (MHRR) and peak exercise were selected for analyses. Significant inter-individual variability in RPE was observed at both relative exercise intensities (6 to 20 RPE range at 60% MHRR; 8 to 20 RPE range at 80% MHRR) for both populations. Thirty-nine percent of healthy subjects and 32% of cardiac patients reported an RPE outside an 11 to 14 range at 60% of MHRR, whereas 32% of healthy subjects and 52% of cardiac patients reported an RPE outside of a 14 to 17 range at 80% of MHRR. Peak RPE was higher for the apparently healthy subjects compared with the cardiac patients (18.8 +/- 1.2 versus 16.5 +/- 1.8; $P < 0.01$).[12]

In a recent study, Chen et al, conducted a meta-analysis to assess the criterion-related validity of the RPE scale in healthy individuals. The results revealed that the overall RPE-HR validity coefficient was 0.62, and the highest RPE-HR correlations were

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found during unusual/unfamiliar exercise tasks. The authors concluded that although RPE scale had been shown to be a valid measure of exercise intensity, its validity might not be as high as previously thought (r = 0.80-0.90), except under certain conditions.[13]

The above review substantiates the fact that there are inconsistencies in the strength of correlation between RPE and HR, which deserves further research. This pilot study has addressed the validity of RPE during exercise, based on HR as the criterion.

METHODS

Subjects

A total of 12 healthy African-American volunteers (6 females and 6 males) were recruited for this pilot project. They ranged between 21-41 years of age, with a mean age of 26.08 years. Exclusion criteria required that the subjects did not have a history of cardiovascular, pulmonary, neuromuscular, or musculoskeletal conditions. This project was a component of a larger IRB-approved study. Prior to participation, the subjects were oriented to the project and signed an informed consent.

Procedures

All subjects performed three graded exercise tests (GXT) over three consecutive mornings. All tests took place between 7-9 a.m., and the subjects were fasting for 12 hours prior to testing. The test consisted of a 45-minute brisk walk on a Landice L7 treadmill (Randolph, NJ); this treadmill is widely used and accepted as the standard in hospitals, rehabilitation centers, and research facilities, although there are no published studies on its validity and reliability. The first 10 minutes was the warm up period, at a speed of 2-3 miles per hour (MPH). For the following 30 minutes the subjects exercised within 70%-85% of their HRmax at a speed of 3-5 MPH. This main 30-minute exercise period was subdivided into a 20-minute acceleration phase, and a 10-minute deceleration phase. During the acceleration phase, the speed was gradually increased by 0.1-0.2 MPH every minute as tolerated. During the deceleration phase, the speed was gradually decreased at the same rate. The last five minutes was the cool down period, with the treadmill speed decreasing below three MPH. The treadmill inclination was fixed at 5° throughout the testing for all subjects. At the first minute, the 5th minute, and then every 5 minutes, the subjects were asked to rate their RPE, using Borg's[1] scale (6-20), which had been posted in front of the subject. Prior to testing, the subjects were instructed (verbatim according to ACSM guidelines[3]) on how to use the Borg's scale. Heart rate was recorded simultaneously, using a Polar A1 electronic heart rate monitor (Woodbury, NY). The subjects were not allowed to view the HR monitor at any time during testing. No other piece of electronic equipment was operated in the exercise lab during testing. Polar HR monitors have proven to be valid, accurate, and reliable, provided that there is no outside electromagnetic interferenc.[3,14-16, 17-22] All RPE and HR data were recorded by the same investigator on an identical form. A total of 360 RPE-HR measurement sets were collected (10 sets per subject per test X 3 tests per subject X 12 subjects).

Data Analysis

Relative association between RPE and HR was computed (with SPSS 11.5) for all measurement sets of all subjects for all 3 days ($N=360$), using Pearson product moment correlation (r).[23] Correlation coefficients between RPE and HR were also computed separately for the data sets from males ($N=180$) and females ($N=180$), in order to assess gender differences. The correlation coefficients were interpreted through the strength of the coefficient, the coefficient of determination (r^2), and significance testing at the $P<0.01$ level employing a two-tailed test.[23]

RESULTS

The overall Pearson r between RPE and HR for all measurement sets of all subjects for all 3 days ($N=360$) was 0.58. This was significantly different from zero at $P<0.01$. The r^2 was 0.34. The r for measurements from males ($N=180$) was 0.60 at $P<0.01$, and r^2 was 0.37. The r for measurements from females ($N=180$) was 0.56 at $P<0.01$, and r^2 was 0.31. Table 1 represents the summary of statistical analyses for means of age, BMI, resting HR, and correlation and coefficient of determination.

Table 1: Summary of statistical analysis

Subjects	*Mean Age*	*Mean BMI*	*Mean Resting HR*	*Data sets*	*r*	*r square*
Female (N=6)	26.83 (SD± 7.68)	27.5 (SD ± 5.43)	76.5 (SD ± 10.13)	N=180	0.56	0.31
Male (N=6)	26.75 (SD ± 8.18)	26.29 (SD ± 3.25)	62.5 (SD ± 17.64)	N=180	0.60	0.37
All (N=12)	26.8 (SD ± 7.42)	27.21 (SD ± 2.45)	70.9 (SD ± 14.56)	N=360	0.58	0.34

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Discussion

The moderate correlation of 0.58 between RPE and HR for all measurement sets supports the findings of the meta-analysis by Chen et al, who reported an overall RPE-HR criterion-validity coefficient of 0.62.[13] Results from this study indicate that the correlation was not nearly as strong as that documented by another study, and the r^2 of 0.34 indicates that only 34% of the RPE variability can be attributed to differences in HR.[5] Also, there was a gender difference in the RPE-HR correlation, although the subjects were relatively homogeneous for age, and BMI (Table 1). Further, this study was limited by the small sample size, and lack of control for any pre-existing differences in fitness level among the subjects. On the basis of the strength of the correlation found in this pilot study, RPE alone may be safely employed to assess exercise intensity in healthy African-American subjects. The authors recommend replication of this study in a larger sample size (e.g., N ³ 50) with additional controls for pre-existing differences in fitness, in order to provide a more accurate estimation of the correlation between RPE and HR.

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