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Validity of Borg Ratings of Perceived Exertion During Active Video Game Play

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ABSTRACT

International Journal of Exercise Science 6(2) : 164-170, 2013. During physically interactive video game play (e.g., Nintendo Wii), users are exposed to potential distracters (e.g., video, music), which may decrease their ratings of perceived exertion (RPE) throughout game play. The purpose of this investigation was to determine the association between RPE scores and heart rate while playing the Nintendo Wii. Healthy adults (N = 13, 53.5 ± 5.4 years old) participated in two exercise sessions using the Nintendo Wii Fit Plus. During each session participants played a five-minute warm-up game (Basic Run), two separate Wii Fit Plus games (Yoga, Strength Training, Aerobics or Balance Training) for fifteen minutes each, and then a five-minute cool down game (Basic Run). Borg RPE and heart rate were assessed during the final 30 seconds of the warm up and cool down, as well during the final 30 seconds of play for each Wii Fit Plus game. Correlation analysis combining data from both exercise sessions indicated a moderate positive relationship between heart rate and RPE ($r = 0.32$). Mixed-effects model regression analyses demonstrated that RPE scores were significantly associated with heart rate ($p < 0.001$). The average percentage of age-predicted heart rate maximum achieved ($58 \pm 6\%$) was significantly greater ($p = 0.001$) than the percentage of maximum RPE indicated ($43 \pm 11\%$). Borg RPE scores were positively associated with heart rate in adults during exercise sessions using the Wii Fit Plus. However, this relationship was lower than observed in past research assessing RPE validity during different modes of exercise (e.g. walking, running) without distracters.

KEY WORDS: Physical activity, exergames

INTRODUCTION

Research involving physical activity often examines an individual's perception of effort, a subjective measurement as to how intensely an individual feels he or she is working. This is accomplished through the use of a ratings of perceived exertion (RPE) scale, such as the one developed by Borg (5). Borg's rating of perceived exertion scale has proven to be a valid method of

predicting physiologic effort during differing modes of exercise (e.g. walking, running, and cycling); however, the strength of the association observed between RPE and physiological measurement (i.e., HR, VO₂) of effort can be weakened when an individual is exposed to distracters while exercising, such as listening to music (1, 6, 18, 19, 20). These distracters have been shown to decrease perception of effort at a given exercise

intensity. If distracters can reduce perception of effort during exercise, individuals may be more motivated to exercise at greater intensities than they would in the absence of a distracter.

Emerging research has reported that physically interactive video games (e.g. Nintendo Wii®) can elicit a caloric expenditure, heart rate, and RPE comparable to low or moderate intensity exercise (2, 8, 11, 13, 15). This research typically involves and presents conclusions involving measures of RPE (2, 8, 11, 15). Despite the use of Borg's RPE scale when assessing the potential exercise benefits of physically interactive video games no studies of which we are aware have examined the validity of the scale during game play. While playing these physically interactive video games, users are exposed to both visual and auditory distracters, via their interactive computer avatar, music, and sound effects. These distracters may reduce players' perception of effort at a given intensity, thus weakening the association between RPE and physiologic measures of effort. Validating the use of the Borg scale during active video game play is warranted to further understand the influence distracters may elicit on an individual's perception of effort. In addition, this study will reinforce the credibility of current literature involving RPE and active video game play.

The purpose of this investigation was to determine the association between RPE scores and heart rate during physically-interactive video game play (Nintendo Wii Fit Plus). It was hypothesized that RPE scores would be positively associated with heart rate during game play. However, because of the various distracters that are

presented by the Wii Fit Plus, the strength of this relationship was hypothesized to be lower than that observed in previous RPE validity studies, where the association between RPE and physiologic measures of effort has been assessed without distracters ($r = 0.58 - 0.9$) (7, 10, 16).

METHODS

Participants

Thirteen (11 female and 2 male) healthy adults (53.5 ± 5.4 years old) participated in the study. Participants were recruited via an e-mail list for an on-campus wellness initiative. Individuals were eligible to participate in the study if they had no contraindications to exercise (e.g. no cardiovascular disease, chronic pulmonary disorders, etc.). Participants were asked to refrain from any outside physical activity on the any days they were scheduled to participate in the protocol. The study was reviewed and approved by the University institutional review board (IRB).

Protocol

Participants visited the exercise science laboratory on three separate occasions. During the initial visit, research procedures were explained, written informed consent was obtained, and participants were familiarized with the Wii Fit Plus game play, as well as the 6 - 20 Borg rating of perceived exertion scale (5). Participants were then assigned to return to the laboratory either the following Monday and Wednesday or Tuesday and Thursday. Upon arrival, participants each received a clean towel, bottled water, and Wii Fit Plus exercise protocol (outlined below). All participants were provided the same protocol, and asked to follow the on screen instructions and perform the exercises

specified to the best of their ability. With the exception of asking questions pertaining to Wii Fit Plus game play, participants were asked to refrain from communicating with study investigators.

Wii Fit Plus Exercise Protocol: The Wii Fit Plus exercise protocol handouts provided to participants are presented in Table 1. The total duration of exercise activity performed each visit was 40 minutes, which did not include any inactive time (i.e. processing menu screens and selecting game options) that participants may have required with the Wii Fit Plus. Although the Wii Fit Plus did not contain either a 'warm up' or 'cool down' exercise category, as a safety precaution investigators felt it necessary to include both. During each session participants underwent a five-minute warm-up (running in place as part of the Basic Run game), performed exercises from two separate Wii Fit Plus categories (Yoga and Strength Training activities on the first day, Aerobics and Balance Training activities on the second day) for fifteen minutes each, and then completed a five-minute cool down (identical to the warm up). The specific activities performed by participants throughout each exercise category were selected by study investigators and chosen in order to provide variety as well as entertainment. If a participant completed all activities in an exercise category prior to reaching the required exercise duration, he or she was instructed to repeat the activities listed under that category until the required duration was reached. RPE scores and heart rate were assessed during the final 30 seconds of the warm up and cool down, as well during the final 30 seconds of each of the two Wii exercise categories played that day. Participants were instructed to report

their RPE score based upon how intensely they felt they were exercising, as a whole, throughout all of the games within each category. Heart rate measurements for each individual participant were taken using validated methods (30 seconds of left radial pulse palpation) by the same study coordinators, all of whom were CPR and first aid certified and had substantial practice in acquiring heart rates through left radial pulse palpation (17). The majority of the exercises selected for the Wii Fit Plus exercise protocol easily allowed for participants to continue exercising while study coordinators palpated and recorded heart rate measurements during the final 30 seconds of exercise. However, this method of assessing heart rate can be unreliable and is later discussed as a limitation.

Statistical Analysis

A single Pearson correlation coefficient for the relationships between HR and RPE during each activity phase (i.e., warm-up, game 1, game 2, and cool-down) for both exercise sessions for all participants was calculated. A probability value could not be calculated for the correlation because each subject had multiple scores in the data set, which violates the assumption of independent scores when using a correlation. However, this approach allowed for comparisons to previous research examining the relationships between RPE and physiologic measures of effort. In order to test the significance of the relationship between HR and RPE, a mixed-effects model was performed. The mixed-effects model adjusts for the nonindependence or nesting of the scores, allowing for the analysis of the relationship between variables when data from the same subject are represented more than once in the data set (3, 4). The ability of RPE to

predict heart rate was tested with activity phase (i.e., warm-up, game 1, game 2, and cool-down) and laboratory visit (day 1, day 2) and a random intercept. Finally, paired samples t-tests were used to compare average percent maximum heart rate (exercise heart rate/220-age * 100) achieved to the average percent maximum RPE (exercise RPE/20 *100) indicated. Average percent maximum heart rate and average percent maximum RPE were calculated by taking the mean of all the heart rate and RPE values, respectively, across all exercise stages.

RESULTS

Correlation analysis combining data from both exercise sessions indicated a moderate positive relationship between heart rate and RPE ($r = 0.32$) (Figure 1). Mixed-effects model regression analyses demonstrated that RPE scores were significantly associated with heart rate measurements ($p < 0.001$). The average percentage of age-predicted heart rate maximum achieved ($58 \pm 6\%$) was significantly greater ($p = 0.001$) than the percentage of maximum RPE indicated ($43 \pm 11\%$).

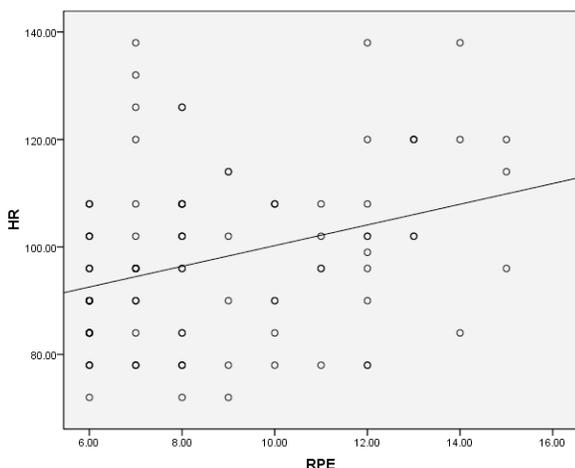


Figure 1. Correlation between heart rate and RPE.

DISCUSSION

This investigation’s primary aim was to determine the association between Borg RPE scores and heart rate measurements during physically interactive video game play using the Nintendo Wii Fit Plus. As was hypothesized, RPE scores were found to be positively and significantly associated with heart rate measurements in adults while using the Wii Fit Plus. Also as hypothesized, the strength of the present relationship between RPE and heart rate ($r = 0.32$) was lower than that previously reported in studies using traditional modes of exercise ($r = 0.58 - 0.9$) (7, 10, 16).

The significant, positive correlation observed between participants’ RPE scores and heart rate measurements indicates potential for Borg’s RPE scale to be a valid instrument for predicting perception of effort during active video game play with the Wii Fit Plus. The strength of this relationship was found to be only moderate ($r = 0.32$), and the mean percent maximum RPE score was found to be significantly lower than mean percent maximum heart rate. This is different from studies examining the relationship between RPE and physiologic measures of effort during traditional modes of exercise (e.g., treadmill walking / running) ($r = 0.58 - 0.90$) (7, 10, 16). It is possible that the visual and auditory distracters associated with the Wii Fit Plus reduced participants’ perceived exertion in a manner that was similar to other, previously examined distracters, such as listening to music (1, 6, 18).

In addition to the role distracters may play in reducing the relationship between RPE and physiologic measures of effort, study design may have also played a role.

Validity of perceived exertion instruments are commonly assessed using progressive exercise tests with treadmill exercise or cycle ergometer exercise (12). Although not necessarily a limitation, the non-progressive design of our Wii Fit Plus exercise protocol could have contributed to the weaker relationship between RPE and heart rate. Progressive exercise tests are designed to incrementally increase in exercise intensity, and any RPE validity research conducted in such a manner allows participants to report their RPE scores as the intensity is increased. Individuals will likely recall their RPE from stage to stage and this could increase the strength of the relationship observed between perceived exertion scores and physiological measurements. In the present study, the Wii Fit Plus exercise protocol was not designed to progressively increase in intensity. This may partially explain why the strength of the relationship between perceived exertion and heart rate from the present study ($r = 0.32$) was less than those utilizing progressive exercise tests ($r = 0.60 - 0.81$) (12).

This investigation is not without limitations. Palpating the radial pulse is a variable method of assessing heart rate and is therefore considered a limitation. Pulse palpations were only used because heart rate monitors were unavailable. Recruiting an all adult sample of participants was another potential limitation, but was done in order to ensure all participants were able to fully understand the Borg RPE scale and could report appropriate ratings of perceived exertion. Investigators were not focused on the generalizability of results to populations of active video game users, but rather on validating the Borg scale for use with the Wii Fit Plus.

To help determine whether the moderate relationship observed between perceived exertion and heart rate was attributable to distracters, future validity research involving physically interactive video games should include an additional non-video game exercise condition. The majority of the Wii Fit Plus exercises can be performed without the game itself, which would eliminate the auditory and visual distracters. Comparing the relationship between RPE and a physiologic measure of effort, where exercise performed using the Wii is compared to the same exercise without the Wii, would illuminate the role that potential distracters associated with Wii play may have on perception of effort. By performing Wii Fit Plus activity without the game present, the Wii Fit Plus visual and auditory distracters that may influence the user would be eliminated.

The present study recruited an all-adult sample of participants in order to best ensure that reported ratings of perceived exertion were accurate. To increase the ability to generalize results to a broader population, future studies examining the validity of RPE during physically active video game play is warranted in a wider range of subjects, especially young adults and children who are traditionally the heaviest users of video games (14, 21). RPE does not appear to be influenced by gender when expressed relative to heart rate and VO_2 at exercise intensities between 70 and 90% maximum or peak workload (22). However, while playing physically active video games boys have previously reported significantly lower RPE relative to girls with no differences in heart rate (8). Therefore, recruiting an equal number of males and females (or an entire sample of a single gender) is encouraged. We also

advise developing a more thorough Wii Fit Plus exercise protocol, encompassing as many games and aspects of the software as possible, which could decrease the likelihood of results being influenced by the specific investigators' games selection. Lastly, repeating this study with an interactive video game that can become progressively more challenging (e.g. Dance Dance Revolution®) could address the concern of study design affecting the relationship between RPE and heart rate. Therefore, future investigations are suggested to incorporate a Wii Fit Plus exercise protocol that progressively increases in intensity.

In conclusion, Borg's rating of perceived exertion scale is widely accepted as a valid method of assessing perceived exertion for a variety of exercise types and was positively associated with a physiologic measure of effort during active video game play in the present study. However, the association between RPE and physiological measures of effort may be weakened when exercising in the presence of distracters. The inclusion of distracters during exercise activity such as those introduced with the Wii Fit Plus, may act as a mental 'buffer' which allows for an increase in individuals' exercise intensity without a concomitant increase in effort perception. This may explain the moderate correlation coefficients noted presently. It is also possible that the non-progressive nature of our Wii Fit Plus exercise protocol could have weakened the relationship between RPE and heart rate.

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