

Intensity of Balance Task Intensity, as Measured by the Rate of Perceived Stability, is Independent of Physical Exertion as Measured by Heart Rate

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Abstract

Objective: To be safe and effective, all therapeutic aspects of balance training must be set and monitored appropriately. There has been no means to assess the intensity component of balance training. The Rate of Perceived Stability (RPS) measures the level of challenge posed to an individual by a balance task. If using the RPS with balance tasks that also tax the cardio-pulmonary systems, such as video game based balance training, individuals may confuse the physical exertion with the balance challenge. The purpose of this study was to determine that the RPS measures the intensity of the balance exercises, independent of physical exertion as measured by heart rate (HR).

Methods: Thirty adults, 19 to 43 years old, played four Wii games (boxing, dancing, tennis, and batting) on four surfaces (foam, wobble, bosu-up and down). HR and RPS were taken at 4 and 8 minutes of each. Statistics performed included: within subjects ANOVA; correlation and ANOVA for all RPS and HR; correlation for each subject, and for all subjects at each condition; regression for HR predicting RPS for each condition.

Results: Repeated measures ANOVA for HR and RPS across conditions were both significant ($p < 0.001$). No correlations between HR's and RPS scores for all subjects, for each subject, or within any condition were significant (all > 0.05). No regressions were significant (all > 0.05).

Conclusion: The self-ratings of stability using the RPS were independent by exertional effects as inferred through HR. The RPS can be used during video game based balance training to assess the intensity of the activity.

Keywords: Heart rate; Physical exertion; Balance exercises; Muscular fatigue

Introduction

Exercise designed specifically to address balance is effective at both reducing fall risk and rate of falls and improving balance and postural control for mobility, gait, and other daily activities across the lifespan and the spectrum of diseases and disabilities [1-5]. Balance training programs include a wide range of activities: strength and endurance training, functional activity practice, progressive balance activities under variable conditions, group exercise programs such as tai chi, motorized perturbation training, and sensory modulation in various postures and conditions, among others. Therapeutic exercise for balance is designed for a patient or client specifically to address identified impairments and limitations and is set initially and progressed over time specifically for each person. Balance training tasks are tailored and the difficulty modulated through a variety of means: excursion of movement, velocity or acceleration of motions, amplitude of externally applied perturbations (e.g., slips, nudges, trips), size, compliance or instability of the support surface, the dual task requirements, externally vs. self-initiated perturbations, the sensory system primarily challenged, among others. However, individuals each

have their unique limitations and strengths; each will find a given activity more or less challenging than someone else. Relying on standardized activities or assumed progressions of difficulty does not necessarily align the intensity or level of challenge an individual will experience to an identical activity. From an individual's point of view, standardized activities and progressions may be over or under challenging. Likewise, the tasks or activities available for balance training may or may not be appropriate for any or all of the individuals who might use them.

To be tailored to best meet the needs of an individual, therapeutic exercise prescription in rehabilitation, including that for balance training, must be dosed appropriately across the parameters frequency, intensity, type and time [6]. This is straightforward for most types of exercise, e.g., the description or name of the exercise, distance run or heart rate reached, amount of weight lifted, degrees moved through active or passive range of motion, number of repetitions, time spent on task, number of times completed per day or week, etc. The initial dosage is set in terms of these parameters based on the client's diagnosis, assessed level of function, prognosis, and precautions. The exercises are progressed or modified within each parameter to challenge where appropriate, while avoiding unsafe or undesired overly challenging conditions. For exercise prescribed specifically to address

balance, the type, frequency and time (duration) are easily defined. There does not exist, however, a measure of balance exercise intensity. This has been pointed out in studies and reviews of balance exercise effectiveness: experts found balance exercise intensity terminology to be vague [7], and reviews have noted that there is no appropriate balance intensity measure at all, even though other dosage parameters are well defined [8,9]. Further, other dosage parameters or inappropriate, unrelated measures are often substituted for balance intensity [9,10]. In other cases, intensity is presumed through standardized or assumed levels of difficulty or progression [11,12]. The inability to define or measure the intensity of a balance training task for an individual negatively impacts balance rehabilitation research and in clinical practice.

The challenge to their balance that people experience from a particular activity (intensity) is similar to pain in that the same stimulus is perceived differently by different people, and that perception is difficult or impossible to measure directly by external means. A particular balance task is more or less challenging to different individuals based on their specific sensory, motor and processing abilities, and the degree to which a person finds an activity challenging cannot be measured externally. Self-perception rating scales are commonly used and have been validated to assess pain levels clinically and in research settings [13,14]. Self-rating scales have also been developed and validated to measure other clinical signs or symptoms, including exertion [15] dyspnea [16], and fatigue [17] among others. In particular, Borg's 15-point Rating of Perceived Exertion (RPE) and the similar Borg CR [10] Scale have been validated to measure aerobic exercise intensity [18,19]. They are very commonly used in place of more cumbersome physiological measures of exertion for setting initial training levels and to guide progression of exercise regimes.

We have developed a scale for self-rating the challenge of a particular balance activity to the individual: the rate of perceived stability (RPS; Figure 1). It is a self-rating scale, and, similarly to pain scales or the RPE scale, it can be used during or immediately after the target activities. This scale provides a measure of the balance exercise intensity perceived by the task performer which allows more appropriate initial prescription and subsequent modulation of balance exercises, facilitating safer and more effective balance training programs. If the intensity is too great there is a risk of injury and if it is too low, it provides ineffective stimulus for improvement. Quantifying the intensity component of balance tasks is particularly crucial in those that present more variables at once that challenge the balance systems; for example, video gaming based balance training presents sensory, motor, visual, attentional and cognitive challenges simultaneously.

Balance training is one major area for the use of video games as a therapeutic modality across physical therapy settings and patient groups. As with gaming in therapy in general, gaming as a tool for balance training has advantages in generating more practice repetitions [20-23] and greater task engagement [24,25], a wider array of games which challenge the gamer in multiple domains, and the ease with which the balance environments can be manipulated simultaneously with the tasks. Many commercial, off-the-shelf video games have also evolved to be used as exercise modalities targeting cardio-respiratory and other aspects of fitness [26,27]. Many of these same games are appropriate to challenge balance in therapeutic balance training programs as well and are fast paced, involve full body motions, and would be expected to impact physical exertion as well as challenging the individual's balance. With more fast paced, challenging games, if

the RPS is being used to quantify the challenge of the balance activity during or immediately after bouts of gaming, it is possible that individuals might confuse their sense of the intensity of the physical exercise with the challenge they feel from the balance task. As balance training programs can demand sustained physical effort, the RPS could potentially be confounded by the subject's physical exertion. The purpose of this study was to determine that the RPS measures the intensity of the balance exercises, independent of physical exertion as measured by heart rate (HR).

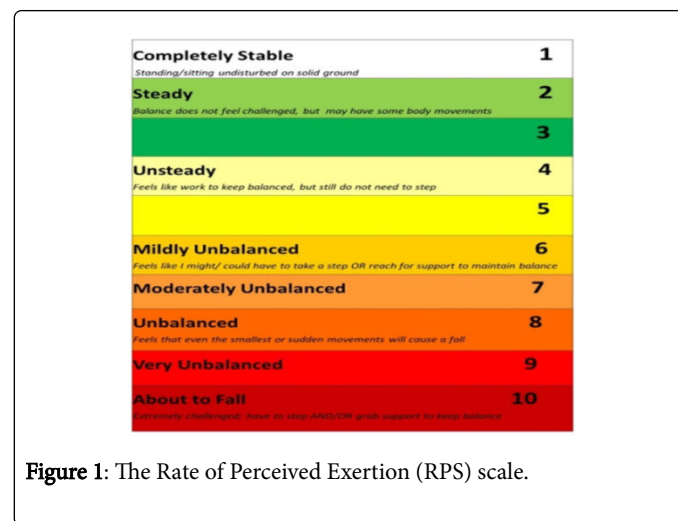


Figure 1: The Rate of Perceived Exertion (RPS) scale.

Methods

This project was approved by the Cleveland State University Institutional Review Board (IRB) and all subjects completed written Informed Consent. Thirty adult participants between the ages of 19 and 43 (mean 25.9 years; SD 5.3 years) participated. They were first instructed in the use of the RPS scale to rate the perceived difficulty of the balance training activities. Participants were then fitted with a chest strap type heart rate monitor (Polar Electro, Lake Success, NY). All participants played four Nintendo Wii video games, selected for their appropriateness as balance training games, including their movement and underlying cognitive and task demands, while standing on one of four different balance training surfaces (Table 1). All subjects trained with the same combination of surfaces and games, in the same order: Foam with boxing, Bosu-Up with dance, Bosu-Down with tennis, and Wobble with baseball. At four minutes and eight minutes of continuous play, without stopping the activity, subjects were asked to rate their RPS using the scale (Figure 1) printed full size and in color on 11 x 17 inch paper hanging just below the gaming monitor. Play for that condition ceased after the 8-minute response. Both RPS and HR were recorded at 4 and at 8 minutes of each condition.

	Condition A	Condition B	Condition C	Condition D
Surface	Foam	BOSU-UP	BOSU-DOWN	Wobble
Game	Boxing	Dancing	Tennis	Baseball

Table 1: Combinations of surface and game.

Within subjects, a repeated measures ANOVA was performed for HR and RPS separately for each of the eight conditions (4 and 8 minutes at each of the 4 games). Overall correlation and ANOVA were

performed for all RPS scores vs. all HR's. A correlation between HR and RPS across conditions was performed for each individual subject, as well as a correlation between HR and RPS for all subjects together at each condition. Regression was performed for HR predicting RPS for each condition across subjects. All data were analyzed using SPSS 22 (IBM, Armonk, New York).

Results

The gaming exercises chosen were adequate to produce a wide range of balance challenge: RPS scores ranged from one to eight (of 10 possible) across conditions. The gaming exercises also induced a range of physical exertion among the subjects: HR ranged from 72 to 160 beats per minute (bpm) across conditions. The balance activities presented enough difference in balance and exertional challenge to assure different RPS scores and HR's within individuals across the conditions. Repeated measures (within subjects) ANOVA for HR across conditions ($p < 0.001$) and RPS across conditions ($p < 0.001$) were both significant.

The study design achieved both HR and RPS variation; however, the HR and RPS were independent of each other. Over all subjects in all conditions, RPS was not correlated with HR. The overall Pearson correlation coefficient for all HR's and RPS scores was .009 and was not significant ($p = 0.864$). Likewise, for none of the individual subjects was HR significantly correlated with RPS. Correlation coefficients for each subject ranged from -0.21 to 0.67, none of which were significant (all > 0.05). Within each condition, across subjects, no correlations between HR and RPS were significant, nor were any regressions of RPS to HR. Table 2 displays the Pearson correlation, its significance, and the significance of the regression for each condition. For individuals or for specific conditions, the subjects' ratings of their balance difficulty were independent of their HR.

Condition	Pearson Correlation	Pearson Correlation Significance (p-values, 1-tailed)	Regression Significance (r^2)/p-value
A at 4 min	0.092	0.315	0.629
A at 8 min	-0.109	0.282	0.565
B at 4 min	0.007	0.485	0.971
B at 8 min	-0.015	0.468	0.937
C at 4 min	-0.135	0.238	0.477
C at 8 min	-0.122	0.261	0.522
D at 4 min	-0.143	0.226	0.452
D at 8 min	-0.024	0.451	0.901

Table 2: Pearson Correlations, Pearson Correlation Significance, and Regression Significance for each condition at 4 and 8 minutes.

Discussion

In balance training, particularly with a modality such as video gaming, the cardio-respiratory systems may be appropriately challenged in addition to the challenge to balance. This may lead people to confuse their sense of physical exertion or exercise intensity with the balance activity challenge or intensity. If this is the case and

exercisers are unable to adequately distinguish their physical exertion from the challenge to their balance, the RPS would be insufficient as a measure of balance exercise intensity. If, however, RPS varies within and across subjects and tasks independently of physical exertion, the RPS would be assumed not to be measuring effects of physical exertion. This study showed that the levels of intensity of the balance exercises measured with the RPS scale were, in fact, independent of physical exercise intensity. The study design did produce a wide range of balance and exertional challenge to the individuals: both HR and RPS were statistically not the same across conditions, yet they varied independently of each other. For individuals or for specific conditions, the subjects' ratings of their balance difficulty were independent of their HR.

Physical activity intensity is the level of effort or the energy expended by a person to do the activity. It is most often and most practically measured in one of two ways: by HR or by RPE [28]. Although the Borg self-rating system (RPE) and HR do in fact share a correlation, it has not proven to be as accurate in predicting full cardiac exertion as has non-subjective HR monitoring [29]. In this particular study, self-rating of RPE might have been difficult or confounded by simultaneous or close-in-time self-rating of RPS. Mechanized, electronic monitoring of HR was used in this study over RPE because it is more objective, more closely correlates to-physiological exertion, and because it can be measured and recorded by an observer without effort or potential confusion on the subject's part.

Physical exertion can lead to fatigue which neither HR nor RPE measure. Ten-point scales do exist to self-rate fatigue, but they were not included in this study for the same reason as the RPE: the use of simultaneous self-rating scales could too easily confuse the subjects or potentially confound the validity of either score. Whether these subjects experienced any level of fatigue is unknown. Muscular fatigue in particular would impact a person's ability to maintain balance by making it more difficult to produce the necessary motor responses to maintain or restore posture. Knowing the differential impact of fatigue on particular balance tasks would be an important area for study, but it does not impact the usefulness of the RPS. Fatigue or lack of fatigue is one factor in the difficulty or intensity perceived by the exerciser in balance activities; the RPS is designed to measure the total challenge of a task to a person at that moment.

Regardless of patient condition or setting, therapeutic exercise is more effective if it is relatively intense, and targeted and individualized to the particular patient [30]. In designing any clinical, home or group exercise program to address balance, the therapist must make clinical decisions about which tasks to choose, relating them to the therapeutic goals, and carefully monitor, progress and evaluate the effectiveness of the chosen intervention [31]. The RPS is a new tool to measure intensity of balance training as there had been no well accepted means to do so previously. It appears that this measure assesses self-perception of balance challenge independently of physical exertion; thus, it offers a promising tool for rating balance exercise intensity.

Conclusions

The RPS is a new tool to measure the level of challenge posed to an individual by a balance task and is important because there had been no means to assess the intensity of balance training, a parameter crucial to safely and effectively setting and progressing any balance training program. If using the RPS, a self-rating tool, with video

gaming as the balance training modality, there could be a physical exertion effect felt by the individual as well. This study demonstrated that the self-ratings of stability using the RPS were not confounded by exertional effects as inferred through HR.

All games were played on Nintendo Wii (Redmond, WA) on the AE Sports Active Personal Trainer. Conditions are: Foam (Neurocom, Clackamas, OR), 65 cm Bosu-ball (Bosu, Ashland, OH) disk side up (Bosu-Up) and disk side down (Bosu-Down) and a 28 cm long by 10 cm high wobble board aligned to induce an anterior-posterior rocking (Wobble).

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