CONCURRENT VALIDITY OF A PICTORIAL RATING OF PERCEIVED EXERTION SCALE FOR BENCH STEPPING EXERCISE

by

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CONCURRENT VALIDITY OF A PICTORIAL RATING OF PERCEIVED EXERTION SCALE FOR BENCH STEPPING EXERCISE

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PURPOSE: To develop and validate a modified OMNI Rating of Perceived Exertion (RPE) scale for use during bench stepping exercise (OMNI-BS); and to examine the reliability of this scale. **METHODS:** Thirty females (age: 19.8±1.8yrs) undertook two experimental trials, separated by 7 days. Concurrent validity was established by examining the relation between the physiological criterion variables, oxygen consumption ($\dot{V}O_2$) and heart rate (HR), with the concurrent variable, RPE from OMNI-BS, during load incremental and load intermittent trials. The load incremental test consisted of 3-min stages. During the first stage subjects stood in front of the bench (resting measurement). Subsequently subjects stepped up and down on the bench at 120 beats per minute. The test was terminated owing to subject fatigue. Exercise intensity increased as bench height increased every 3-min. The intermittent test consisted of three, 3-min, exercise bouts, that reproduced exercise stages I (low intensity), III (moderate intensity), and V (high intensity) performed in the load incremental test. The order of these three exercise bouts was counterbalanced. Test re-test reliability between trials of the OMNI-BS RPE scale was examined by comparing RPEs obtained during stages I, III, and V. **RESULTS:** *Intraclass Correlation* analysis from the load incremental and load intermittent trials indicated a strong

positive association between RPE and $\dot{V}O_2$ (r=0.96 and r=0.95) and HR (r=0.95 and r=0.95). Test re-test reliability also demonstrated a strong positive association of RPEs between trials (r=0.95) for the entire data set. However, separate correlation analysis conducted on each of the three stages indicated the following associations: 1) stage I: low intensity; r=0.475; *p*=0.009; 2) stage III: moderate intensity; r=0.559; *p*=0.002; and 3) stage V: high intensity; r=0.793, *p*<0.001. The Bland-Altman method indicated a moderate level of agreement in RPE between trials. **CONCLUSION:** Concurrent validity and test re-test reliability for the OMNI-BS RPE scale were established for adult females performing bench stepping exercise.

Keywords: Rating of Perceived Exertion, OMNI scale, Bench Stepping, Concurrent Validity, Reliability.

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PREFACE

Acknowledgments

Dr. Silva – who introduced me and helped me on my first steps in the scientific world, and encouraged me to begin this PhD program.

Dr. Kim – who helped to develop the methodology and conducted statistical analysis of this study, which were crucial for accomplishing the findings presented

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Thank for love and support of my family.

The more important in my live: All Honor and Glory to God

1.0 INTRODUCTION AND RATIONALE

1.1 INTRODUCTION

Perception is an active process defined as the cognitive interpretation of sensations (Dishman, 2002; Noble & Robertson, 1996). Sensations, in turn, involve a passive process defined as the stimulation of sensory nerve fibers by a stimulus or signal (Buckworth & Dishman, 2002; Noble & Robertson, 1996).

Perceived exertion, which combines both active and passive processes, is defined as the subjective feeling of effort, strain, discomfort, and/or fatigue that the subject experiences during exercise (Robertson, 2004). Indeed, perceived exertion is a complex process, in which signals from the external environmental, and central and peripheral regions from within the body are integrated to form a perceptual gestalt.

The contemporary view of factors that influence perceived exertion during dynamic exercise is described by a "*global model.*" This model provides a comprehensive explanation of the external and internal signals or stimuli that shape perceived exertion. Consonant with this model is that the rating of perceived exertion results from the complex integration of physiological mediators (for example: oxygen consumption, metabolic acidosis, and skin temperature), psychological factors (for example: anxiety, motivation, task aversion, and exercise experience), performance milieu (for example: competitive strategy and competitive

history), specific exertional symptoms (i.e., sweating, skin temperature, pain), and nonspecific exertional symptoms (i.e., general fatigue and clinical status) (Robertson & Noble, 1997; Noble & Robertson, 1996).

The degree that these signals, and consequent sensory cues are augmented or reduced, seems to be dependent on exercise intensity. For example, during intense exercise when the physiological demand is elevated, there is a concomitant increase in exertional perceptions. The integration of central and peripheral signals results in an external response that can be defined as the RPE or *perceptual response* (Robertson & Noble, 1996). Consequently, the meaningful evaluation of how "each individual feels" during exercise depends on multiple components and may be further shaped by previous experience (Noble & Robertson, 1996).

Additionally, perceived exertion can have quantitative properties since the physical stimulus leads to a proportional individual physiological responses (Buckworth & Dishman, 2002). The physical stimulus can be a measure such as power output (Watts – W) on a cycle ergometer. In this context, a specific power output will result in a physiological response that is proportional to the magnitude of the power output. These physiological sensory cues can then trigger a cognitive quantitative interpretation, i.e., a rating of perceived exertion.

Furthermore, it is necessary to have a standard metric that can be used to measure perceived exertion. As a result, the first rating scale to be used to evaluate perceived exertion was developed by Borg in 1962 (Buckworth & Dishman, 2002; Borg, 1998).

The Borg, 15-category or 6-20, rating of perceived exertion (RPE) scale was constructed in the late 60's, and was then modified in 1980 (Borg, 1998). The last version of the Borg 6-20 rating of perceived exertion scale (1980's) includes a numerical range of six to twenty along with

nine verbal descriptors, spanning the exertional continuum from “6,” “No exertion at all” and ending with “Maximal exertion,” which corresponds to a numerical rating of “20” (Borg, 1998).

The validation of the Borg 6-20 RPE scale was performed by comparing RPE with a physiological variable, initially heart rate and then later with oxygen uptake. According to Borg, the rationale for choosing “6” as the starting point on the scale, is when multiplied by 10, it corresponds to a typical resting heart rate (Borg, 1998). The other numbers on the Borg 6-20 RPE scale can also be multiplied by 10, giving the equivalent heart rate expected for normal, healthy, middle-aged men or women during the entire range of exercise intensities. The concurrent validation process was performed during cycle ergometer exercise, and later during treadmill running. Correlation coefficients between RPE and heart rate were reported to be around .85 for both exercise modalities (Borg, 1998).

Even though, the Borg 6-20 RPE scale proved to be a valid and reliable scaling metric to measure ratings of perceived exertion, Borg developed the category-ratio scale, (i.e., CR10 scale) in 1981 (Borg, 1998). Rating of perceived exertion attained using the Borg 6-20 scale has been shown to be linearly related to heart rate, oxygen uptake, and power output. On the other hand, the CR10 scale can be used to assess the relation of RPE to physiological variables that increase in a non-linear fashion during progressively incremented exercise (i.e., ventilation and lactic acid) (Borg, 1998). This scale employs ratio principles, with an absolute zero point, and avoids a ceiling effect at the highest exercise intensities, which made the “scale more finely graded” (Borg, 1998). The seminal work of Borg has lead to numerous investigations dealing with the impact of exercise modality, gender, age, and training status on ratings of perceived exertion. One such line of research has lead to the development and validation of the OMNI RPE scales (Borg, 1998; Robertson & Noble, 1997).

The initial OMNI RPE scale was developed in an attempt to improve the rating of perceived exertion during aerobic exercise in children. Robertson et al. (2000) were concerned with the applicability of previously developed RPE scales in this population because children may not understand the scales, thereby, leading to questionable validity of these scaling metrics for use in pediatric cohorts. Therefore, the OMNI RPE scale was created to improve upon methodological and semantic limitations found when children rated their perceived exertion using scales designed for adults (Robertson et al., 2000; Robertson, 2004). The OMNI picture system includes exercise-mode specific pictorials and verbal descriptors distributed along a comparatively narrow numerical range (0-10), which facilitates the rating of perceived exertion during cycle ergometry exercise for children and adolescents (Robertson et al., 2000; Robertson, 2004).

The first OMNI-Cycle RPE scale for children/adolescents was developed in 2000 employing an estimation paradigm – with the purpose to establish concurrent validity. Rating of perceived exertion was the concurrent variable, whereas oxygen uptake and heart rate were the criterion variables. The correlation coefficients from the concurrent validation, between RPE and heart rate and oxygen uptake were r=.93, and r=.94, respectively (Robertson et al., 2000; Robertson, 2004). Additional formats of the OMNI RPE scale have been developed and validated for utilization by children during treadmill walking and running (Utter et al., 2002), stepping (Robertson et al., 2005), and resistance exercise (Robertson et al., 2005). Moreover, construct and concurrent validity have been established for adult versions of the OMNI RPE scales during cycling (Robertson et al., 2004), resistance exercise (Robertson, 2003), and treadmill walking and running (Utter et al., 2004).

1.2 RATIONALE

Since its development in the 1980's, bench stepping aerobics has become one of the most common and popular forms of aerobic exercise among women. However, the effectiveness of self-regulation of exercise intensity during bench stepping exercise remains questionable (Ozcan & Kin-Isler, 2007; Laukkanen et al., 2001; Grant et al., 1998; Darby et al., 1995). A majority of investigations involving bench stepping exercise used heart rate monitors to regulate exercise intensity. Other studies used ratings of perceived exertion obtained from the Borg 6-20 RPE Scale, or heart rate (HR) measured by palpation (Grant et al., 1998; Grant et al., 2002; Darby et al., 1995; Ozcan & Kin-Isler, 2007). However, the use of heart rate monitors during bench stepping exercise in health-fitness settings can be problematic due to the cost of this equipment, whereas the palpation procedure requires practice to accurately assess pulse rate. In addition, even though an individual may have this skill, the palpation procedure requires frequent pauses during exercise, which reduces the time on stimulus.

Additionally, limitations of the Borg RPE scale may be attributed to its nonspecific mode design. This may lead to a difficult perceptual process for individuals self-regulating exercise intensity during a bench stepping exercise routine. Currently, there is a lack of research examining the relation between RPE and the gold standard measurement of aerobic capacity, oxygen consumption ($\dot{V}O_2$) during bench stepping exercise. Therefore, the accuracy of using target RPE to self regulate exercise intensity during bench stepping group exercise is unknown (Grant et al., 1998).

Indeed, this limitation was reported by Laukkanen et al. (2001), who warned about the mismatch between RPE estimated using the Borg 6-20 RPE scale and the percentage of heart rate maximum during bench stepping exercise. One study conducted by Ozcan and Kin-Isler

(2007), reported that the Borg 6-20 RPE scale is reliable but not a valid method for regulating exercise intensity during bench stepping exercise, especially when compared to heart rate and blood lactate in adult males. Therefore, given this limitation of the Borg 6-20 RPE scale, it is possible that a perceptual scaling system such as a modified OMNI RPE scale improved the self-regulation of exercise intensity during bench stepping exercise.

The newly developed OMNI Bench Stepping (OMNI-BS) RPE scale retained the characteristics of the OMNI RPE scales previously validated, including the same number of pictorial and verbal descriptors, with the exception of the first verbal descriptor. The original adult OMNI RPE scales have "extremely easy," which was associated with zero, as its first verbal descriptor. The newly developed OMNI-BS scale replaced "extremely easy" with "rest" (Robertson, 2004). The rational for this modification is based on classical psychophysics that assumes that human senses have zero as a starting point, represented numerically by "zero" (Noble & Robertson, 1996). Therefore, the first verbal descriptor was modified for "*rest*." (Noble & Robertson, 1996).

The original OMNI scales are classified as interval scales. These scales provide information of the magnitude differences between numerical categories (Robertson & Noble, 1996). The newly developed OMNI-BS scale maintained the same interval scale characteristics and added a zero point. However, the newly developed OMNI-BS scale can still be classified as an interval scale. This scale modification may improve the accuracy of rating perceived exertion during bench stepping.

In addition, the newly developed scale included exercise mode specific pictorials of a female subject stepping on benches. Increasing perceived exertion was depicted by an increase in the number of risers supporting the bench and the body position of the subject. Therefore,

consistent with the previously validated OMNI rating of perceived exertion scales, the verbal and pictorial descriptors established a verbal-visual correspondence in exertional properties (Robertson, 2004).

Finally, validation of the OMNI Bench Stepping RPE scale resulted in an easy, efficient mode specific method to rate exertional perceptions during one of the most common and popular aerobic exercise modalities among women in health-fitness settings worldwide.

1.3 STATEMENT OF THE PROBLEM

The primary purpose of this investigation was to develop and validate a modified OMNI RPE pictorial scale format for use during bench stepping exercise (OMNI-BS). The subject cohort consisted of young healthy adult women. Although several mode specific OMNI RPE scales have already been validated, an OMNI scale for use during bench stepping exercise has not been developed. The present investigation employed the procedures used previously by Robertson (2004) to validate the newly generated OMNI-BS scale. Concurrent validity was determined by examining the relation between the concurrent variable – RPE for the overall body, obtained from OMNI-BS scale, with the physiological criterion variables – oxygen consumption ($\dot{V}O_2$) and heart rate (HR). The secondary purpose of this investigation was to examine the reliability of the OMNI-BS RPE scale by comparing RPEs between the first and second experimental trials during stages I, III, and V.

1.4 HYPOTHESES

1. It was hypothesized that the ratings of perceived exertion obtained from the OMNI-BS scale during the load-incremented bench stepping protocol distributed as a strong ($r > .80$) positive linear function with:

    a) Oxygen consumption.

    b) Heart rate.

2. It was hypothesized that RPEs obtained from the OMNI-BS scale, exhibited a moderate-strong test re-test reliability ($r > .70$) between the first and second experimental trials during stages I, III, and V.

2.0 REVIEW OF THE LITERATURE

The sensory system can be described as an innate process, crucial to human survival. Throughout the day, our sensory system is receiving signals or stimuli, from the external environmental and/or internal areas of our body. The intensity of this stimulation enables our brain to perceive these signals as an important stress (or not), which requires a corresponding response. How each person perceives these stimuli depends on many individual factors, of these factors previous experience with the stimulus is thought to be critically important in shaping the perception. The same type or magnitude of a stimulus can be perceived differently between individuals, therefore resulting in a unique or singular response – an individual's perceptual style (Noble & Robertson, 1996).

The sensory system includes the senses of touch, taste, smell, hearing, and sight (Noble & Robertson, 1996). Moreover, it has been demonstrated that humans also have a sense of effort. The effort sense can be defined as a complex sensory experience, depending of a multitude of extrinsic and intrinsic signals. In other words, the perception of effort during exercise is a process that "involves multiple physiological inputs, modulated by several psychosocial variables" (Noble & Robertson, 1996). The procedure to measure the response produced by the perception of effort involves using various psychometric systems, such as rating of perceived exertion scales. The following section, will present a more in depth discussion of the development of perceived exertion as a specific field of scientific inquiry.

2.1 PSYCHOPHYSICS

Before discussing perceived exertion as an independent field of study, it is crucial first to provide background information on the key principles of psychophysics. Psychophysics is the science that investigates the relation between sensation and stimulus by measuring the quantity of both factors (Noble & Robertson, 1996). An early dimension of psychophysics focused on the development of various metric systems capable of measuring what an individual feels. In general, many of these rating scales were based on the premise that most individuals have the potential to express basic life events using numbers.

The seminal work of Weber and Fechner formed the foundation of psychophysics (Borg, 1998). Weber was interested in the discrimination threshold and in developing the "method of limits" and the "constant stimuli" concepts. On the other hand, Fechner's line of research focused on detection and identification of the sensory perception process. Fechner's Law assumed that the relation between the sensation of hand grip strength and physical intensity can be expressed as a logarithmic function (Borg, 1998), and was an early step in the development of psychometric scales to assess perceived exertion.

Stevens changed the focus of the classical psychophysical investigations and started to explore the response instead of the stimulus. Therefore, the question of "How do subjects make numerical judgments based on their sensory experience?" was investigated by using scaling methods (Noble & Robertson, 1996).

2.2 CLASSICAL VIEW OF PERCEIVED EXERTION DURING EXERCISE

In 1958, Borg reported initial findings concerning the relation between work capacity and fatigue while performing a test on a cycle ergometer. This early investigation was the foundation for the study of perceived exertion during dynamic exercise. Next, several investigations regarding perceived exertion during dynamic exercise were conducted by Borg during his work at the University of Pittsburgh during the 1960's. The rationale behind these early studies was based on a theoretical framework proposed by Borg. One of the initial arguments of Borg was the perception of physical and mental work should integrate results from the perceptual, performance and physiological *effort continua* (Figure 1) (Borg, 1998). Therefore, "both physiological and perceptual responses should be used as indicators of physical and mental workload" (Borg, 1998).

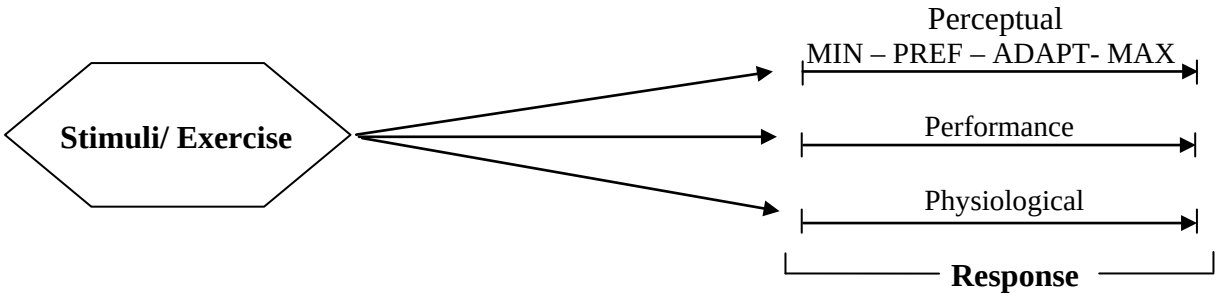

Figure 1. Effort Continua Model

(Adapted from Borg, 1998)

The perceptual *effort continuum* includes variations in intensity, from a minimum to a preferred level, adaption to stress, and maximal intensity level. This process occurs in response to sensory cues. The performance *effort continuum* is simply a physical measure, such as time to

perform a specific task, watts on cycle ergometer and speed on treadmill. The physiological *effort continuum* can be measured by physical methods, such as absolute or relative values of oxygen uptake, heart rate, ventilation, muscle acidosis, and hormones. Some of those respond in a linear function with stimulus intensity (oxygen uptake) and others in a nonlinear function (lactate acid) (Borg, 1998).

According to Borg, all three *effort continuum* are "integrated into a kind of gestalt" that provides a global rating of an individuals' perceived exertion. Additionally, the different factors associated with the *effort continuum* can be specific to the working muscles or the cardiorespiratory system leading to a differentiated RPE associated with the legs (local) or chest (central). Therefore, local signals contribute to the sensory experience and in some cases RPE associated with respiratory-metabolic factors may dominate the perception of effort (i.e. during intense aerobic exercise) (Borg, 1998).

In addition to this theoretical framework, Borg reported that physical and social environmental factors can influence pshychophysiological responses. The physical environment consists mainly of factors such as altitude, ambient temperature, music and noise, air conditions, and the social context (Borg, 1998). In addition, nutritional status and medication (i.e., stimulants or sedatives drugs), can play a role in perceived exertion (Borg, 1998). The following physiological factors can also influence RPE: heart rate, oxygen uptake, lactate concentration in blood and muscle, ventilation, respiratory rate, catecholamines, blood sugar, and tissue temperature (Borg, 1998). Lastly, motivation, emotional state, and personality type were the main psychological factors that Borg considered could mediate perceived exertion. In summary, the interaction of all these factors seems to influence the perception of exertion during dynamic exercise (Borg, 1998).

Finally, Borg defined perceived exertion as “the degree of heaviness and strain experienced in physical work as estimated according to a specific rating method,” such as the Borg RPE scales that will be presented in the following session (Borg, 1998). Initially, Borg used a simple method of halving or doubling numerical categories along a ratio scale to explore the stimulus-response relation (Borg, 1998). Borg and Dahlstrom reported an intra-test reliability coefficient of .95 and .98, between perceived “heaviness and strenuousness” and the pedal resistance while performing short-term cycling (Borg, 1998).

Additionally, experiments were conducted involving long-term exercise to investigate changes in perceived exertion when a large muscle mass is involved for a protracted period. Borg in 1973, (Borg, 1998) investigated the rating of perceived exertion, obtained from the CR10 scale, in fit subjects while walking or running on a treadmill at different speeds. The findings demonstrated that when the exercise intensity changed from a speed of 0 to 3 mph, the RPE did not change significantly. However, at speeds greater than 3 mph, the perception of exertion increased greatly, displaying a curvilinear response (Borg, 1998).

In the following years, other experiments focusing on perceptual judgments of effort on a cycle ergometer were conducted, but the scaling methods were still being refined. In addition, Borg suggests that the lack of standardized ergometers and reproducible power outputs may limit the validity of these early scaling metrics. Therefore, those preliminary results may be biased by the methodology used (Borg, 1998).

Currently, the scaling metrics frequently utilized to measure perceived exertion during exercise have interval or ratio scale properties. The interval scale can differentiate quantities because it has equidistance between each number, and can display verbal descriptors along the scale.

A more sophisticated method involves *ratio scaling*, which includes the characteristics of interval scales with inclusion of an absolute zero. The absolute zero is considered an advantage because it provides a reference for the subject (Borg, 1998; Noble & Robertson, 1996).

2.2.1 The classical Borg RPE scales

Clearly Borg concentrated his efforts in developing a metric system that could be used to evaluate perceived exertion during physical work/exercise. The first RPE scale was developed in 1962 (Buckworth & Dishman, 2002; Borg, 1998). The Borg, 15-grade or 6-20, RPE scale was constructed in the later 1960's, and then was modified in 1980 (Borg, 1998). The last version of the Borg 6-20 RPE scale (1980's) includes a numerical range of 6 to 20 along with nine verbal descriptors spanning the exertional continuum from "6," "No exertion at all" and ending with "Maximal exertion" which corresponds to a numerical rating of "20" (Borg, 1998).

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Even though, the Borg 6-20 RPE scale proved to be a valid and reliable scaling metric to measure ratings of perceived exertion, Borg developed and validated a second scale, the category-ratio scale, the CR10 scale in 1981 (Borg, 1998). Ratings of perceived exertion attained using the Borg 6-20 scale have been shown to be linearly related to heart rate, oxygen uptake, and power output. On the other hand, the CR10 can be used to assess the relation of RPE to physiological variables that increase in a non-linear fashion during progressively incremented exercise (i.e., ventilation and lactate acid) (Borg, 1998). This scale employs ratio principles, with an absolute zero point, and avoids a ceiling effect at the highest exercise intensities, which made the "scale more finely graded" (Borg, 1998).

2.3 CONTEMPORARY VIEW OF PERCEIVED EXERTION DURING EXERCISE

The contemporary view of factors that influence perceived exertion during dynamic exercise is described by the "*global explanatory model"* of perceived exertion. This model provides a comprehensive explanation of the external and internal signals or stimuli that shape perceived exertion (Figure 2). The Global Explanatory Model assumes that ratings of perceived exertion during exercise result from the complex integration of physiological signal mediators (i.e., oxygen uptake, metabolic acidosis, and skin temperature); psychological factors (i.e., anxiety, motivation, task aversion, and exercise experience); performance milieu (i.e., competitive strategy and history); and exertional symptoms classified as specific (i.e., sweating, skin temperature, and pain) and nonspecific (i.e., general fatigue and clinical status) (Robertson & Noble, 1997; Noble & Robertson, 1996).

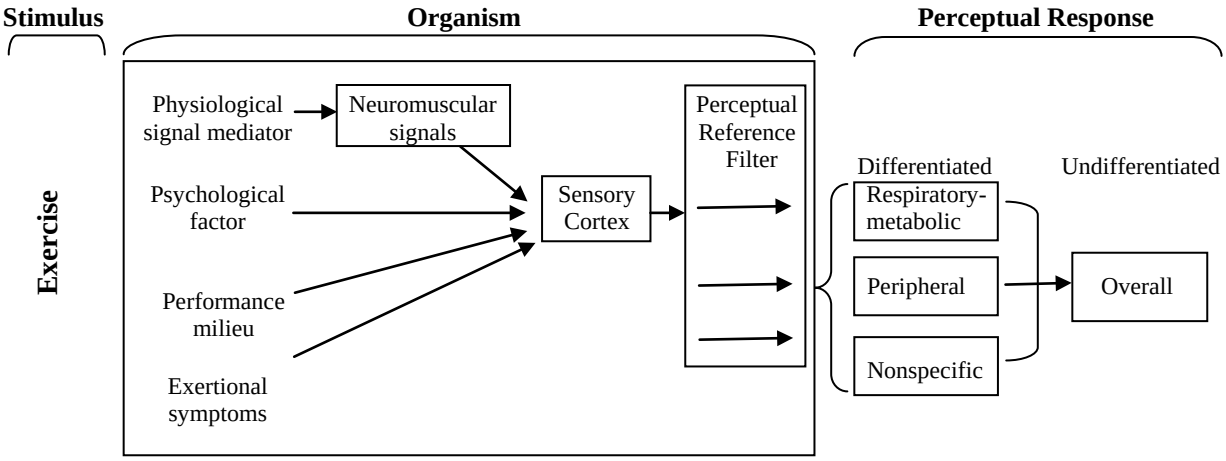


Figure 2. Global Explanatory Model of Perceived Exertion

(From Noble and Robertson, 1996)

Physiological responses during exercise such as increases in oxygen consumption will produce a corresponding skeletal muscle tension that will require an increase in central feedforward commands form the motor cortex. In turn, central efferent commands are transmitted to the sensory cortex, which by interaction with peripheral afferents will generate perceptual signals of exertion (Robertson, 2001).

The perceptual reference filters seem to be the antecedent step before the individual makes a decision and rates their perceived exertion. The filters accumulate information regarding the individual's previous experience. Hence, dependent of the magnitude of the stimulus, the filters fine tune the perceptual response. Therefore, it is likely that the previous experience has a great effect on the individual's ability to rate their perceived exertion. Moreover, this complex process influences the individual's perceptual style (Robertson, 2001).

2.3.1 Physiological mediators

Physiological responses caused by an increase in exercise intensity, serve as stimuli that mediate the perceptual signals of exertion. These physiological signals can be classified in three areas: respiratory-metabolic, peripheral and nonspecific.

Respiratory-metabolic Mediators. Ratings of perceived exertion have a proportional and direct association with ventilation in different testing modes and cycling pedaling frequencies (Franklin et al., 1983; Robertson et al 1979). In addition, changes in respiratory rate caused by exercise seems to be of one the primary physiological mediators of the respiratory-metabolic signals of perceived exertion (Robertson, 1982). Evidence have been shown that both respiratory gases, oxygen consumption and carbon dioxide production, influence perceived exertion (Smutok et al., 1980; Robertson et al., 1986). As expected heart rate, a common cardiovascular indicator of exercise intensity, displays a direct association with rating of perceived exertion (correlation coefficients range from r =.42 - .94). This relation has been established using several exercise modalities (Robertson & Noble, 1997).

Peripheral Mediators. One of the most important peripheral perceptual signals is linked with blood acidosis during high-intensity dynamic exercise (Robertson, 1986). However, there is still a lack of evidence regarding the association between RPE and muscle acidosis. Nonetheless, during a progressive cycle ergometer test, muscle lactate concentration displayed a positive accelerated association with the differentiated RPE, for the legs, as a function of increases in power output (Noble et al., 1983). Other peripheral perceptual signals that may influence the RPE are: percentage of fast- or slow-twitch muscle fibers, blood flow to the limbs, and blood glucose or muscle glycogen and plasma free fatty acids or glycerol availability for providing energy (Robertson & Noble, 1997).

Nonspecific Mediators. The components of the nonspecific mediators are those related to hormones (i.e., catecholamines), temperature (i.e., body core and skin temperature), and pain. However, experimental evidence for the association between RPE and these components is still inconsistent (Robertson & Noble, 1997).

2.3.2 Psychological mediators

The psychological mediators of exertional perception are classified as situational and dispositional factors. Although experiments failed to prove hypnosis influences perceived exertion, other situational factors appear to be related to the perception process. For example, knowledge of exercise duration can influence perceived exertion. If subjects have their attention focused on the external environmental (i.e., exercise time) RPE may be influenced. However, these psychosocial attributes may be associated with RPE only at low-moderate exercise intensities, because at higher intensities the physiological factors become the dominator mediators for triggering sensory cues that will impact RPE (Robertson & Noble, 1997).

The main dispositional factors that can systematically alter the RPE during dynamic exercise are sensory augmentation-reduction, locus of control, sex role typology, cognitive style, self-efficacy, and personality type. Among these factors, the following seem to be associated with higher RPE during dynamic exercise: sensory augmenters, individuals with an external lack of control, feminine-typed women or men, individuals who use associative cognitive strategy during exercise, and individuals classified as Type B. Conversely, individuals with high self-efficacy, who are extroverted, androgynous, and Type A report lower RPE during submaximal exercise than individuals with the opposite personal characteristics (Robertson & Noble 1997).

2.4 THE OMNI SYSTEM OF PERCEIVED EXERTION SCALE

In Latin, the word *omnis* is equivalent to “totality.” This English version of this word *omni* has been incorporated into a series of newly developed perceptual scaling metrics. The OMNI system means that the RPE scales were developed with the purpose to be applied for all types of exercise modes, individual characteristics, or physical activity settings (Robertson, 2004).

The initial OMNI RPE scale was developed in an attempt to improve the rating of perceived exertion of children during aerobic exercise. Robertson and associates were concerned with the applicability of the previously developed RPE scales in this population because children may not understand the scales, thereby, leading to questionable validity of these scaling metrics for use in pediatrics cohorts. Therefore, the OMNI RPE scale was created to improve upon methodological and semantic limitations found when children rated their perceived exertion using scales designed for adults (Robertson et al., 2000; Robertson, 2004).

The procedures behind the development of the new OMNI RPE scales consisted of four steps. First, pictorials were drawn by an artist showing children and adults of both genders performing different exercises with different degrees of exertion. The pictures were made in shades of gray on white background to provide a wide generalization over the human skin tones. The exercise modalities selected were cycling, walk/run, stepping, and weightlifting. The subsequent step consisted of showing these mode-exercise specific pictures of children to young boys and girls, likewise pictures of adults exercising were shown to clinically normal adult males and females. Subjects were asked to provide verbal descriptors associated with the perceived exertion on each pictorial. The third step included a semantic differential analysis of those verbal descriptors; in which six descriptors were chosen separately for children and for adults. The most common root word for children was “tired,” while adults used the words “easy” and “hard” to

define the level of effort depicted in the pictorials. Lastly, these six verbal cues were placed equidistance along a narrow numerical range of 0 to 10. Similarly, the four pictorial descriptors were placed equidistance on the scale. Verbal descriptors were placed on the zero as a starting point. In addition, numbers, pictorials, and verbal descriptors were aligned along a graded format providing additional visual evidence of increasing exercise intensity, and thereby, perceived exertion (Robertson et al., 2000; Robertson, 2004).

In summary, the OMNI picture system includes exercise-mode specific pictorials and verbal descriptors distributed along a comparatively narrow numerical range (0-10), which facilitates the self-regulation of exercise intensity during various exercise modalities for children, adolescents and adults (Robertson et al., 2000; Robertson, 2004).

The first OMNI RPE scale was developed in 2000, for use by children/adolescents while riding a cycle ergometer. The study design employed an estimation paradigm with the purpose to establish concurrent validity. Rating of perceived exertion was the concurrent variable, whereas oxygen uptake and heart rate were the criterion variables. The correlation coefficients from the concurrent validation, between RPE and heart rate and oxygen uptake were r=.93, and r=.94, respectively (Robertson et al., 2000; Robertson, 2004).

Additional formats of the OMNI RPE scale have been developed and validated for utilization by children during treadmill walking and running (Utter et al., 2002), stepping (Robertson et al., 2005), and resistance exercise (Robertson et al., 2005). Similar procedures were used for validating the adult OMNI RPE scales. Both construct and concurrent validity have been established for adult versions of OMNI RPE scales for during resistance exercise (Robertson et al., 2003), cycling (Robertson et al., 2004), and treadmill walking and running (Utter et al., 2004). Furthermore, the reliability coefficients of the OMNI RPE scale were found

to range between r=.91 to .95 during graded treadmill exercise in adolescents girls (Pfeiffer et al., 2002). The following section will describe the process used to validate the Adult OMNI RPE scales.

2.4.1 Adult OMNI-Resistance RPE scale

The first validation of the OMNI RPE for an adult cohort was conducted by Robertson and colleagues in 2003, focusing on resistance exercise. The concurrent validity was established using a cross-sectional, perceptual estimation experimental design consisting of clinically normal females (n=20) and males (n=20). Participants were classified as recreational weight trainers. Subjects undertook one orientation and three experimental trials, in which they performed one set of biceps curl and another set of knee extension exercise in a counterbalanced order. Each set consisted of 4, 8 and 12 repetitions, presented in a counterbalanced order (Robertson et al., 2003).

The concurrent validity was determined by correlations between RPE for the active muscle and overall body (which served as dependent variables) with total weight lifted (Wt_{tot}) and blood lactate concentration (Hla) (which served as the criterion, independent variable). In both genders positive linear regression coefficients were found ($p<0.01$) between Wt_{tot} and RPE for the active muscle and overall body (r ranged from .79 to .89). In addition, RPE for active muscle displayed a positive linear coefficient with Hla ($r=.87$, $p<0.01$). A non-significant gender interaction indicated that RPE for active muscle and for overall body did not differ between male and female individuals based upon work performed during biceps curl or knee extension exercise (Robertson et al., 2003).

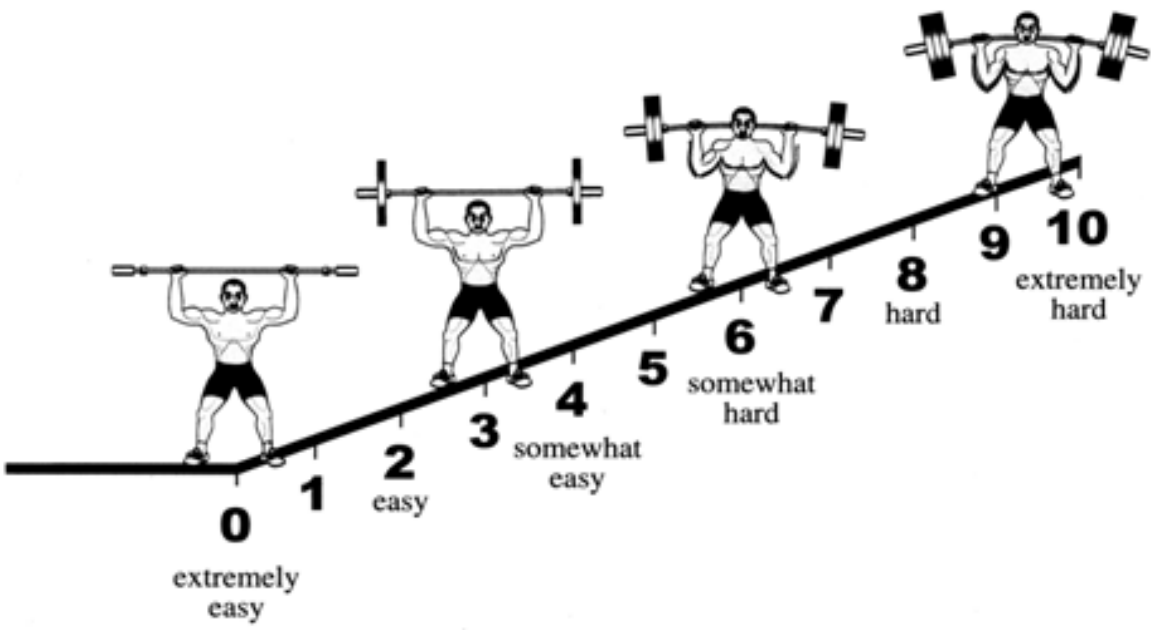


Figure 3. OMNI-Res RPE scale

(Robertson et al., 2003)

In conclusion, these findings provided concurrent validation of the OMNI-Resistance scale for measuring RPE for the active muscle and for the overall body in young recreationally trained male and female weight lifters while performing both upper- and lower-body resistance exercises. Therefore, it was recommended that the OMNI-Resistance RPE scale be used to prescribe and monitor exercise training, as well as to evaluate changes in neuromuscular fitness (Robertson et al., 2003).

2.4.2 Adult OMNI-Cycle RPE scale

The validation of the adult OMNI-Cycle RPE scale was conducted by Robertson and colleagues in 2004. Concurrent and construct validity was established using a cross-sectional, perceptual estimation experimental design consisting of clinically normal males (n=20) and females (n=20). Participants were classified as recreationally active. Subjects undertook one orientation (familiarization with cycle ergometer) and an experimental trial, in which they performed a load-incremented maximal cycle ergometer test until volitional fatigue (Robertson et al., 2004).

The concurrent validity was determined using criterion (i.e., stimulus) and concurrent (i.e., response) variables. The RPE for the overall body, legs and chest were the concurrent (i.e., as dependent variables), while oxygen consumption and heart rate responses were the criterion (or independent variables), measured at the same time-point while subjects performed the cycle ergometer estimation protocol. Construct validity was determined from a comparison between RPEs obtained from the Borg 6-20 scale (criterion metric – independent variable) with RPEs from the OMNI-Cycle scale (conditional metric – dependent variable). The presentation of the RPE scales and the recording of each RPE were carried out in a counterbalanced order for all subjects.

The concurrent validation was established for both genders. Positive linear regression coefficients were found ($p<0.01$) between RPE for the overall body, legs and chest with oxygen consumption and heart rate. The correlation coefficients between RPEs with oxygen consumption ranged from .87 to .90 for females, and .94 to .95 for males. Whereas the correlation between RPEs and heart rate were r=.81 to .83 for females, and .86 to .90 for males ($p<0.01$). Similarly, construct validation was established for both genders. Positive linear

regression coefficients were found ($p<0.01$) for the RPE obtained from the Borg 6-20 scale and for all RPEs (overall body, legs and chest) obtained from the OMNI-Cycle scale ($p<0.01$). The correlation coefficients between RPE from Borg and RPE for overall body, legs, and chest from OMNI scale are shown in Table 1 (Robertson et al., 2004).

Table 1. Correlation coefficients between the OMNI-Cycle and BORG 6-20 RPE scales.

	Male (n=20)	Female (n=20)
Overall body	.97	.96
Legs	.94	.93
Chest	.92	.94

*For all values $p<.01$.

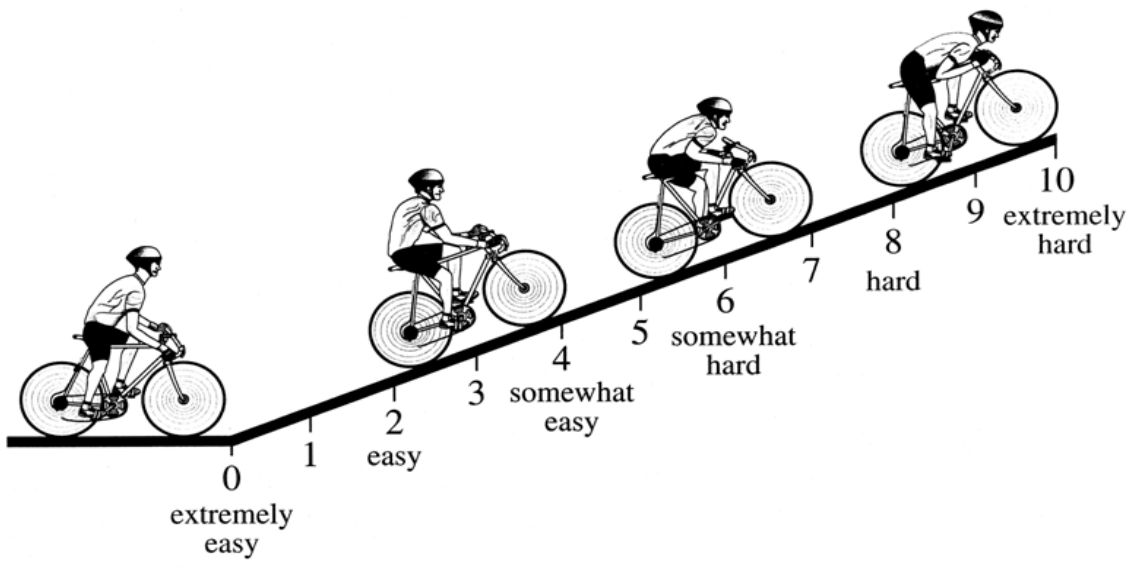


Figure 4. OMNI-Cycle RPE scale

(Robertson et al., 2004)

In conclusion, these findings provide concurrent and construct validation of the OMNI-Cycle to measure differentiated and undifferentiated RPEs in young recreationally active males and females while performing a load-incremented cycle ergometer protocol. Therefore, it is recommended that the OMNI-Cycle RPE scale can be used to prescribe and monitor exercise training, as well as to evaluate changes in fitness (Robertson et al., 2004).

2.4.3 Adult OMNI-Walk/Run RPE scale

The validation of the adult OMNI-Walk/Run RPE scale was conducted by Utter and colleagues in 2004. Concurrent and construct validity was established using a cross-sectional, perceptual estimation experimental design consisting of clinically normal recreationally active males (n=33) and females (n=34). Subjects undertook a maximal graded exercise test (GXT) on a treadmill, using the Bruce protocol, in which they performed a load-incremented maximal test until volitional fatigue (Utter et al., 2004).

Concurrent validity was determined by examining the relation between criterion (i.e., stimulus) and concurrent (i.e., response) variables. The rating of perceived exertion for the overall body was the concurrent (or dependent variable), while the oxygen consumption ($\dot{V}O_2$), relative maximal oxygen consumption (%$\dot{V}O_{2max}$), pulmonary ventilation ($\dot{V}e$) respiratory rate (RR), respiratory exchange rate (RER), and heart rate (HR) responses were the criterion (or independent variables). All measurements were obtained at the same time-point while subjects performed a graded treadmill test. Construct validity was determined from a comparison between RPEs obtained from the Borg 6-20 scale (criterion metric – independent variable) with RPEs

from the OMNI-Walk/Run scale (conditional metric – dependent variable). The presentation of the rating of perceived exertion scales was carried out in a counterbalanced order for all subjects.

Concurrent validation was established for both genders. Positive linear regression coefficients were found ($p<0.01$) between RPE for overall body with $\%\dot{V}O_{2max}$, $\dot{V}e$, HR, RR, and RER ($p<0.01$). The correlation coefficients between OMNI-Walk/Run RPE for the overall body with the physiological criterion variables are shown in Table 2.

Table 2. Correlation coefficients between the OMNI-Walk/Run RPE scale and physiological variables.

	Male (n=33) r	Female (n=22) r
Relative Maximal Oxygen Consumption – $\%\dot{V}O_{2max}$	.86	.85
Pulomonary Ventilation – $\dot{V}e$	.78	.79
HR – Heart Rate	.75	.84
Respiratory Rate – RR	.69	.67
Respiratory Exchange Ratio – RER	.82	.88

*For all values $p<.05$.

Similarly, construct validation was established for both genders. Positive linear regression coefficients were found for the RPE obtained from the Borg 6-20 scale and the OMNI-Walk/Run scale ($p<0.01$). The correlation coefficients between RPE from Borg and RPE for overall body from OMNI scale were $r=.96$ for both male and females ($p<0.01$) (Utter et al., 2004).

In conclusion, these findings provided concurrent and construct validation of the OMNI-Walk/Run RPE scale for the overall body in young recreationally active male and female subjects while performing a graded treadmill exercise test. Therefore, it is recommended the OMNI-Cycle RPE scale can be used to prescribe and monitor exercise training, as well as to evaluate changes in fitness (Utter et al., 2004).

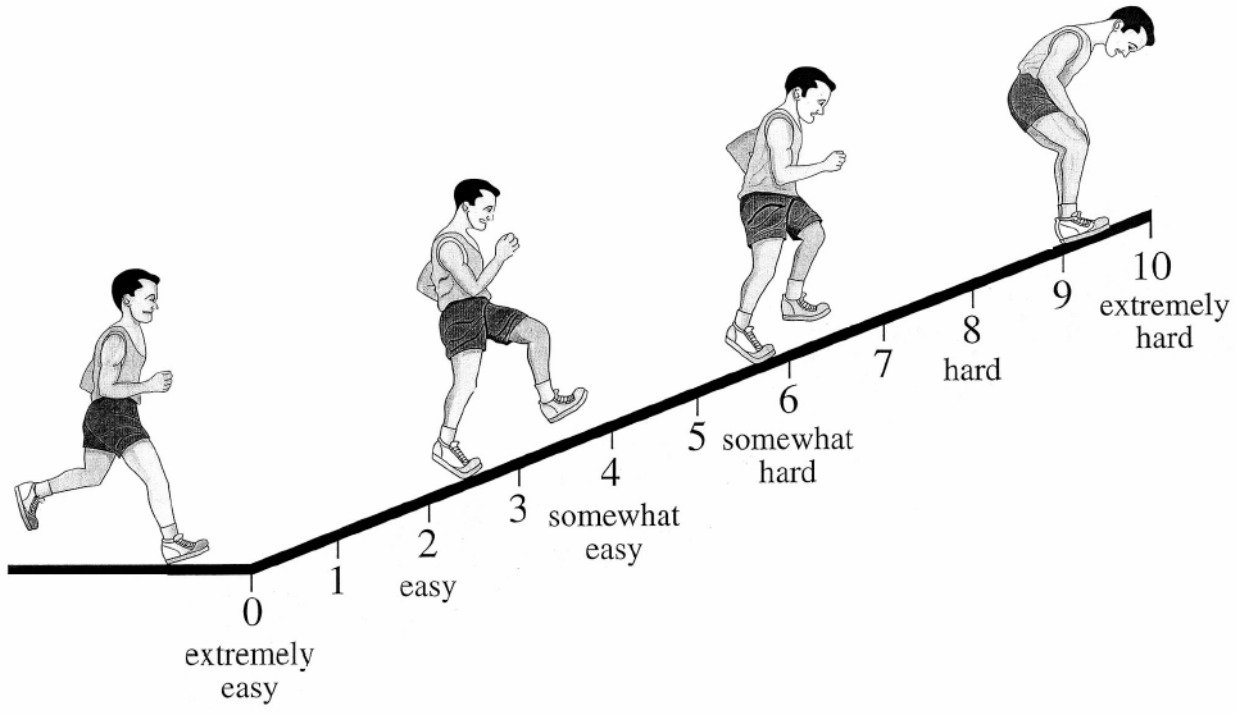


Figure 5. OMNI-Walk/Run RPE scale

(Utter et al., 2004)

The evidence from the concurrent and construct validation supports the utilization of the OMNI RPE scales in adult men and women (as well as in children and adolescents). Therefore,

the OMNI RPE scales can be used to evaluate individual responses to various exercise modalities, develop exercise prescriptions, self-regulate exercise intensity, monitor training, and evaluate changes in fitness in both nonweight bearing and weight bearing exercise.

2.5 BENCH STEPPING EXERCISE MODALITY

Many of adults who exercise belong to fitness clubs. One of the main advantages of a fitness club is that multiple exercise modalities can be performed in a group setting. Group classes are associated with increases in adherence and enjoyment because they promote more positive interaction and reinforcement due to the social contact; the exercise routine is often performed to music; and the presence of a fitness instructor who provides leadership and encouragement and serves as a health-fitness role model (Fox et al., 2000; Woodby-Brown et al., 1993).

Several group class modalities have been created; however, bench stepping is considered to be one of the most common and popular forms of aerobic exercise among women (Ozcan & Kin-Isler, 2007; Laukkanen et al., 2001; Grant et al., 1998; Darby et al., 1995). This exercise modality can elicit an appropriate level of physiological stress, thereby, promoting health and fitness-related benefits. The next section will describe the characteristics of bench stepping, its benefits, and the current methods used to monitor exercise intensity during this exercise modality.

2.5.1 Bench stepping training characteristics

Bench stepping involves stepping up and down on a single bench in choreographed, group-led movements to cadenced musical arrangements. A low impact version was developed as a safe alternative for beginners, in which at least one foot remains in contact with the floor or the bench at all times (Darby et al., 1995). On the other hand, a high impact version can be performed for the advanced practitioner (Darby et al., 1995). The high impact version consists of similar choreographies adding jumping and hopping. In both versions, it is recommended that the bench stepping routine be set to a music arrangement paced at a cadence of 120-128 footstrikes·min^{-1} (or beats·min^{-1}) which elicits 30-32 completed cycles of steeping up and down in each minute (Olson et al., 1991; AFAA, 1997).

The exercise intensity during bench stepping is primarily increased by adding risers under the bench. Olson and colleagues (1991), demonstrated that the oxygen consumption increases progressively as the bench height increases at 120 footstrikes·min^{-1} ($p<0.05$). A 6 inch (15.2 cm) bench led to an oxygen consumption of 28.4 mL·kg^{-1}·min^{-1}, whereas the 12 inch (30.5 cm) bench led to an oxygen consumption of 37.3 mL·kg^{-1}·min^{-1}. Similar results were also reported by Woodby-Brown et al., (1993) for bench heights of 4 (10.16 cm), 6 (15.2 cm) and 8 inch (20.3 cm) ($p<0.001$), and by Stanforth and Stanforth (1996) for bench height of 6 (15.2 cm), 8 (20.3 cm) and 10 inch (25.4 cm) ($p<0.001$), also at 120 footstrikes·min^{-1}. More recently, Grier et al., (2002) indicated that a 2 inch (5.08 cm) increase in bench height can promote an increase of 10 beat·min^{-1} in heart rate, 3.09 mL·kg^{-1}·min^{-11} in oxygen consumption, and 1.53 RPE units (Borg 6-20 scale). Additionally, the findings determined that there was not a significant interaction between bench heights and cadence, thereby suggesting that the increases in bench height is the main factor responsible for increases in metabolic demand during this exercise routine.

The intensity also can be elevated by performing complex movements (Olson & Williford, 1996), involving the legs and arms simultaneously, arm movements over the head, select movements performed faster with higher amplitude, adding jumping or hopping patterns (Darby et al., 1995), and adding external weight such as handheld weights (Olson et al., 1991) or waist belts (Stanforth & Stanforth, 1996).

A recent intervention study conducted by Kravitz et al. (1997), did not find significant differences in body composition, cardiorespiratory fitness and muscular strength, between the experimental groups that performed the bench stepping routine with or without handheld weights. A pair of hand held weights of .91kg was used in weeks 2-4, the weight was increased to 1.36 kg during weeks 5-8, and 1.81 kg during weeks 9-12. Nonetheless, physiological variables (i.e., oxygen consumption and peak torque of shoulder and knee muscles) increased after 12 weeks of training, indicating that the bench stepping routine is effective for promoting cardio-respiratory, neuromuscular and body composition benefits ($p<0.01$). In the next section the scientific evidence regarding the physiological and psychological benefits of this exercise modality will be presented.

2.5.2 Benefits of bench stepping training

The physiological demand during bench stepping predominantly utilizes primarily aerobic metabolism to provide energy for muscle contraction. Therefore, oxygen consumption and the heart rate responses serve as the primary dependent variables in the majority of studies that have explored the effects of this exercise modality on health and fitness. For example one of the first studies involving bench stepping was conducted by Goss and colleagues (1998), which indicated that energy cost during a bench stepping session was appropriate for providing physiological

benefits. Bench stepping training can increase the total daily energy expenditure that is a common recommendation for those individuals who wish maintain their weight or lose weight, as well as, who wish to improve their health-fitness status.

Similarly, Woodby-Brown et al., (1993) reported that the mean oxygen consumption during a 10 minute bench stepping session, in young adult women, corresponded to 45, 56 and 66 %$\dot{V}O_{2max}$, for bench heights of 4, 8 and 10 inches, respectively. More recently, another study determined that cardiovascular responses after 8 minutes of bench stepping ranged from 60 to 73 percentage of oxygen uptake reserve (Grier et al., 2002). Additionally, Olson et al., (1991), determined that the respiratory exchange ratio (RER) during 20 minutes of bench stepping ranged from .78 to .88 for bench heights ranging from 6 to 12 inches. These results indicated that bench stepping is an activity predominantly dependent on aerobic metabolism.

Although bench stepping is considered an aerobic exercise modality, other investigations have been conducted with the purpose to evaluate the effects of bench stepping training on neuromuscular attributes and on anaerobic performance (Koenig et al., 1995; Kravitz et al., 1997, Kin-Isler & Kosar, 2006). Koenig et al. (1995), conducted a study with 24 healthy adults, 24 – 61 years-old, who were randomly assigned to bench stepping or control experimental groups. The bench stepping training consisted of 50 minutes per session, three times per week, at 65-85% of maximal heart rate. The thirteen participants in the experimental group were randomly assigned to perform the exercise routine on 4 inch (10.2cm) or 6 inch (15.2 cm) benches. After 10 weeks of the intervention, muscle strength, power, endurance of the quadriceps and hamstring muscles were measured by computerized isokinetic dynamometry. The authors report that these neuromuscular attributes did not significantly improve in either group.

Conversely, Kravitz et al. (1997), investigated the effects of 12 weeks of bench stepping with or without handheld weights in 44 adult women (ages 18 to 36 yr). The exercise protocol for both groups consisted of 30 minutes per session, three times per week, at 75 – 90% of maximal heart rate. Both groups had significant improvements ($p<0.01$) in $\%\dot{V}O_{2max}$, treadmill run time, %body fat, fat-free mass, and muscular strength. Significant changes in peak torque from pre to posttest for the shoulder muscles were observed for: flexors Δ%: 6.9, extensors Δ%: 11.1, horizontal adductors (9.0%), and horizontal abductors (6.7%); and for knee flexors (9.1%) and knee extensors (1.7%) (all $p<0.01$, except knee extensors).

After 10 weeks of bench stepping, anaerobic performance examined by the mean power relative to body weight in the Wingate test increased in adult males and females. In addition, women but not men had an increased anaerobic power measured by the vertical jump test (Kin-Isler & Kosar, 2006).

Bench stepping routines combined with resistance training may enhance health and fitness outcomes related to both cardiovascular and neuromuscular attributes (Kraemer et al., 2001). Moreover, Evans and Cureton (1998) compared the effects of bench stepping performed on land and underwater. Oxygen uptake was lower in water than land by 35.1% at a bench height of 7 inches and by 38,9% when using a 13 inch bench ($p=0.02$). However, bench stepping underwater resulted in the recommended physiological demand associated with improvements in health and fitness. Therefore, a bench stepping routine performed underwater can be an option for those individuals with special health conditions who are not cleared to perform exercises on land due to its higher impact (Evans & Cureton, 1998).

Exercises performed on land are associated with greater impact forces than underwater exercise, and are associated with higher risk for muscle skeletal injuries. Wiliford et al., 1998,

reported that bench stepping is safer than running, resulting in a lower injury incidence, while resulting in similar improvements in fitness (i.e., improvements on oxygen consumption). In the case of those individuals who need to perform a lower impact exercise it is recommended to use a 6 inch bench height because it results in less ground reaction force (791.3 Newton (N)) than 8 (851.5 N) or 10 (891.2 N) inch benches ($p<0.05$) (Maybury & Waterfield, 1997).

Finally, the chronic physiological adaptations caused by bench stepping training were reported to be similar to other aerobic modalities (Scharff-Olson et al., 1996). Furthermore, some evidence suggests that bench stepping has beneficial psychological effects, such as reducing tension, depression, fatigue and anger while increasing vigor (Hayakawa et al., 2000; Kennedy & Newton, 1997).

2.5.3 Bench stepping training – monitoring of exercise intensity

Although bench stepping aerobics are one of the most common and popular forms of aerobic exercise among women, questions remain about the effectiveness of various strategies for monitoring exercise intensity, and the self-regulation of the exercise intensity. A majority of investigations involving bench stepping exercise control the exercise intensity using heart rate monitors. Other studies used rating of perceived exertion obtained from the Borg 6-20 RPE Scale, or heart rate (HR) measured by palpation (Ozcan & Kin-Isler, 2007; Grant et al., 2002; Laukkanen et al., 2001; Grant et al., 1998; Darby et al., 1995; Thomas & Long, 1993; Olson et al., 1991).

The use of heart rate monitors during bench stepping exercise in health-fitness settings can be problematic due to the cost of this equipment. Whereas the palpation procedure seems to be an accurate measure of the pulse rate, it requires practice to guarantee accuracy. Therefore,

several investigations reported that the palpation method is not an appropriate tool to monitor exercise intensity during bench stepping. In addition, even though an individual may have this skill, the palpation procedure requires frequent pauses during the exercise session, which reduces the time on stimulus (Ozcan & Kin-Isler, 2007; Grant et al., 2002; Pronk et al., 1995; Bell & Bassey, 1994; Grant et al., 1998).

Additionally, the inconsistencies between rating of perceived exertion obtained by using the Borg 6-20 scale and physiological variables may be attributed to its nonspecific mode design. This may lead to a difficult perceptual process for individuals self-regulating exercise intensity during a bench stepping exercise routine. Olson et al., (1991), reported that HR and RPE responses diverged during minutes 0 to 15 of a bench stepping session performed by adult female subjects. For example, at minute 5 the HR responses were approximately 130 beats·min^{-1} for the 6 inches bench, and 145 beats·min^{-1} for the 8, 10 and 12 inches benches, whereas RPE obtained from Borg 6-20 scale were approximately 9 and 10, respectively. According to Borg, when RPE from the 6-20 scale is multiplied by 10, it should be similar to HR, therefore the estimated HR based upon the RPE at minute 5 should be approximately 90 beats·min^{-1} for the 6 inch bench, and 100 beats·min^{-1} for the 8, 10 and 12 inch benches. Therefore, these results indicated a mismatch between HR and RPE.

Similar findings were also reported by Thomas and Long (1993) in adult women. The means of HR during 28 minutes of bench stepping ranged from 148 to 160 beats·min^{-1}, while the RPE obtained from the Borg 6-20 scale ranged from 11 to 14. The correlation coefficients between HR and RPE during the bench stepping routine ranged from r=-.06 to .27 ($p>0.05$). In this case, the authors recommended caution when using the RPE to monitor the exercise intensities during bench stepping.

Additionally, it appears that the association between the HR and $\dot{V}O_2$ is stronger during a high (r=.89) and low impact (.90) of bench steeping session, than the association between the RPE and $\dot{V}O_2$ (r=.84 and .45, respectively) obtained from the Borg 6-20 scale (Grant et al., 1998). Currently, there is a lack of research examining the relationship between RPE and the gold standard measurement of aerobic capacity, oxygen consumption ($\dot{V}O_2$) during bench stepping exercise. Therefore, the accuracy of using target RPE to self regulate exercise intensity during bench stepping group exercise is unknown (Grant et al., 2002; Thomas & Long, 1993).

Indeed, Laukkanen et al. (2001) conducted a study with dancers who performed exercises on the floor and on a bench. In a preliminary attempt to overcome the semantic limitations associated with the Borg 6-20 RPE scale, the investigators placed drawings of facial expressions to express differences in exercise intensities along the scale. The findings indicated that some participants achieved the target exercise intensity while others could not. Therefore, it was recommended that heart rate monitors not RPE be used to assess exercise intensity during bench stepping since there was a mismatch between RPE estimated using the Borg 6-20 RPE scale and the percentage of heart rate maximum responses. Recently, Ozcan and Kin-Isler (2007) reported that the Borg 6-20 RPE scale is reliable but not a valid method for regulating exercise intensity during bench stepping exercise, especially when compared to heart rate and blood lactate criterion variables in adult males. Therefore, it is possible that a perceptual scaling system such as a modified OMNI RPE scale may improve the self-regulation of exercise intensity during bench stepping exercise.

The newly developed OMNI Bench Stepping (OMNI-BS) RPE scale retained the characteristics of the previously validated OMNI RPE scales, including the same number of pictorial and verbal descriptors, with exception of the first verbal descriptor. The original adult

OMNI RPE scales have “extremely easy” as the first verbal descriptor. Whereas the newly developed OMNI-BS scale replaced “extremely easy” with “rest” (Robertson, 2004). The rational for this modification is based on classical psychophysics that assumes that human senses have a starting point, represented numerically by “zero” (Noble & Robertson, 1996). Therefore, the first verbal descriptor was modified for “*rest*.”

The original OMNI scales can be classified as interval scales, as these scales provide information of the magnitude differences between numerical categories (Noble & Robertson, 1996). The newly developed OMNI bench stepping rating of perceived exertion scale maintained the same interval scale characteristics and added a zero point. However, the newly developed OMNI bench stepping scale can still be classified as an interval scale. This modification may improve the accuracy of rating of perceived exertion during bench stepping.

In addition, the newly developed scale included exercise mode specific pictorials of a female subject stepping on benches. Increasing perceived exertion was depicted by an increase in the number of risers supporting the bench and the body position of the subject. Therefore, consistent with the previous validated OMNI rating of perceived exertion scales, the verbal and pictorials descriptors established a verbal-visual correspondence in exertional properties (Robertson, 2000).

2.6 CONCLUSION

The validation of the OMNI Bench Stepping rating of perceived exertion scale resulted in an easy, efficient, and mode specific method for use during one of the most common and popular aerobic exercise modalities among women practiced in health-fitness settings worldwide.

Therefore, the newly developed OMNI Bench Stepping rating of perceived exertion scale may ultimately be used for in graded exercise testing, exercise prescription, the self-regulation to exercise intensity, monitoring of training, and for evaluating changes in fitness levels.

3.0 METHODS

The University of Pittsburgh Institutional Review Board approved this investigation protocol before subject recruitment begins.

3.1 SUBJECTS

Thirty non-smoking adult females, between 18 and 35 years-old, served as subjects for this study. Subjects from all fitness and physical activities levels were recruited, thereby providing a wide range of individual variability for the validation of the newly developed OMNI RPE scale for bench stepping exercise.

Additionally, it was required that potential subjects have participated in at least three bench stepping exercise routines consisting of stepping up and down on a bench during the previous three months. This requirement ensured a minimal knowledge and skill of the basic movements (stepping up and down on the bench) used during the experimental protocols.

Lastly, potential subjects must be clinically normal, and not have cardiovascular, metabolic, or orthopedic contraindications to exercise participation. Prior to participation potential subjects completed a medical history questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q) (ACSM 2005) (used routinely in the research conducted by the Center for Exercise Health-Fitness Research Laboratory – Department of Health and Physical Activity,

University of Pittsburgh) (Appendix A and B). Potential subjects could be excluded from this investigation for the following: a body mass index greater than 30.0 kg/m^2 (considered to be obese).

3.2 RECRUITMENT PROCEDURES

The recruitment of potential subjects involved flyers posted throughout the campus and in university health-fitness centers. This advertisement included general information regarding the study, such as the investigator phone contact, stipend, and inclusion and exclusion criteria for participating in the study (Appendix C). When potential subjects contact the primary investigator, they were asked if they have previous experience with bench stepping routines. Next, the primary investigator scheduled the first experimental session, in which they were read the following to determine eligibility: “In order to participate in this study, you must have participated in at least three bench stepping exercise routines in the previous three months. Confirm that you are eligible to participate in this study (yes / no)" (Appendix D). Once subjects confirm eligibility, the subsequent experimental procedures were conducted (screening, pre-exercise assessments, exercise test).

In order to be eligible to participate in this investigation potential subjects must have undertaken at least three bench stepping exercise sessions in the previous three months.

3.3 EXPERIMENTAL DESIGN

The concurrent validation employed a within subject cross-sectional design, in which subjects undertook two experimental trials: load-incremented and load-intermittent estimation (Figure 6).

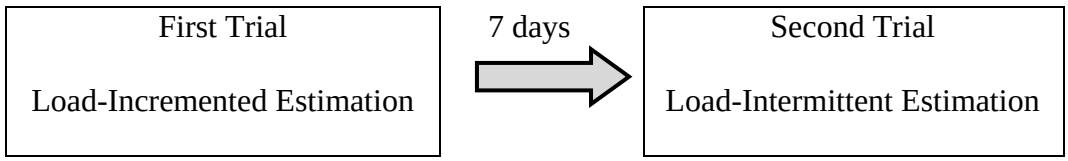


Figure 6. Experimental design.

The first trial was a load-incremented bench stepping perceptual estimation protocol (Figure 7).

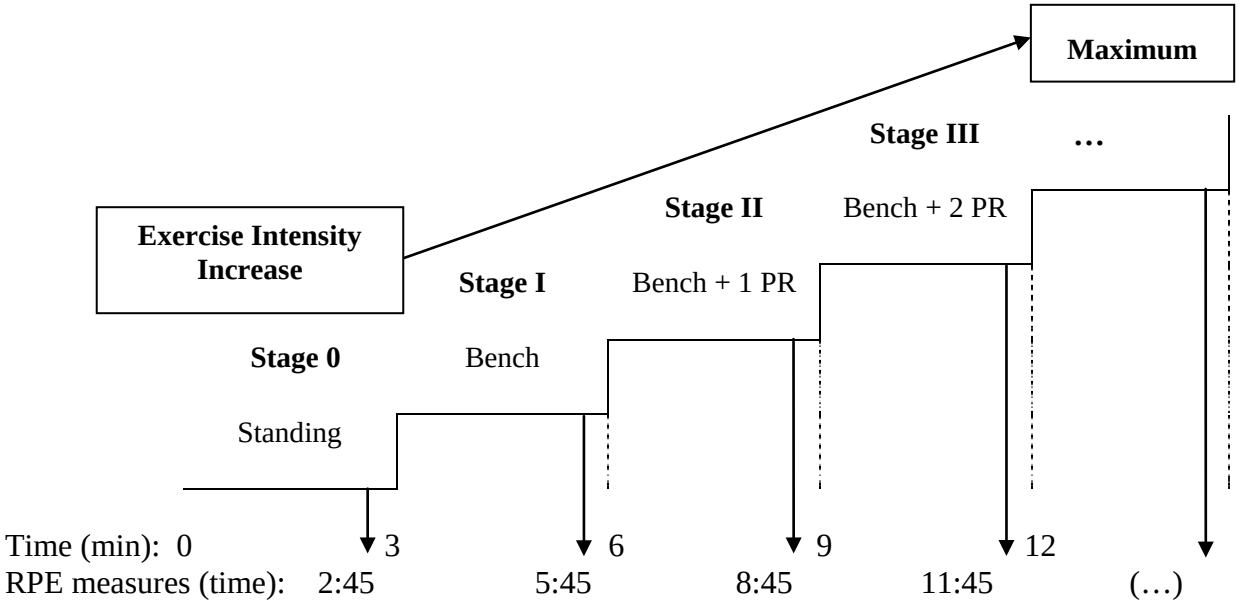
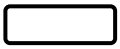
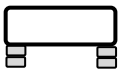
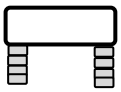


Figure 7. Load-Incremented Perceptual Estimation protocol

PR = pair(s) of risers

Physiological criterion variables ($\dot{V}O_2$ and HR), and RPE from the OMNI-BS scale variables were obtained at the same time-points. Seven days after the first trial, on the same day of the week at a similar time of the day, test re-test reliability was examined by an intermittent estimation perceptual protocol. The second experimental trial consisted of three exercise bouts that reproduced the exercise stages I, III, and V performed in the first experimental trial. These exercise bouts were referred to as "low, moderate, and high intensity," respectively (Table 3). The presentation of these three exercise bouts was carried out in a counterbalanced order.

Table 3. Intermittent Estimation Perceptual Protocol.

	*Exercise Bout (counterbalanced)		
	Low Intensity (LI)	Moderate Intensity (MI)	High Intensity (HI)
Stage	I	III	V
Number of pair(s) of raisers under the bench	0 - only the bench 	2 	4 

*Counterbalanced code. Code A = LI-MI-HI / Code B = LI-HI-MI / Code C = MI-LI-HI / Code D = MI-HI-LI / Code E = HI-LI-MI / Code F = HI-MI-LI.

For both experimental trials, subjects were instructed to abstain from vigorous physical activity and to avoid caffeine- or alcohol-containing products 24 hours prior to the test, and wear exercise clothes and shoes. All data recording forms were prepared before each test by the primary investigator. These forms included the counterbalanced order of the exercise bouts, and the subject ID number (Appendix D, E, and G).

3.3.1 Pre-exercise assessment

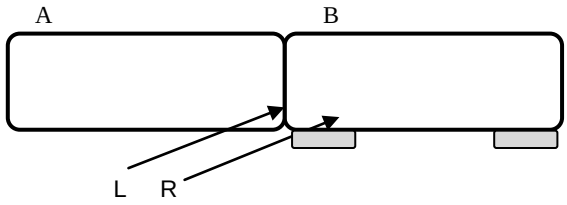
Potential participants confirmed eligibility and signed the written informed consent before the pre-exercise assessment (Appendix D and I). Next, personal information was obtained (i.e., name, date of birth and contact phone in case of emergency). Only the primary investigator has access to this information (the master sheet). Each subject was assigned an ID number that was used in all data collection forms, i.e., medical history, PAR-Q, and experimental protocols (Appendix A, B, D, E, and G).

Once the primary investigator confirmed that eligible participants do not have any contraindications to performing a maximal exercise and have answered negatively to all questions included in the PAR-Q, height was measured using a stadiometer (Detecto Scales Inc., Brooklyn, NY). Next, the percentage of body fat and body weight were measured by a bioelectrical impedance analysis (BIA) scale (TBF-300A, Tanita, Arlington Heights, IL). Body mass index (BMI) was then calculated. Those potential participants with BMI >30.0 $kg \cdot m^2$ could be excluded from the study.

After these procedures have been completed, subjects received standard information and instructions regarding the utilization of the RPE scales, and the experimental protocols. In addition, the primary investigator 1) asked each subject if they have previous experience with RPE scales, which was recorded in the load-incremented data sheet, and 2) explained to the subjects the purpose of the mouthpiece and the nose clip that were used during the exercise tests.

3.3.2 Load-incremented perceptual estimation protocol

The experimental protocol begun with “stage 0,” in which the subject stood in front of bench allowing a recording of resting physiological and perceptual variables. Subsequently at minute three, “stage I” begun with the subject stepping up and down on the bench. Each stage lasted three minutes (Appendix E). Subjects were required to perform the bench stepping exercise test at a cadence of 120 beats per minute (controlled by a metronome). In addition, a co-investigator counted and recorded the number of steps performed throughout each stage. The protocol started with two benches placed beside each other. The first bench used, was prepared without risers (only a platform), whereas the second bench included a pair of risers under the bench (Figure 8).



Arrows show the moment when subject switched the bench to perform the next exercise stage. During the last 10 second of each stage, the subject was allowed to change the bench, after they step down from bench “A” with right (R) and left (L) foot. Them, the next movement with the right (R) foot, was stepping up on the bench on their side (“B” bench) followed by the left (L) foot. Thereafter, subjects continued stepping down and up until the next stage, when the subject moves to the bench “A,” which employed two pairs of risers. This protocol continued until the test is terminated.

Figure 8. Demonstration of Bench Placement during the Estimation Protocol.

A co-investigator was responsible for preparing the subsequent bench height with the risers. This procedure was performed to facilitate the transition between exercise stages.

Therefore, while subjects are performing the movement on one bench, the other one was ready for the following stage. In addition, these procedures guaranteed that the subject did not stopped between exercise stages, thereby, performing a continuous incremented exercise protocol.

RPE for the overall body was assessed during the last 15 seconds of each stage using the OMNI-BS scale. In addition, oxygen uptake ($\dot{V}O_2$ mL·kg^{-1}·min^{-1}) and carbon dioxide production (VCO_2 mL·kg^{-1}·min^{-1}, STPD) were measured using an open-circuit respiratory metabolic system (TrueMax 2400, Parvo Medics, Salt Lake City, UT). Measures were obtained using 30-second samples throughout the test. Calibration of the metabolic system was conducted prior to each test. Heart rate was measured during the last 10 – 5 seconds of each stage throughout the test (Polar Electro Inc., Woodbury, NY). The test was terminated when the subject self-reports maximal exertion – fatigue (RPE 9 or 10) – or they did not maintain the bench stepping cadence for more than 10 seconds. Additionally, at least two, of the following criteria was achieved to consider that maximal oxygen uptake was attained.

End test criteria:

- Subject reached at least 85% of age predicted HR_{max} (calculated by: 226 - age);
- Subject self-reported maximal exertion – fatigue, RPE = 9 or 10;
- The change in $\dot{V}O_2$ between consecutive stages was $\leq$ 2.1 mL·kg^{-1}·min^{-1};
- Respiratory exchange ratio (RER) $\geq$ 1.1.

Standard instructions given to the participants and investigators during the load-incremented perceptual estimation trial are presented in Appendix F.

3.3.3 Test-retest reliability – intermittent estimation perceptual protocol

To determine the test-retest reliability, an intermittent estimation perceptual protocol was administered seven days after the first experimental trial, on the same day of the week at a similar time of the day. The second trial consisted of three exercises bouts that corresponded to the exercise stages I (low), III (moderate), and V (high) performed in the first experimental trial.

A) During the low intensity exercise bout, subjects performed the bench stepping pattern only on the bench (no risers);

B) During the moderate intensity exercise bout, subjects performed the bench stepping pattern on the bench with two pairs of risers; and,

C) During the high intensity exercise bout, subjects performed the bench stepping pattern on the bench with four pairs of risers.

The presentation of these three exercise bouts was carried out in a counterbalanced order. Each exercise bout consisted of 3 minutes with the same bench stepping pattern (steeping up and down, swinging the arms besides the trunk) performed in the first experimental trial. Subjects were required to perform the bench stepping exercise test at a cadence of 120 beats per minute (controlled by a metronome). In addition, a co-investigator counted and recorded the number of steps performed throughout each stage. Oxygen consumption ($\dot{V}O_2$) was recorded every 30-seconds throughout the test. At 2:45 of each bout, the RPE for the overall body from the OMNI-BS scale, and heart rate were recorded. Subsequently, subjects had a rest period of 10 minutes, in which the heart rate was recorded from minute 1 to 9. During the last resting minute (9 to 10), the investigator set up the subject in front of the bench for the following exercise bout.

Standard instructions given to the participants and investigators during the intermittent estimation perceptual trial are presented in Appendix G. The instructions utilized in the load-

incremented perceptual estimation protocol regarding the orientation, definition, and memory-anchoring RPE procedures were repeated before the instructions of the second experimental protocol (intermittent perceptual estimation).

3.3.4 Pilot testing

A pilot study was conducted with two subjects to determine if the load-incremented perceptual estimation protocol elicits a linear increase in the physiological concurrent variables (i.e., $\dot{V}O_2$ and HR) as the test stages increase. The results from the pilot study showed that the RPE obtained from the OMNI Bench Stepping Scale increases linearly as a function of increases in oxygen uptake (r = 0.99 and 0.91, for subject 1 and 2, respectively – Figure 9), and heart rate (r = 0.99 and 0.88, for subject 1 and 2, respectively).

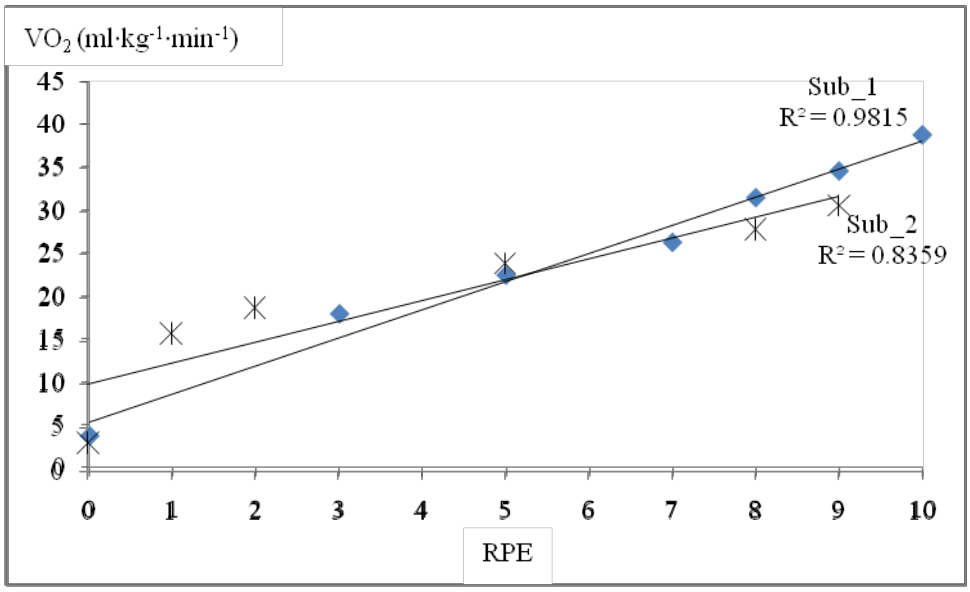


Figure 9. Correlation Analysis between the RPE Obtained from the OMNI Bench Stepping Scale with Oxygen Uptake ($\dot{V}O_2$).

3.4 OMNI-BENCH STEPPING RPE SCALE

3.4.1. OMNI-Bench stepping scale construction – anchor design

The newly generated bench stepping RPE scale retained all of the characteristics of the previous OMNI-RPE scales, except for one change in the first verbal descriptor.

The following points were considered during the construction of the OMNI-BS RPE scale:

i. The number of pictures and their position on the scale should be similar to the validated OMNI RPE scales.
ii. The number of verbal and numerical descriptors should be similar to the validated OMNI RPE scales;
iii. Balanced, interval scale criteria, were displayed along the scale;
iv. The OMNI-BS contained exercise mode specific drawings (pictorial descriptor);
v. The bench height increments (adding risers) represented the increases in exercise intensity;
vi. The body position of the pictorials indicated a progression of exertion from rest to maximal.

3.4.2. Rational for pictorials descriptor

The main procedure to increase exercise intensity during bench stepping exercise is by adding risers under the bench. The numbers of risers under the bench were range from zero to four. Additionally, the mode-specific pictorials were developed based on a typical movement pattern

used during bench stepping. One foot is on the floor, and the other foot is placed on the bench. In addition, body position depicted in the pictorials was also indicated changes in exercise intensity.

3.4.3. Rational for the change in the verbal descriptors

The newly developed OMNI Bench Stepping (OMNI-BS) RPE scale retained the characteristics of the OMNI RPE scales previously validated, including the same number of pictorial and verbal descriptors, with exception of the first verbal descriptor. The original adult OMNI RPE scales has "extremely easy" as the first verbal descriptor. The newly developed OMNI-BS scale replaced "extremely easy" with "rest" (Table 4 and Figure 10) (Robertson, 2004).

Table 4. Original and Modified OMNI Scales

Original OMNI RPE Scales		Proposed OMNI-BS Scale	
Verbal	Numerical	Verbal	Numerical
"Extremely Easy"	*"0"*	***"Rest"***	*"0"*
"Easy"	*"2"*	*"Easy"*	*"2"*
"Somewhat Easy"	*"4"*	*"Somewhat Easy"*	*"4"*
"Somewhat Hard"	*"6"*	*"Somewhat Hard"*	*"6"*
"Hard"	*"8"*	*"Hard"*	*"8"*
"Extremely Hard"	*"10"*	*"Extremely Hard"*	*"10"*

The rational for this modification is based on classical psychophysics that assumes that human senses have as a starting point (Robertson & Noble, 1996). The original OMNI scales are classified as an interval scale that provides information on the absolute differences between numerical categories (Robertson & Noble, 1996).

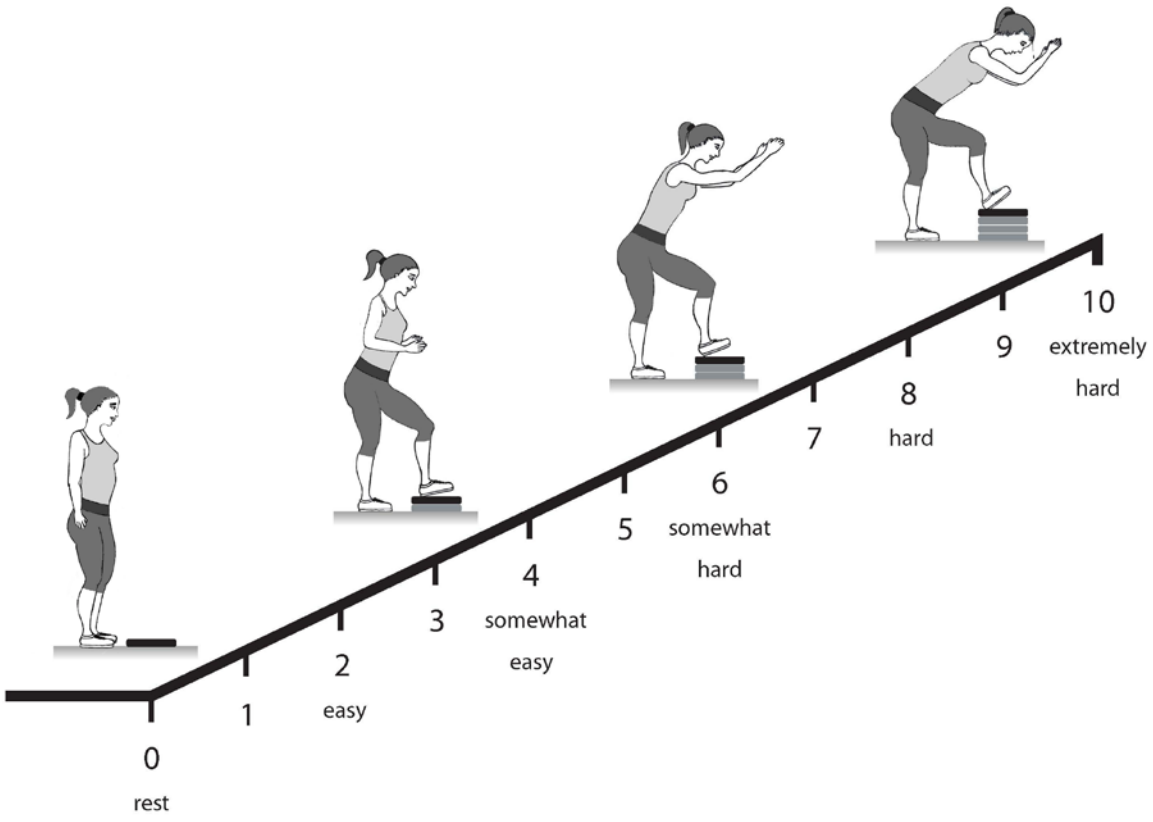


Figure 10. Proposed OMNI-BS Scale of perceived exertion.

The newly proposed OMNI-BS scale maintained the interval scale criteria of the original OMNI RPE scales and added a zero point. This modification may improve the accuracy of rating perceived exertion during bench stepping exercise. In addition, inclusion of the verbal descriptor "rest," is consistent with the fact that exercise has not started. Consequently, at rest there is no

physical stimulus caused by exercise and therefore no sensory cues impacting the perception of exertion. This specific information was included in the “instructions to the subject” session (Attached F).

Another advantage to changing he verbal descriptor associated with zero, is to improve the accuracy of the Physical Activity Index (PAI) in assessing caloric expenditure. The PAI is a method for monitoring training load that is derived by multiplying the exercise intensity, measured by RPE, with the exercise duration or step count. As previously reported the first descriptor of the original OMNI scale, has the verbal descriptor “extremely easy” corresponding to “zero.” At the beginning exercise or at lower exercise intensities, participants can rate their perceived exertion extremely easy. However, when “zero” is multiplied by the exercise duration, or steps count, the resulting PAI will be “zero.” Consequently, energy expenditure will be underestimated.

3.5 STATISTICAL ANALYSES

Descriptive data for perceptual and physiological variables were calculated as means and standard deviations. Evidence for concurrent validity was determined using linear regression, *Intraclass Correlation,* and *Pearson* correlation analyses (SPSS 16.0 for Windows). The level of significance was set at $p<.05$.

To provide evidence regarding the concurrent validation of the OMNI Bench Stepping scale, this investigation employed an estimation paradigm in which all independent variables, for the validation process, were obtained during a single progressively incremented exercise test. RPE obtained from the OMNI-BS scale served as the dependent variable. The criterion

(independent) variables related to the concurrent validity process are the oxygen uptake and heart rate. The test re-test reliability was examined by using *Intraclass Correlation Coeficient* (ICC), which provided a *test-retest reliability coefficient*. In addition, a two-way within-subject ANOVA was used to compare means of the independent variables (RPE obtained from the OMNI-BS, oxygen consumption and heart rate measurements), between the first and second experimental trials during stages I, III, and V. The analysis of oxygen consumption and heart rate were used to confirm that the intensity of the two experimental trials was similar.

To confirm if the hypotheses proposed in this investigation is true, the association of the independent with dependent variables was determined by *Intraclass Correlation* and *Pearson* correlation analysis. The criteria established to accept the veracity of the hypothesis related to the validation process, was a positive, linear, and strong correlation (greater than .80). In addition, a moderate-strong *test-retest reliability coefficient* (greater than .70) was expected. Lastly, the means of the independent variables could not differ between experimental trials in each of the stages I, III, and V. The statistical analyses was performed by using the SPSS version 16.0 (Inc, Chicago, IL).

3.5.1 Power analyses

A power analysis for correlation methods based on a moderate effect size (0.5), alpha of 0.05 and a power of 0.8 determined the required sample size of 24 subjects (one tail test). This calculation was performed using the *G Power 3.0*.

The statistical power of 0.80 was previously used by Robertson et al (2004) in the validation of the Adult OMNI-Cycle RPE scale, which established the validation of the OMNI RPE scale with physiological criterion variables (r=.81-.95) and the RPE Borg scale (r=.92-.97).

4.0 RESULTS

The primary purpose of this investigation was to develop and validate a modified OMNI RPE scale for use during bench stepping exercise routines in adult women (OMNI-BS). Concurrent validity was established by examining the relation between the physiological criterion variables, oxygen consumption ($\dot{V}O_2$) and heart rate (HR), with the concurrent variable, RPE obtained from the OMNI-BS, during load-incremented and load-intermittent experimental trials. The secondary purpose of the present study was to determine test re-test reliability of the OMNI-BS RPE scale by comparing RPE obtained during stages I, III, and V of the load incremental trial to similar intensities that were administered during the load intermittent trial. These three exercise stages correspond to low, moderate, and high exercise intensities, respectively. Additionally, limits of agreement of RPE obtained between trials were examined by the Bland-Altman procedure (*95% limits of agreement* – LoA) for the entire data set and for each exercise stage. Lastly, physiological criterion variables obtained at the end of each of the three exercise stages, were compared between experimental trials using a two-way (trial x exercise intensity) ANOVA with repeated measures.

4.1 SUBJECTS

Thirty-one adult females participated in this investigation, however one subject was excluded because she did not achieved the criteria established for maximal oxygen uptake during the load-incremented test – trial 1. Therefore, the final sample included 30 subjects. All participants had previous experience in bench stepping. However, the majority of the participants (60.0%) did not have previous experience with RPE scales ($\chi^2_1 = 1.20$; $p = 0.273$). Subjects, on average, had a body mass index (BMI) that can be categorized as normal (ACSM, 2006). The range of $\dot{V}O_{2peak}$ values indicates this investigation included subjects from low to high fitness levels, providing a wide range of individual aerobic capacities for the validation process. Subject characteristics are presented in Table 5.

Table 5. Subject characteristics.

	Minimum – Maximum	Mean ± Std. Deviation
Age (years)	18 – 25	19.8 ± 1.8
Height (cm)	152.4 – 172.7	164.0 ± 5.6
Weight (kg)	48.5 – 77.8	61.8 ± 7.1
BMI ($kg \cdot m^2$)	19.0 – 28.5	22.9 ± 2.4
Body Fat (%)	15.7 – 36.0	24.4 ± 4.6
$\dot{V}O_{2peak}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	27.2 – 46.5	36.6 ± 4.5
Maximum Heart Rate ($beats \cdot min^{-1}$)	175.0 – 209.0	191.2 ± 8.6

4.2 CONCURRENT VALIDITY

Concurrent validity was established by using *Intraclass Correlation* (ICC) analysis by clustering individuals. First, this procedure computes the correlation for each individual. Next, an average correlation value across subjects is calculated. Physiological criterion variables, oxygen consumption and heart rate, were separately analyzed with the RPE obtained from the OMNI-BS scale during the load-incremented perceptual estimation protocol. A very strong positive association was found between oxygen consumption and RPE obtained from the OMNI-BS scale (r = 0.96). Figure 11 displays an individual example of the relation between these variables, in which RPE increases concurrently with oxygen consumption ($\dot{V}O_2$).

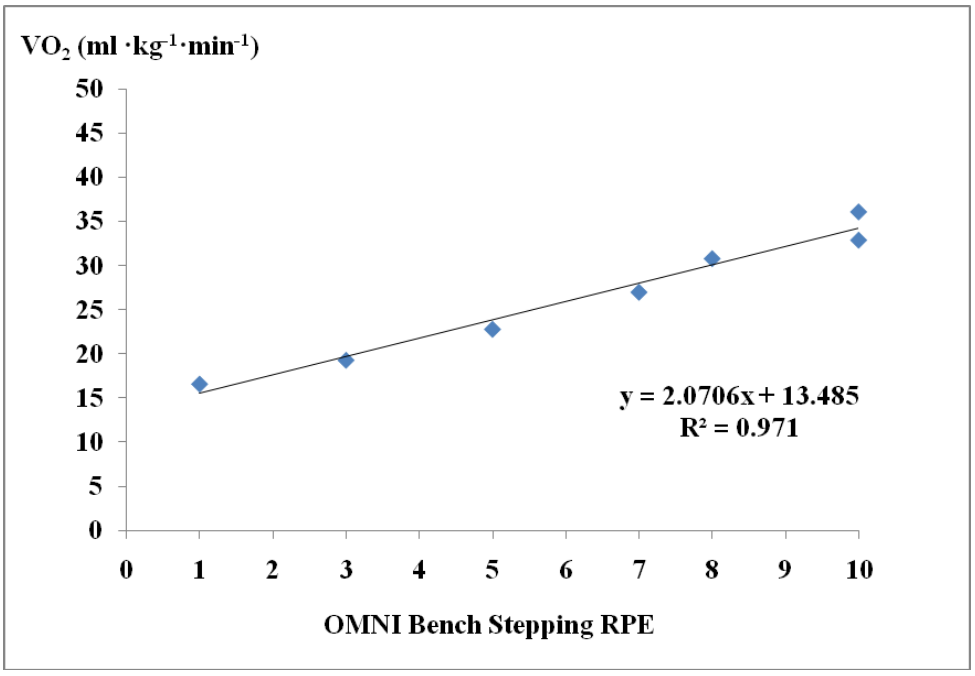


Figure 11. Individual Correlation Analysis between the RPE Obtained from the OMNI Bench Stepping Scale with Oxygen Consumption ($\dot{V}O_2$) (Trial 1).

Similarly, a very strong positive association was found between heart rate and RPE obtained from the OMNI-BS scale (r = 0.95).

Figure 12 displays an individual example of the relation between these variables, in which RPE increases concurrently with heart rate (HR). Collectively, these results provide strong evidence of concurrent validity of the OMNI-BS RPE scale in adult women during a load-incremented perceptual estimation protocol.

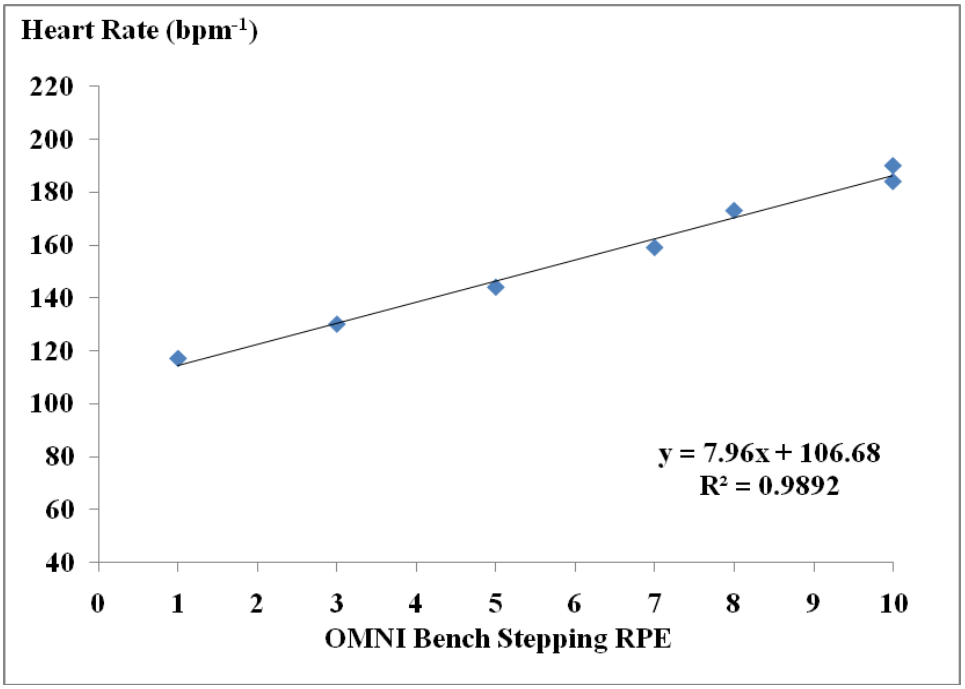


Figure 12. Individual Correlation Analysis between the RPE Obtained from the OMNI Bench Stepping Scale with Heart Rate (HR) (Trial 1).

Additionally, to provide further evidence regarding the validity of the OMNI-BS RPE scale, data from the load-intermittent perceptual estimation protocol were analyzed by the same statistical procedure explained previously.

A very strong positive association was found between oxygen consumption and RPE obtained from the OMNI-BS scale (r = 0.95). Figure 13 displays an individual example of the relation between these variables, in which RPE increases concurrently with oxygen consumption ($\dot{V}O_2$).

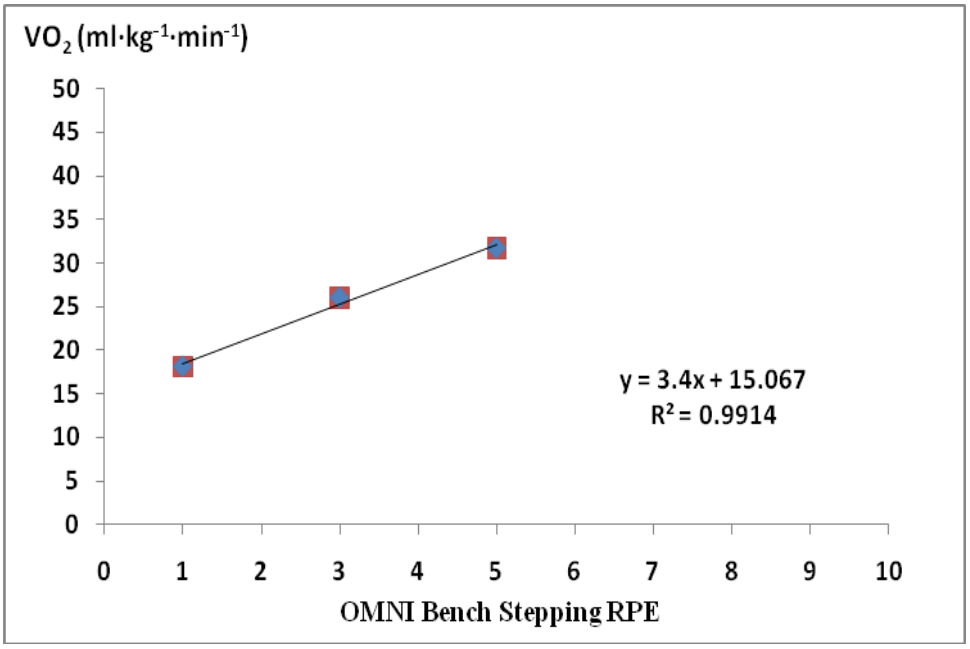


Figure 13. Individual Correlation Analysis between the RPE Obtained from the OMNI Bench Stepping Scale with Oxygen Consumption ($\dot{V}O_2$) (Trial 2).

Similarly, a very strong positive association was found between heart rate and RPE obtained from the OMNI-BS scale (r = 0.95).

Figure 14 displays an individual example of the relation between these variables, in which RPE increases concurrently with heart rate (HR). Therefore, these results provide additional evidence for concurrent validity of the OMNI-BS RPE scale in adult women during a load-intermittent perceptual estimation protocol.

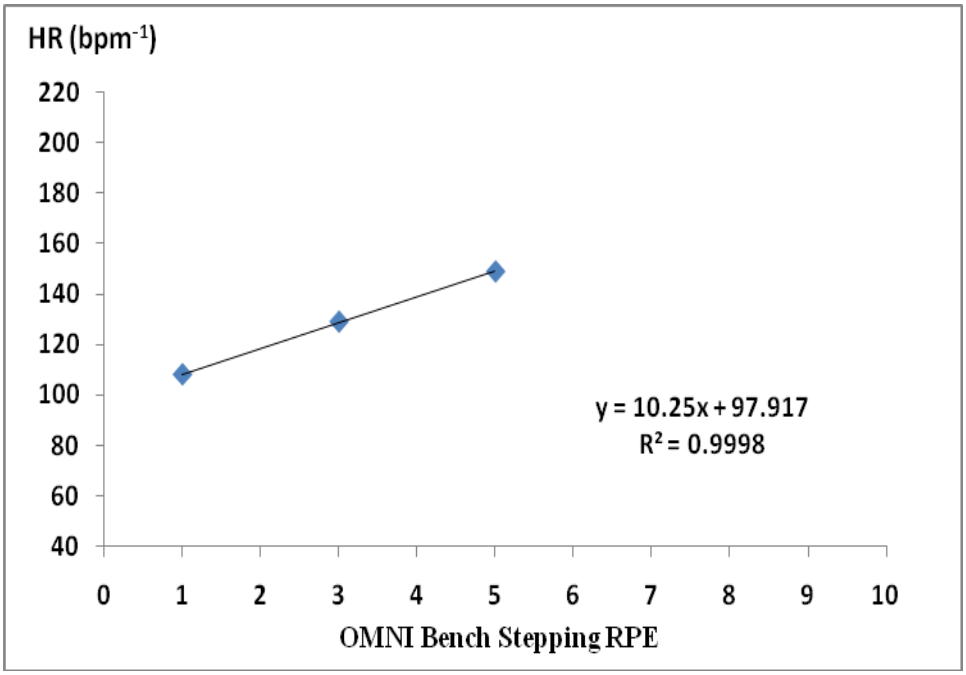


Figure 14. Individual Correlation Analysis between the RPE Obtained from the OMNI Bench Stepping Scale with Heart Rate (HR) (Trial 2).

4.3 RELIABILITY OF THE OMNI-BENCH STEPPING RPE SCALE

Test re-test reliability of the OMNI Bench Stepping Rating of Perceived Exertion scale (OMNI-BS) was examined using *Intraclass Correlation* (ICC) analyses. Analysis of the RPE obtained from stages I, III, and V of the load-incremented and load-intermittent perceptual estimation protocols demonstrated a strong positive association (r = 0.95). In addition, separate correlation analysis was conducted on each of the three stages. The following associations were observed for the low (r = 0.475; p = 0.009), moderate (r = 0.559; p = 0.002); and high (r = 0.793; $p < 0.001$) exercise intensities. In order to provide further evidence regarding the reliability of the OMNI-BS Rating of Perceived Exertion scale, the 95% limits of agreement (LoA) were also calculated

and plotted according to the Bland-Altman technique for the entire data set and separately for stages I (low intensity exercise), III (moderate intensity exercise), and V (high intensity exercise) (Figure 15).

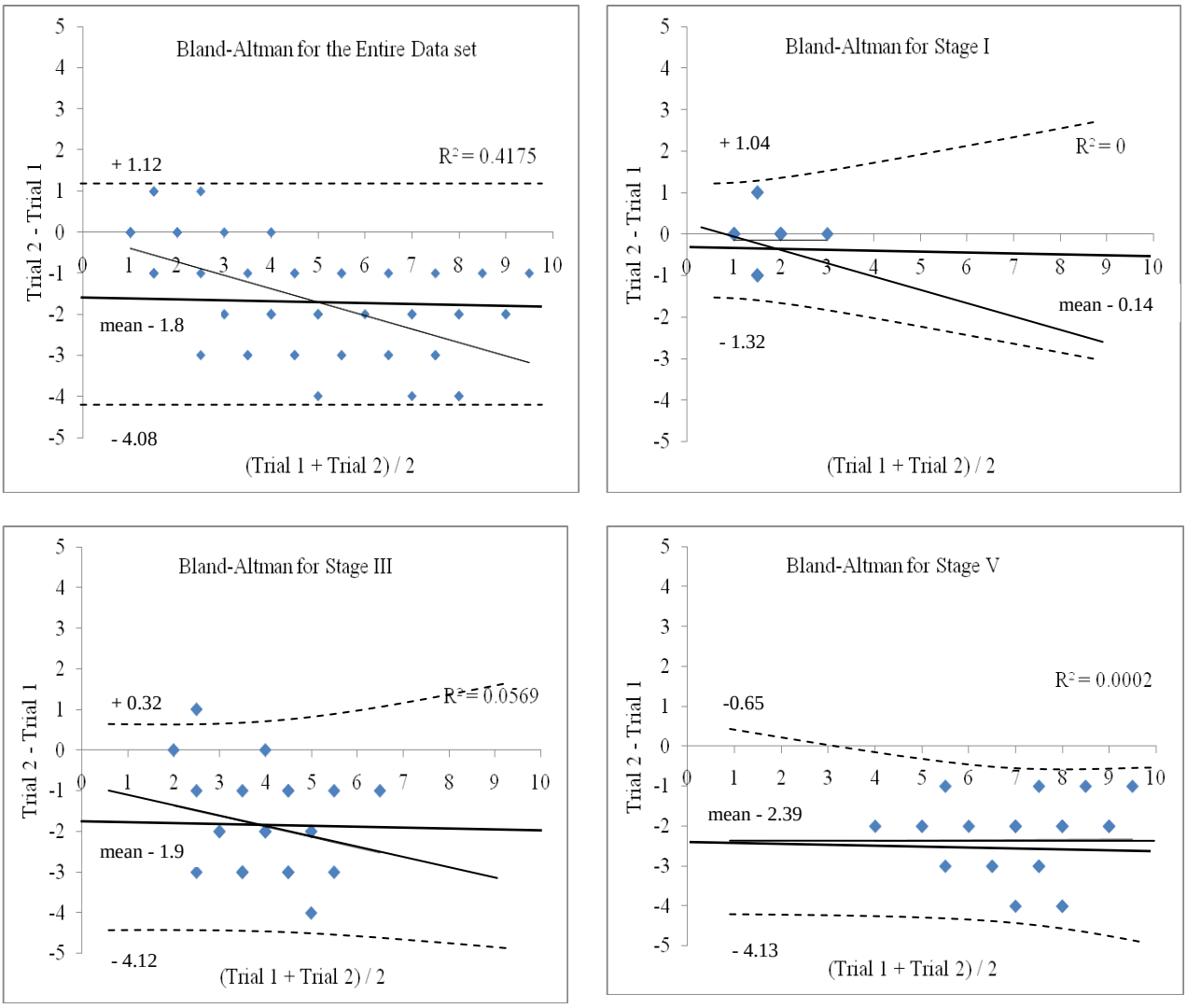


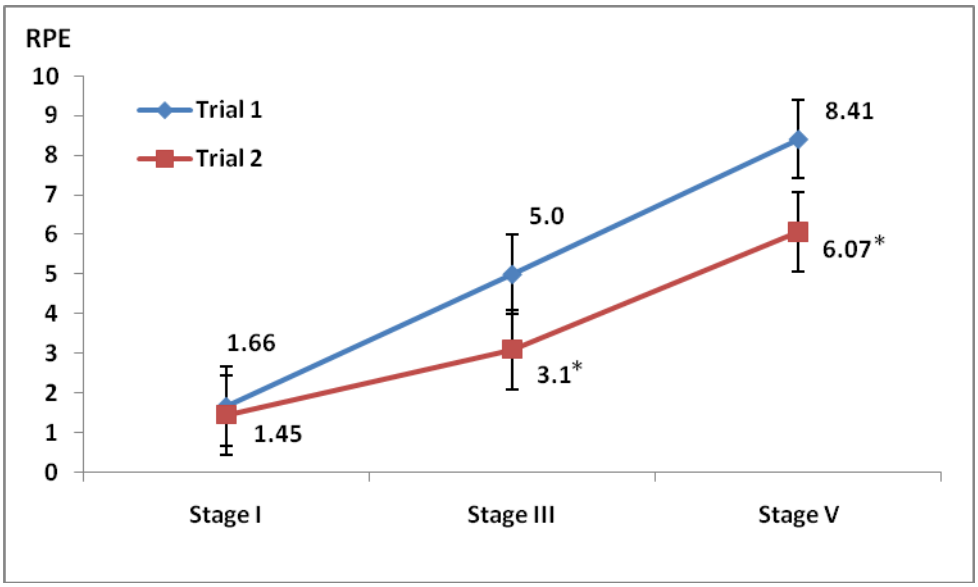
Figure 15. 95% limits of agreement between RPE obtained in Trial 1 and Trial 2.

4.3.1 Comparisons of Perceptual and Physiological Variables between Experimental Trials

Three separate two way (trials x exercise intensity/stages) repeated measures ANOVA were used to compare: 1) OMNI-BS RPEs, 2) oxygen consumption, and 3) heart rate between the experimental trials during stages I, III, and V. The results of these analyses are presented in the following sections:

OMNI-BS Rating of Perceived Exertion.

Significant main effects were noted for experimental trial ($F_{1, 28}$ = 149.91; $p < 0.001$; η^2_p = 0.843) and exercise intensity ($F_{2, 56}$ = 558.74; $p < 0.001$; η^2_p = 0.952). In addition, a significant interaction effect ($F_{2, 56}$ = 60.22; $p < 0.001$; η^2_p = 0.683) was observed. *Post hoc* analysis indicated that a) exertion experienced during the load-incremented protocol (Trial 1) was greater ($p < 0.001$) than the load-intermittent protocol (Trial 2), except for stage I (t_{28} = 1.651, p = 0.110); b) there was a progressive increase in RPE as exercise intensity increased ($p < 0.001$) (from stage I to V); and c) RPE was greater in trial 1 than in trial 2 during stages III (moderate intensity exercise; t_{28} = 9.176; $p < 0.001$) and V (high intensity exercise; t_{28} = 14.070; $p < 0.001$) (Figure 16).

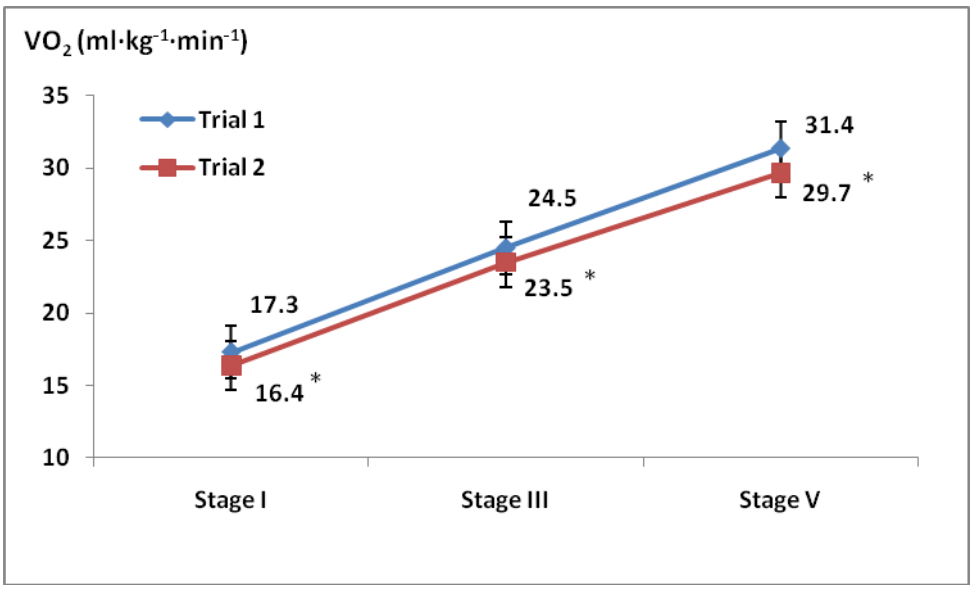


*Different from Trial 1 ($p < 0.001$).

Figure 16. Comparisons of RPE between the experimental trials across the three exercise intensities.

Oxygen uptake.

Significant main effects for experimental trials ($F_{1, 28} = 29.73$; $p < 0.001$; $\eta^2_p = 0.515$), and exercise intensity ($F_{2, 56} = 1972.13$; $p < 0.001$; $\eta^2_p = 0.986$) were noted. However, there was not an interaction effect ($F_{2, 56} = 2.110$; $p = 0.131$; $\eta^2_p = 0.070$). *Post hoc* analysis indicated that a) oxygen consumption during the load-incremented protocol (Trial 1) was greater ($p < 0.01$) than during the load-intermittent protocol (Trial 2); and b) there was a progressive increase ($p < 0.001$) in oxygen consumption as exercise intensity increased (from stage I to V) (Figure 17).

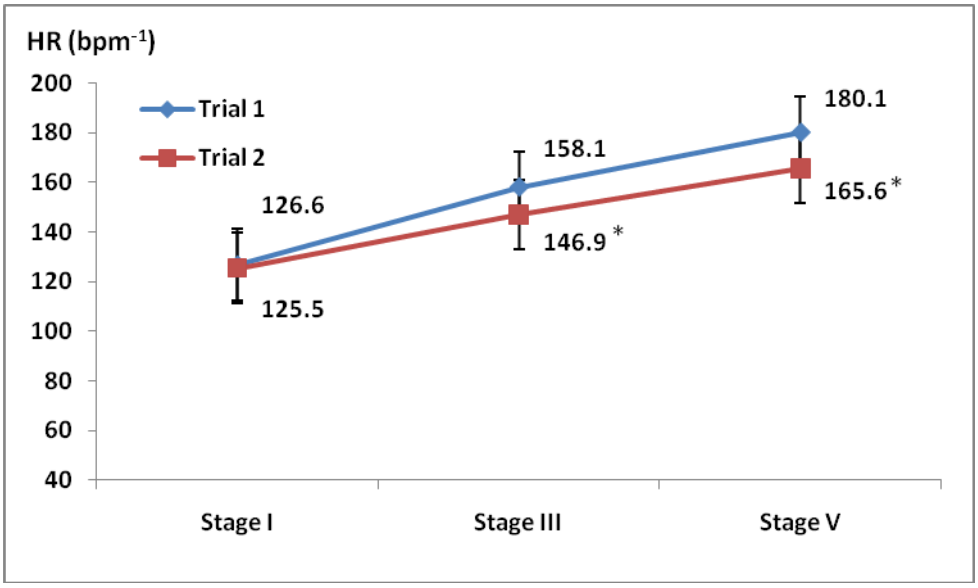


*Different from Trial 1 ($p < 0.01$).

Figure 17. Comparisons of Oxygen Consumption ($\dot{V}O_2$) between the experimental trials across the three exercise intensities.

Heart Rate.

Significant main effects were noted for experimental trials ($F_{1, 28} = 30.92$; $p < 0.001$; $\eta^2_p = 0.525$), and exercise intensity ($F_{2, 56} = 799.54$; $p < 0.001$; $\eta^2_p = 0.966$). In addition, a significant interaction effect ($F_{2, 56} = 52.61$; $p < 0.001$; $\eta^2_p = 0.653$) was observed. *Post hoc* analysis indicated that a) heart rate during the load-incremented protocol (Trial 1) was greater ($p < 0.001$) than during the load-intermittent protocol (Trial 2), except for stage I ($t_{28} = 0.599$, $p = 0.561$); b) there was a progressive increase in heart rate as exercise intensity increase (from stage I to V); and c) HR was greater in trial 1 than in trial 2 during stages III (moderate intensity exercise; $t_{28} = 5.572$; $p < 0.001$) and V (high intensity exercise; $t_{28} = 9.316$; $p < 0.001$) (Figure 18).



*Different from Trial 1 ($p < 0.001$).

Figure 18. Comparisons of Heart Rate (HR) between the experimental trials across the three exercise intensities.

5.0 DISCUSSION

The purposes of this investigation were to develop and validate a new format of OMNI RPE scale for use during bench stepping exercise, and to examine the test-retest reliability of this scale during low, moderate, and high exercise intensities. Therefore, the experimental design called for a perceptual estimation paradigm consisting of two experimental trials. Physiological and perceptual responses from both experimental trials were used to determine the validity of the OMNI Bench Stepping RPE Scale (OMNI-BS). In addition, perceptual data from both experimental trials obtained during stage I, III, and V, were used to test the reliability of the OMNI-BS scale. The perceptual and physiological responses (i.e., RPE, $\dot{V}O_2$ and HR) were also compared during trial 1 and 2.

5.1 A NEW OMNI RPE SCALE FORMAT

A new format of the OMNI pictorial system was developed maintaining the same interval, category criteria of the previously validated OMNI RPE scales. However, the first verbal descriptor and pictorial were modified. The modification consisted of "zero" not one being the lowest number on the scale. The verbal descriptor associated with the number one in the original OMNI format i.e., "*extremely easy*," was replaced by "*rest.*" Additionally, the pictorial descriptor corresponding to the number one in the previous OMNI scales depicts an individual

performing low intensity physical activity. The pictorial placed above the zero in the newly modified OMNI-BS scale is an individual at rest (i.e., standing). Consistent with other OMNI RPE scales the pictorial is mode exercise specific, i.e., a female standing next to or stepping on a bench.

The first verbal and pictorial descriptor is consistent with an individual who is not performing physical activity, and therefore, is not feeling any exertion caused by exercise. The standard anchoring instructions given to the subject before the exercise trial were modified, as following: "*Please, look at the person on the left side of the scale who is not doing any exercise, and therefore, is not feeling any exertion caused by exercise. If you feel like this person when you are in the bench stepping session, the exertion will be "rest." In this case, your rating should be the number "0" (point to "0" on the scale)*" (Mays, 2009).

The rationale for the modification proposed was two fold: 1) to enable participants to more precisely rate the level of exertion across the stimulus-response range by providing a reference point corresponding to rest; and 2) to improve the accuracy of the physical activity index (PAI) which can be used to estimate caloric expenditure during physical activities.

According to traditional psychophysics, human senses have a starting point where the stimulus cannot be perceived, or the stimulus is so weak leading to perceptual *noise*. This perceptual starting point can represent an "*absolute zero*" or "*abstract zero*" reference point (Stevens, 2008; Kaernback, 2004). The OMNI-BS RPE scale provides a "*zero*" as a starting point to the participant and not an "*absolute zero,*" because many individuals experience pre-excitatory physiological responses (i.e., increase in heart rate) before the exercise session starts. These physiological changes can be considered as *noise*. However, since individuals in the

present investigation were given standard memory anchoring instructions, they should not have translated this *noise* into the exertional milieu, before exercise session started (Kaernback, 2004).

Conversely, interval category scales can demonstrate a *ceiling effect* in individuals with a very high cardiorespiratory capacity because they have the ability to continue exercising even at a maximal level, such as when maximal oxygen consumption ($\dot{V}O_{2max}$) has been achieved. In other words, some individuals can achieve their maximal aerobic capacity and rate their perception of physical exertion as "*10*" or "*Extremely hard*" in one exercise stage, but because they are very fit, they are able to maintain this intensity for a comparatively long duration even completing additional exercise stages while repeating the same rating of effort. This has been called the *ceiling effect* of the scale because ratings greater than "*10*" are not possible (Borg, 1998; Noble & Robertson, 1996). However, a basic tenent of classical psychophysics is that human senses can achieve a maximum response with its corresponding physical or physiological outcome in one experiment and this may not be the same in the future, i.e., "maximum physiological capacity" can be changed by practice, learning, or in this case, by improvements in fitness (Kaernback, 2004). Therefore, even if the *ceiling effect* occurs in high fit individuals, this effect may be temporary and may not occur in the general population. Consequently, it cannot be considered as a limitation for the utilization of interval RPE scales, especially when used in a fitness or clinical setting. Furthermore, classical psychophysics recommends the utilization of the absence of a stimulus as a reference, because the terminal threshold (maximum) cannot serve as a reference (Stevens, 2008).

In addition, the application of "*rest*" or "*zero*" as the starting point can have important applications in physical activity settings for measuring training load and predicting energy expenditure. Generally speaking, three important components of an exercise prescription are:

intensity, duration, and frequency. The benefits from exercise are dependent on each of these components. Therefore, it is important to have an effective procedure to measure each aspect. Exercise duration can be easily measured by time spent performing an activity (i.e. minutes). Exercise frequency, is easily quantify and typically measured by the number of sessions/days per week. However, an easy and cost-effective procedure to measure exercise intensity needs to be developed (Weary-Smith, 2007).

A common method used to measure exercise intensity is based on the heart rate response, which can be evaluated by using heart rate monitors or palpation (ACSM, 2006). Nonetheless, both approaches can be problematic when applied in fitness and clinical settings. Heart rate monitors are expensive, whereas the low cost palpation technique requires practice to accurately measure heart rate, and requires periodic pauses during exercise that reduces time on stimulus. In contrast, RPE may be an easily used and cost-effective instrument to evaluate exercise intensity. In fact, the American College of Sports and Medicine (ACSM 2006) recommends using RPE to monitor exercise intensity during aerobic and resistance exercise. In addition, RPE it can be used to measure training load and predict energy expenditure.

Weary-Smith (2007) examined this application of rating of perceived exertion. RPE was used as a measure of exercise intensity and step count as an index of the volume of exercise. The product of RPE and steps count results in a physical activity index (PAI), which can be used to estimate kilocalorie expenditure. This study involved young adult women during walking/running on a treadmill and used the OMNI Walk/Run RPE scale to estimate the level of exertion. The findings from this study provide evidence that RPE when coupled with step count is an easy and effective approach to calculating energy expenditure. In spite of some clear advantages of this method, at low exercise intensities individuals may estimate the level of

exertion as "*Extremely easy*" that corresponds to a "*0*" on the original OMNI scale format. However, when this value ("0") is multiplied by step the PAI would be zero. As a result, the total activity load and energy expenditure of the PAI will be underestimated at low exercise intensities.

A modification of the original OMNI format was carried out in the present study attempt to eliminate this limitation. Hence, when an individual is performing lower intensity exercise, their rating of perceived exertion will be greater than or equal to the number "*1,*" and not "*zero*" when using the newly developed OMNI-BS RPE scale. This was confirmed in the present investigation in both experimental trials. During the load-incremented experimental trial, all participants rated "*zero*" at the end of the rest period or "stage 0" while standing in front of the bench. After subjects began to perform exercise (stepping up and down on the bench) their RPE was greater than or equal to "*1*." Similarly, during the load-intermittent experimental trial, in which exercise intensities were counterbalanced, all participants had a RPE greater or equal to "*1*" during exercise. Therefore, this scale modification improved the accuracy of the PAI in predicting energy expenditure at low exercise intensities.

5.2 CONCURRENT VALIDITY

One of the most common methods used in psychophysics and exercise research for establishing concurrent validity is by magnitude or category estimation (Stevens, 2008; Borg, 1998; Noble & Robertson, 1996). In the case of RPE scale validation, a category estimation method is typically used that consists of an exercise test, in which subjects are exposured to exercise intensities than span the physiological perceptual continuum. This procedure can also be called a load-

incremented or graded maximal exercise test and allows the individual to experience a wide range of exercise intensities (Noble & Robertson, 1996). The *Global Explanatory Model* of perceived exertion states that a physiological stimulus will lead to a concomitant perceptual response. Consequently, it is expected as exercise intensity increases a concurrent perceptual response will result (Noble & Robertson, 1996).

Validity of the adult versions of OMNI RPE scales have been established by examining the association between physiological criterion variables with perceptual variables in various exercise modalities, such as resistance exercise (Robertson et al., 2003), cycling (Robertson et al., 2004), and treadmill walking and running (Utter et al., 2004). In the case of the OMNI Resistance RPE scale, a strong positive linear association between RPE for the active muscle and overall body with total weight lifted (r ranged from 0.79 to 0.89) and blood lactate concentration (r = 0.87) was found (Robertson et al., 2003). Similarly, during cycling and treadmill walking-running, a strong positive linear association between RPE (overall body, legs, and chest/breathing) and oxygen consumption (r ranged from 0.87 to 0.95 for cycling and 0.85 to 0.86 for treadmill walking-running) and heart rate (r ranged from 0.81 to 0.90 for cycling and 0.75 to 0.84 for treadmill walking-running) was found (Robertson et al., 2004; Utter et al., 2004). Regarding the traditional Borg 6-20 RPE scale, correlation coefficients between RPE and heart rate were reported to be around 0.85 during cycle ergometer exercise and treadmill running (Borg, 1998). The findings from the present investigation are consistent with previous validation studies. A strong positive linear association between RPE with oxygen consumption (ICC = 0.96, $p<0.05$) and heart rate (ICC = 0.95, $p<0.05$) during bench stepping exercise was observed.

Although the category estimation procedure has been used widely in the exercise field, a limitation has also been pointed out (Noble & Robertson, 1996; Whaley et al., 1997, Lamb et al.,

1999). Subjects may be influenced to estimate a higher perceived exertion during a graded exercise test due to the fact that exercise stages change, leading to progressive increments in exercise intensity. This phenomenon is known as *anticipation bias*, in which a previous RPE can influence the following RPE (Noble & Robertson, 1996). In addition, the frequency that perceived exertion is estimated may also influence subsequent RPEs (Corbett et al., 2009).

When examining the present data from an ideographic perspective, the majority of subjects increased RPE stage-by-stage during the load-incremented protocol. However, similar validation evidence was found during the load-intermittent protocol (R=0.90-0.92), which was administered in a counterbalanced order. Therefore, concurrent validity of the OMNI-BS scale may not have been influenced by *anticipation bias* (Noble & Robertson, 1996).

Nonetheless, the short time on stimulus (three minutes) and longer rest period (ten minutes) provided during the load-intermittent trial did not have result in the same magnitude of physiological demand that occurred during the load-incremented protocol. Furthermore, it is reasonable to assume that the rest time between exercise bouts provided a complete recovery from the short time on stimulus, even for subjects with the lowest fitness level (Noble & Robertson, 1996). Consequently, oxygen consumption, heart rate, and RPE were significantly lower during the second experimental trial at all three stages when compared to the first experimental trial (except for RPE and heart rate during stage I, which did not significantly differ; $p > 0.05$). The cumulative physiological demand during the continuous load-incremented protocol may explain the greater oxygen consumption, heart rate and RPE noted presently in the first trial. Lastly, all subjects stepped on the bench with the same frequency (120 beats·min^{-1}) indicating that subjects were exposed to the same protocol during both experimental trials.

5.3 RELIABILITY

The OMNI-BS RPE scale demonstrated strong reliability (r = 0.95) across the exercise intensities employed in the present investigation. This finding is consistent with the hypotheses presented previously (page 8). It was hypothesized that a moderate-strong correlation (i.e., r > .70) would be found between the first and second experimental trials during stages I, III, and V. However, further *Pearson* correlation analysis for each of the three exercise stages indicated a 1) low association of RPE's during the low intensity exercise (stage I; r = 0.48; $p = 0.009$); 2) moderate association of RPE's during the moderate intensity exercise (stage III; r = 0.56; $p = 0.002$); and 3) a strong association of RPE's during the high intensity exercise (stage V; r = 0.79, $p < 0.001$).

Only a few studies have examined the reliability of the OMNI RPE scale (Pfeiffer et al., 2002) and/or the Borg 6-20 RPE scale (Pfeiffer et al, 2002; Skinner et al., 1973; Stamford, 1976; Lamb et al., 1999, Noble & Robertson, 1996). The first study to examine the reliability of a RPE scale was conducted by Skinner et al., in 1973 in male subjects, in which the Borg 6-20 scale was used (Noble & Robertson, 1996). Reliability coefficients calculated from RPE estimated during a graded exercise test and intermittent cycle test were 0.80 and 0.78, respectively. Later, Stamford in 1976, conducted a similar experiment using females subjects. In this investigation, the reliability coefficients for the graded exercise test and intermittent cycle test were 0.90 and 0.71, respectively. In addition, the reliability of the Borg 6-20 RPE scale during a stool stepping test and a submaximal running treadmill test were both 0.76. These results indicated that the Borg 6-20 RPE scale is a reliable metric for use during cycle ergometry and stool stepping (Noble & Robertson, 1996). Pfeiffer et al., (2002) conducted an investigation with adolescents girls undergoing graded treadmill exercise, in which the OMNI RPE scale showed better reliability (R = 0.95) than the Borg 6-20 RPE scale (R = 0.78).

Recently, several studies have indicated there may be limitations associated with the use of *Pearson Correlation* analysis to determine the validity and reliability of RPE scales as the *Pearson* correlation analysis does not assess the level of agreement, but the degree of association between two variables. This lead to a new statistical procedure being proposed, i.e., "*95% limits of agreement* (LoA)" (Nevill & Atkinson, 1997; Lamb et al., 1999; Bland & Altman 1986). Bland and Altman (1986) originally proposed this method which is based on the differences between the two measurements, which when graphed provides a qualitative scheme to judge the agreement between individual test-retest measurements.

Lamb et al., (1999) assessed the test re-test reliability of the Borg 6-20 RPE scale with this alternative statistical procedure. Subjects undertook two sessions of the same GXT protocol on a treadmill, separated by 2-5 days. RPE and heart rate reserve (%HRR) did not differ between sessions from exercise stages 1 to 4. Comparisons between exercise sessions for each stage, indicated that reliability coefficients of the Borg RPE scale decreased slightly as exercise intensity increased (R = 0.82; 0.80; 0.77; and 0.75, respectively for stages 1 to 4), while the limit of agreement was found to widen to almost three RPE units as exercise intensity increased. Based upon this comparatively wide limit of agreement a perception of "hard (heavy) (RPE = 15)" could vary from "very hard (RPE = 17)" or "extremely hard (RPE = 19)". This lead Lamb and co-authors to question the reliability of the Borg 6-20 RPE scale.

The results of the present study displayed on the Bland-Altman plots (Figure 15) indicate a negative tendency. This negative tendency of RPE between trials can partially be explained by the significantly lower physiological demand ($\dot{V}O_2$ and HR) in the second trial. Nonspecific factors may have influenced the perceptual response during trial 1 (load-incremented protocol).

These potential factors may have included compensatory muscle recruitment and postural adjustments to maintain balance, especially at higher exercise intensities. This may have contributed to increased fatigue and higher RPEs. These nonspecific factors may have been less pronounced during trial 2 (load-intermittent protocol), because subjects only performed three exercise stages, the stages were administered in a counterbalanced order, and a 10-min rest period separated each stage (*Global Explanatory Model of Perceived Exertion* pages 15 and 16 – Robertson & Noble, 1997; Noble & Robertson, 1996). As a result, the RPE should be lower which, was the case in stages III and V.

The conclusions regarding the reliability of the OMNI-BS RPE scale may be influenced by the statistical procedure utilized. Based upon the quantitative ICC analysis the OMNI-BS RPE scale has been shown to be highly reliable ($r = 0.95$). However, the qualitative approach of the Bland-Altman procedure indicates a comparatively wide confidence limit suggesting a somewhat lower level of agreement between trials.

In summary, the negative tendency and comparatively wide confidence limit observed in the Bland-Altman plot cannot be considered as a major limitation of the OMNI Bench Stepping RPE scale. The OMNI-BS RPE scale was consistent with the Global Explanatory Model of Perceived Exertion in that RPE and physiological criterion variables increased concurrently as a function of exercise intensity.

In conclusion, previous investigations have provided evidence for the reliability of RPE scales. The findings from the present study provide evidence of the reliability of the OMNI Bench Stepping scale. This reliability can be partially attributed to the format of the OMNI system, which enables subjects to establish their physiological-perceptual sensory range on the scale, thereby, leading to a reliable rating of the perception of physical exertion.

5.4 FUTURE RESEARCH

Although several studies have provided evidence of the validity of the OMNI Rating of Perceived Exertion system and its effectiveness for prescribing and monitoring exercise intensity, the following topics should be investigated as a way to expand the knowledge base regarding the perception of physical exertion.

1. The validity of the new format of the OMNI Bench Stepping Scale can be examined in other mode-specific versions of the OMNI RPE scales for children, young adults and older adults.
2. Even though previous studies have demonstrated there were not significant gender differences in RPE at relativized physiological criterion variables (%$\dot{V}O_{2max}$ and %HR $_{max}$) (Robertson et al., 2000), future studies could compare the RPE responses between genders using the OMNI-BS scale.
3. Bench stepping protocols underestimate the true maximal cardiorespiratory capacity of males (Keren et al., 1980). Therefore, future studies could compare maximal oxygen consumption achieved in the bench stepping protocol used in this investigation with a walking-running maximal protocol. Nevertheless, it is crucial to recognize that other step protocols have reported lower peak physiological responses than the protocol used in the present study (estimated $\dot{V}O_{2peak}$ is approximately 25.8 to 29.5 ml kg $^{-1}\cdot min^{-1}$) (ACSM, 2006). Therefore, $\dot{V}O_{2peak}$ resulting from the protocol used in the present study should be compared to the maximal physiological responses to progressively incremented treadmill exercise.

4. This investigation used only undifferentiated RPE (for the overall body) during both experimental protocols. Examining the differentiated RPE (for legs and for chest and breathing) may provide additional validity evidence for the OMNI-BS scale.
5. In order to examine the applicability of the OMNI-BS RPE scale in an ecologically valid manner, it is recommended an interventional study be conducted, involving tracking subjects while self-regulating at specific target RPEs, or during group exercise. In this way, the prescription and monitoring of exercise intensity using RPE can be examined in a more realistic setting.
6. Use the OMNI-BS RPE scale to evaluate changes in the fitness level of participants in bench stepping classes.
7. The current investigation may not be an accurate assessment of the test re-test reliability of the OMNI-BS RPE scale as trial 1 and 2 consisted of different exercise protocols. Therefore, in order to provide additional evidence about the test re-test reliability of OMNI-BS RPE scale, an investigation should compare the RPE responses by using the same experimental protocols. For example, by using two identical intermittent estimation or production protocols. Also, protocols with more than three exercise stages should be employed.
8. Lastly, it is recommended that ICC (quantitative) and Bland-Altman (qualitative) statistical procedures continue to be used in examining test re-test reliability of RPE scales.

5.5 CONCLUSIONS

Both experimental trials provided strong evidence regarding the concurrent validity of the OMNI Bench Stepping RPE scale. The load-incremented protocol, used presently, is the based on the classical procedure used to establish the validity of RPE scales, in which cardiorespiratory and perceptual responses are measured across a wide range of exercise intensities. The load-intermittent protocol supported the validity of the OMNI Bench Stepping RPE scale in a more realistic context, because it consisted of discrete exercise stages representing a range of exercise intensities commonly prescribed to healthy adults. In addition, the reliability of the OMNI Bench Stepping RPE scale was established using sophisticated statistical procedures (*Intraclass Correlation* and *95% Limits of Agreement*). The present results demonstrated a strong association of RPE between trials (ICC: R = 0.95) and a moderate agreement. Collectively these findings indicate that the OMNI-BS RPE scale is reliable. In conclusion, the results obtained from this investigation provide evidence of concurrent validity and test-retest reliability of the OMNI Bench Stepping RPE scale (OMNI-BS) in adults females during bench stepping.

APPENDIX A

ID# _____

University of Pittsburgh - Center for Exercise and Health-Fitness Research

MEDICAL HISTORY

		Yes	No
1.	History of heart problems, chest pain, or stroke?		
2.	Increased blood pressure?		
3.	Any chronic illness or condition?		
4.	Difficulty with exercise?		
5.	Advice from a physician not to exercise?		
6.	Recent surgery? (Last 12 months)		
7.	Pregnancy? (Now or within the last 3 months)		
8.	History of breathing or lung problems?		
9.	Muscle, joint, back disorder, or any previous injury still affecting you?		
10.	Diabetes or thyroid condition?		
11.	Cigarette smoking?		
12.	Increased blood cholesterol?		
13.	History of heart problems in your immediate family?		
14.	Hernia or any condition that may be aggravated by lifting weights?		
15.	Do you have any condition limiting your movement?		
16.	Are you aware of being allergic to any drugs or insect bites?		
17.	Do you have asthma?		
18.	Do you epilepsy, confusions, or seizures of any kind?		
19.	Do you follow any specific diet?		

Please explain in detail any "YES" answer:
Family History
Has any member of your family had any of those listed above?

APPENDIX B

ID# _____

University of Pittsburgh - Center for Exercise and Health-Fitness Research

Physical Activity Readiness Questionnaire – PAR-Q

Now I am going to ask you a few questions to determine if you are eligible to complete the bench stepping exercise…

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
   No _____ Yes _____ If yes, specify: _____

2. Do you feel pain in your chest when you do physical activity?
   No _____ Yes _____ If yes, specify: _____

3. In the past month, have you had chest pain when you were not doing physical activity?
   No _____ Yes _____ If yes, specify: _____

4. Do you lose your balance because of dizziness or do you ever lose consciousness?
   No _____ Yes _____ If yes, specify: _____

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
   No _____ Yes _____ If yes, specify: _____

6. Is your doctor currently prescribing drugs (for example, water pills) for a blood pressure or heart condition?
   No _____ Yes _____ If yes, specify: _____

7. Do you know of any other reason why you should not do physical activity?
   No _____ Yes _____ If yes, specify: _____

APPENDIX C

University of Pittsburgh

RESEARCH STUDY

DEPARTMENT OF HEALTH AND PHYSICAL ACTIVITY

CENTER FOR EXERCISE AND HEALTH-FITNESS RESEARCH

University of Pittsburgh Department of Health and Physical Activity is now recruiting healthy, adult females (18-35 years old) with previous experience performing bench stepping routines for a research study to determine ratings of perceived exertion during bench stepping exercise.

Each participant will complete:
Two exercise sessions stepping up and down on a bench. The first session is a maximal graded exercise test, and the second session consists of three exercise bouts stepping up and down on a bench, with three different heights, to determine how women feel during this activity.

To be eligible you must:
1. Be healthy (non-obese) and non-smoker.
2. Have participated in at least three bench stepping exercise routines (stepping up and down on the bench) in the previous three months.

Upon completion of the two exercise session, subjects will receive $20.00

For more information and to see if you qualify, call Maressa Krause at 412-320-6831 or e-mail mpk19@pitt.edu; maressakrause@hotmail.com for more details.

APPENDIX D

MASTER SHEET

In order to participate in this study, you must have participated in at least three bench stepping exercise routines in the previous three months. Confirm that you are eligible to participate in this study." **( ) yes ( ) no**

Personal Information – **ID # _____**

Family Name: _____ First Name: _____

Data of Birth: _____ Phone: _____

Emergency Contact: _____ **SS #** _____

Sub ID	Last Name	First Name	Recall – BS*	Ex Bout Code**
1				A
2				B
…				

**Intermittent Estimation Perceptual Trial – counterbalanced codes of exercise bouts:

LI = low intensity; MI = moderate intensity; HI = high intensity.

Code A = LI-MI-HI Code B = LI-HI-MI Code C = MI-LI-HI
Code D = MI-HI-LI Code E = HI-LI-MI Code F = HI-MI-LI.

APPENDIX E

LOAD-INCREMENTED ESTIMATION PERCEPTUAL PROTOCOL

Data: _____ **Subject ID#: _____**

Previous Experience with RPE scale: ( ) yes ( ) not **Resting HR: _____**

Stage	**Time (min)**	***RPE_O** (at 2:45 of each stage)	**HR (bpm)**	**VO_2 (ml/kg/min)**	**Step Count**
0 (standing)	**0:00 – 2:50**				
I	**3:00 – 5:50**				
II	**6:00 – 8: 50**				
III	**9:00 – 11: 50**				
IV	**12:00 – 14: 50**				
V	**15:00 – 17: 50**				
VI	**18:00 – 20: 50**				
	max				

Investigator: _____

APPENDIX F

LOAD-INCREMENTED ESTIMATION PERCEPTUAL PROTOCOL – PROCEDURES

Pre-test Instructions. Orientation for the Load-incremented Perceptual Estimation Protocol. As previously reported, subjects will receive the standard instructions regarding the definition of RPE and memory-anchoring procedures, immediately before the estimation trial. Next, subjects will receive the standard instructions related to the basic bench stepping movements used during the exercise protocol, i.e., stepping up and down, alternating the right and left foot, and simultaneously, swinging their arms forward/backward beside the trunk. If necessary, subjects can perform a short practice trial (one minute) before the test begins, in this case the subject will rest for five minutes in a seat position prior to the estimation test.

Standard Instructions – RPE definition. We define perceived exertion as the *feeling of effort, strain, discomfort and/or fatigue* that you experience in your body during exercise. During this exercise test, we will use the OMNI-BS.

Standard Instructions – Memory-Anchoring Procedure. **OMNI-BS scale:** We would like you to use the number on this scale to tell us how your whole body feels when you are in the bench stepping exercise session (show – OMNI-BS scale).

Please, look at the person on the left side of the scale who is not doing any exercise, and therefore, is not feeling any exertion caused by exercise. If you feel like this person when you are in the bench stepping session, the exertion will be "*rest."* In this case, your rating should be the number "0" (point to "0" on the scale).

Now, look at the person on the right side of the scale who is exhausted. If you feel like this person looks during the bench stepping exercise session, the exertion is equivalent to "*Extremely hard*." In this case, your rating should be the number "10" (point to 10" on the scale).

If your exertion feels somewhere between "*Rest"* ("0") and "*Extremely hard*" ("10"), then give a number between 0 and 10.

We will ask you to point to the number that tells how your **whole body** feels. Remember, there is no right or wrong answer. Your number can change as you exercise. Use both the pictures and the words on the scale to help you to select a number. Use *any* of the numbers to tell how you feel when you are in a bench stepping exercise session.

Do you have any questions?

In order to determine if the subject understands how to use the scale to rate their perceived exertion, the following questions will be asked:

1. What is your feeling of exertion right now? Please, point to a number on this scale (show OMNI-BS RPE scale). (The RPE should be "zero", if it is not the case, the instructions will be read to the subject again. In addition, it will be explained to the subject that this scale is used to measure perceived of exertion while exercising, therefore, if the exercise

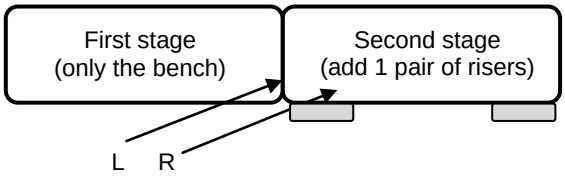
session did not start, there is no exertion caused by exercise, and therefore the appropriate response should be “rest.”)

2. How did you feel when you performed the most exhausting bench stepping exercise session that can you remember? Please, point to a number on this scale (show OMNI-BS RPE scale). The RPE should be higher than five, if it is not the case, the instructions will be read to the subject again.

Standard Instructions – Load-Incremented Estimation Protocol. Today, you are going to perform a bench stepping test that consists of a basic movement used during a typical bench stepping routine:

- You will stepping up and down on the bench and then on the floor, alternating between the right and left foot. Simultaneously, you should allow your arms to swing naturally forward/backward, with the elbows in a flexed position, beside the trunk. Stepping frequency will be regulated by a metronome set at 120 bpm (resulting in 30 completed cycles stepping up and down in one minute).
- The test protocol will begin with a single bench (a platform without risers), will consist of progressively incremented 3-min exercise stages. Then at each subsequent stage, the exercise intensity will increase by the addition of one pair of risers (one riser the right side, and one the left side, under the bench). To facilitate the transition between exercise stages, two bench steps will be placed next to one another (see figure below and show the benches for the subject). While you are performing the movement on one bench, the other bench will be prepared for the next stage (with one more pair of risers). We will remind you, 10 seconds in advance, when you are going to the next exercise stage, and then, you

will need to begin stepping on the other bench. This procedure will be repeated every three minutes.



- We will ask you to rate your RPE for the overall body using the OMNI-BS scale during the last 15 seconds of each exercise stage.

Standard Instructions to Investigator – Load-Incremented Estimation Protocol.

1. The main investigator briefly will explain the procedures of this investigation to the potential participants and will obtain the written informed consent. Next, the primary investigator will obtain subject' personal information (i.e., family and first name, contact phone, birth date, and an emergency phone contact), and will assign an ID number that will be used in all of the data sheets. The bench stepping recall obtained in the first telephone contact between the subjects with the investigator will be added to the personal information sheet.

2. Subjects will complete the medical history and PAR-Q questionnaires (confirmation of inclusion criteria: there are not contraindications to undertake maximal exercise and have all negative responses on the PAR-Q).

3. Measure height (using the stadiometer) and body mass (using the BIA), and calculate BMI (confirmation of exclusion criteria).

4. Record if the subject has a previous experience with RPE scale

5. Subject will be fit with a heart rate monitor.

6. Read all standard instructions to the subject.

7. Explain the importance of keeping the lips sealed around the mouthpiece.

8. Record resting heart rate.

9. Fill in the computer subject information as following: OMNI-BS/Est, Sub_Id. Select in Mode Exercise: Others – maximal test, and in the next screen: No Computer Control, wait around 15 seconds for stabilization of the gases, and lastly, initiate the experimental protocol – pressing "OK";

10. Record RPE and heart rate during the last 15 seconds of the each stage.

11. Record the number of steps for each stage throughout the test.

Reminders to the subject during the test:

- If the subject is not swinging her arms as instructed previously, the following reminder will be read: "move your arms naturally, let your arms swing forward/backward, with your elbows in a flexion position, beside your trunk." This statement will be repeated when needed.
- **During the last 10 seconds,** of each 3-min stage, the subject will be reminded that they are going to the next exercise stage, in which the bench step will be a little higher than the previous one.

APPENDIX G

INTERMITTENT ESTIMATION PERCEPTUAL PROTOCOL

Data: _____ **Subject ID#: _____**

Resting HR: _____ **†Counterbalanced CODE: _____**

†Exercise Bout	**Time (min)**	**RPE_ O OMNI-BS**	**HR (bpm)**	**VO_2 (ml/kg/min)**	**Step Count**
1 = _____	**0:00 – 3:00**	**at 2:45 -**			
***10-min rest**	3:00 – 12:59				
2 =_____	**13:00 – 16:00**	**at 15:45 -**			
****10-min rest**	16:00 – 25:59				
3 = _____	**26:00 – 29:00**	**at 28:45 -**			

During Rest Period:

	Min 4	Min 5	Min 6	Min 7	Min 8	Min 9	Min 10	Min 11	**Min 12**
*HR									
	Min 17	Min 18	Min 19	Min 20	Min 21	Min 22	Min 23	Min 24	**Min 25**
**HR									

After recorded HR at min 9, set up the subject in front of the bench for the next exercise bout.

Investigator: _____

APPENDIX H

INTERMITTENT ESTIMATION PERCEPTUAL PROTOCOL – PROCEDURES

Pre-test Instructions. Intermittent Perceptual Estimation Protocol. Today, you are going to perform a bench stepping test that consists of a basic movement used during a typical bench stepping routine:

- You will stepping up and down on the bench and then on the floor, alternating between the right and left foot. Simultaneously, you should allow your arms to swing naturally forward/backward, with the elbows in a flexed position, beside the trunk. Stepping frequency will be regulated by a metronome set at 120 bpm, resulting in 30 completed cycles stepping up and down in one minute.
- The test protocol will consist of three separated exercise bouts, in which you will performed 3 minutes of bench stepping only on the bench, the bench with two pairs of risers, and the bench with four pairs of raisers.
- At 2:45 of each exercise bout we will ask you to rate your perceived exertion for the overall body using the OMNI-Bench Stepping scale.
- Subsequently, you will have a rest period between each exercise bout of 10 minutes, you will remain in a seated position from minute 1 to 9. During the last minute of recovery you will stand in front of the bench and wait for the next exercise bout to begin.

Standard Instructions to Investigator – Intermittent Perceptual Estimation Protocol.

1. Subject will be fit with a heart rate monitor.

2. Read all standard instructions to the subject.

3. Explain the importance of keeping the lips sealed around the mouthpiece.

4. Record resting heart rate.

5. Fill in the computer subject information as following: OMNI-BS/R, Sub_Id. Select in Mode Exercise: Others – submaximal test, and in the next screen: No Computer Control, wait around 15 seconds for stabilization of the gases, and lastly, initiate the experimental protocol – pressing "OK";

6. Record RPE and heart rate during the last 15 seconds (at 2:45) of the each exercise bout.

7. Record the number of steps for each stage throughout the test.

8. Record HR from minute 1 to 9 during the rest period.

9. During the last minute of rest period, set up the subject to the following exercise bout.

Reminders to the subject during the test:

- If the subject is not swinging her arms as instructed previously, the following reminder will be read: "move your arms naturally, let your arms swing forward/backward, with your elbows in a flexion position, beside your trunk." This statement will be repeated when needed.

APPENDIX I

INFORMED CONSENT

TITLE: Concurrent Validity of a Pictorial Rating of Perceived Exertion Scale for Bench Stepping Exercise

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Why is this research being done?

Feelings of effort, also known as ratings of perceived exertion (RPE), are commonly used to define the intensity training zone and to regulate exercise intensity. The OMNI Picture System of Perceived Exertion is a recent tool in the field of perceived exertion. Since its development in the 1980's, bench stepping has become a popular form of aerobic exercise among women. However, the effectiveness of self-regulation of exercise intensity during bench stepping exercise is unknown. The primary purpose of this study is to develop and validate a modified OMNI Rating of Perceived Exertion Scale for use during bench stepping exercise (OMNI-BS). The secondary purpose of this study is to examine the reliability of the OMNI-BS RPE scale by comparing RPEs between the two experimental trials.

Who is being asked to take part in this research study?

Twenty-four healthy female adults (18-35 yrs old), who have participated in at least three bench stepping exercise routines in the last three months are being invited to take part in this research study. If you have a muscle or bone, heart disease, prior heart attack, blockages of arteries in legs, lung disease, and diabetes mellitus (high/low blood sugar) and/or if you are knowingly pregnant or you are a current smoker, you will not be eligible to participate in this research study. To minimize risks associated with maximal aerobic exercise testing, you will be asked to complete a Physical Activity Readiness Questionnaire (PAR-Q) and a medical history form, which asks questions about your current health status.

What procedures will be performed for research purposes?

If you decide to take part in this research study, you will complete two testing session of 30-40 minute of duration each. The first testing session will consist of stepping up and down on a bench, with progressive increases in exercise intensity to obtain your maximal aerobic fitness (VO_{2max}). Exercise intensity will increase as bench height increases, every 3-min. The second session will be performed 7 days later, on the same day of the week at a similar time of the day. It consists of three, 3-min, exercise stages with a 10-min rest between each stage. This test consists of stepping up and down on a bench with three different heights, which corresponds to low, moderate, and high exercise intensities.

If an abnormal response occurs during exercise, such as dizziness or chest pain, test will be immediately stopped and you will be given proper medical attention. Emergency equipment will be on site for all testing procedures and staff personnel are certified in CPR and First Aid by the American Heart Association. If you have an abnormal response to the test, you will be told of the findings and will be encouraged to contact your primary care clinician. The risk of falling can increase as the bench height increases. For this reason, a co-investigator will be close (beside) to you throughout the test to provide body support if necessary to prevent you from falling.

All procedures will take place at the Center for Exercise and Health-Fitness Research located in Trees Hall at the University of Pittsburgh. The testing session will include the following procedures administered by the principal investigator who is a doctoral student at the Department of Health and Physical Activity at the University of Pittsburgh:

Experimental Procedures:

1. Before starting the study protocol, you will complete a medical history form and a physical activity readiness questionnaire (PAR-Q). Both forms will take less than five minutes to complete.
2. Your height will be measured using a standard physicians' scale.
3. Body weight and body composition will be assessed using a Tanita bioelectrical impedance analyzer (BIA) scale. The BIA is a non-invasive pain-free procedure for assessing body composition in which a low-grade electrical impulse is transmitted through the body. The resistance to current flow through tissues reflects the relative amount of fat present. You will remove your shoes and socks and stand on the scale for approximately 10 seconds to obtain body composition assessment on the Tanita scale. During the body composition measurement there may be a potential for the hair on your arms and legs to stand up. Body mass index (BMI) will then be calculated. Those potential participants with BMI >30.0 $kg \cdot m^2$ will be excluded from the study.
4. Prior to the exercise sessions, you will be asked if you have previous experience with RPE scale, and you will receive standard instructions on RPE scaling procedures. The investigator will first read you the following definition of RPE: *"The perception of physical exertion is defined as the subjective intensity of effort, strain, discomfort, and/or fatigue that you feel during exercise."* You will then be read a set of instructions from a script on how to use the RPE scale during the exercise session.
5. A heart rate monitor will be placed around your chest and secured in place with an elastic strap. A rubber mouthpiece, connected to a headset, will be placed in your mouth during the bench stepping exercise to determine the amount of oxygen that you use during exercise. A

clip will be attached to your nose to insure that all the air that you breathe comes in and out through your mouth. Some individuals become anxious when fitted with the nose clip and mouthpiece. If this occurs, please inform the technician performing the test and the test will be stopped. Your heart rate and the amount of oxygen that your body uses will be measured during the bench stepping exercise.

6. Based on the information you provide on the medical history and PAR-Q, if you do not have any conditions that would limit your ability to exercise, you will complete the first testing session in order to determine your aerobic fitness (VO_{2max}). You will be administered the exercise test on a bench, stepping up and down while maintaining a cadence of 120 beats per minute (bpm) – this corresponds to 30 complete steps up and down. The exercise intensity will increase every 3 minutes as bench height is increased (adding pairs of risers under the bench). You will be encouraged to continue until fatigued. However, you may stop the test at any time for any reason. Additionally, the investigator will measure your heart rate and RPE for your overall body every stage.
7. Seven days after you have completed the first trial, you will return to complete the submaximal trial on the bench (stepping up and down) on the same day of the week at a similar time of the day. The second trial will consist of three, 3-min exercise bouts. A 10-min rest period will be placed between bouts. This session will last approximately 30-min. Each exercise bout will consist of 3-min, stepping up and down on the bench while maintaining a cadence of 120 bpm. The exercise bouts will corresponds three different targets exercise intensity: low, moderate, and high, which reproduces the stages I, III, and V of the first exercise protocol.

The experimental trial will be conducted in the Human Energy Research Laboratory (HERL) where the temperature will range from 70 degrees Fahrenheit to 74 degrees Fahrenheit and humidity will be less than 60%.

What are the possible risks, side effects, and discomforts of this research study?

Risks of the exercise test

Abnormal responses, such as mental confusion, shortness of breath, chest pain, heart attack, and death, to maximal aerobic exercise tests in young healthy adults are rare, occurring in less than 1% of people (less than 1 out of 100 people tested). However, some common risks, occurring in 1% to 25% of people (1 to 25 out of 100 people tested), of maximal exercise testing include; heavy breathing, dizziness, muscle fatigue, headache, and overall fatigue. As with any experimental procedure, there may be adverse events or side effects that are currently unknown, and certain of these unknown risks could be permanent, severe, or life-threatening. There is also a risk of falling when performing the stepping exercise.

Risks of the study monitors

Risk associated with study monitors (e.g., heart rate monitor, mouthpiece, etc.) include redness, irritation, and chafing. Dryness of the mouth and throat may occur due to the mouthpiece.

Risk of breach of confidentiality

In very rare cases, people not associated with this research study may inadvertently see your identifiable research results. We will do everything in our power to prevent this from happening by keeping all research records in locked files, and identify all specimens and medical information by a

research record number, rather than by your name or social security number. The codebook containing your name and number will be kept secure by the Study Coordinator/Investigator.

What are possible benefits from taking part in this study?

You will likely receive no direct benefit from taking part in this research study. However, you will receive information regarding your aerobic fitness level, percent body fat and the importance of promoting cardiovascular health.

If I agree to take part in this research study, will I be told of any new risks that may be found during the course of the study?

You will be promptly notified if, during the conduct of this research study, any new information develops which may cause you to change your mind about continuing to participate.

Will my insurance provider or I be charged for the costs of any procedures performed as part of this research study?

Neither you, nor your insurance provider, will be charged for the costs of any procedures performed for the purpose of this research study.

Will I be paid if I take part in this research study?

You will be paid $20.00 upon completion of the second testing session. There will be no partial compensation for completion of less than the two trials.

Who will pay if I am injured as a result of taking part in this study?

University of Pittsburgh researchers and their associates who provide services at UPMC recognize the importance of your voluntary participation in their research studies. These individuals and their staffs will make reasonable efforts to minimize, control, and treat any injuries that may arise as a result of this research. If you believe that you are injured as a result of the research procedures being performed, please contact immediately the Principal Investigator or one of the Co-Investigators listed on the first page of this form.

Emergency medical treatment for injuries solely and directly related to your participation in this research study will be provided to you by the hospitals of the UPMC. It is possible that the UPMC may bill your insurance provider for the costs of this emergency treatment, but none of these costs will be charged directly to you. If your research-related injury requires medical care beyond this emergency treatment, you will be responsible for the cost of this follow-up unless otherwise specifically stated below. There is no plan for monetary compensation. You do not, however, waive any legal rights by signing this form.

Who will know about my participation in this research study?

Any information about you obtained from this research will be kept as confidential (private) as possible. All records related to your involvement in this research study will be stored in a locked file cabinet. Your identity on these records will be indicated by a case number rather than by your name,

and the information linking these case numbers with your identity will be kept separate from the research records. You will not be identified by name in any publication of the research results.

Will this research study involve the use or disclosure of my identifiable medical information?

This research study will not involve the use or disclosure of any identifiable medical information. your participation in this research study:

Who will have access to identifiable information related to my participation in this research study?

In addition to the investigators listed on the first page of this authorization (consent) form and their research staff, the following individuals will or may have access to identifiable information related to your participation in this research study:

1. Authorized representatives of the University of Pittsburgh Research Conduct and Compliance Office may review your identifiable research information for the purpose of monitoring the appropriate conduct of this research study.

2. In unusual case, the investigators may be required to release identifiable information related to your participation in this research study in response to an order from a court of law. If the investigators learn that you or someone with whom you are involved is in serious danger or potential harm, they will need to inform, as required by Pennsylvania law, the appropriate agencies.

3. Authorized people sponsoring this research study, because they need to make sure that the information collected is correct, accurate, and complete, and to determine the results of this research study.

4. Authorized representatives of the UPMC hospitals or other affiliated health care providers may have access to identifiable information related to your participation in this research study for the purpose of (1) fulfilling orders, made by the investigators, for hospital and health care services (e.g., laboratory tests, diagnostic procedures) associated with research study participation; (2) addressing correct payment for tests and procedures ordered by the investigators; and/or (3) for internal hospital operations (e.g., quality assurance).

For how long will the investigators be permitted to use and disclose identifiable information related to my participation in this research study?

The investigators may continue to use and disclose, for the purposes described above, identifiable information related to your participation in this research study for a minimum of five years after final reporting or publication of a project.

Is my participation in this research study voluntary?

Your participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above, is completely voluntary. (Note, however, that if you do not provide your consent for the use and disclosure of your identifiable information for the purposes described above, you will not be allowed, in general, to participate in this research study).

Whether or not you provide your consent for participation in this research study will have no affect on your current or future relationship with the University of Pittsburgh. Whether or not you provide your current medical information for participation in this research study will have no effect on your current or future medical care at a UPMC hospital or affiliated health care provider or your current or future relationship with a health care insurance provider.

May I withdraw, at a future date, my consent for participation in this research study?

You may withdraw, at any time, your consent for participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above. Any identifiable research information recorded for, or resulting from, your participation in this research study prior to the date that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

To formally withdraw your consent for participation in this research study you should provide a written and dated notice of this decision to the principal investigator of this research study at the address listed on the first page of this form.

Your decision to withdraw your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh. Your decision to withdraw your consent for participation in this research study will have no effect on your current of future medical care at a UPMC hospital or affiliated health care provider or your current or your future relationship with a health care insurance provider.

If I agree to take part in this research study, can I be removed from the study without my consent?

It is possible that you may be removed from the research study by the researchers to protect your safety or if you are unable or unwilling to complete the research protocol.

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VOLUNTARY CONSENT

All of the above has been explained to me and all of my questions have been answered. I understand that any future questions I have about this research study during the course of this study, and that such future questions will be answered by the investigators listed on the first page of this consent document at the telephone numbers given. Any questions I have about my rights as a research subject will be answered by the Human Subject Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668). By signing this form, I agree to participate in this research study.

Participant's Signature	Printed Name of Participant	Date

CERTIFICATION OF INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual, and I have discussed the potential benefits, and possible risks associated with participation. Any questions the individual has about this study have been answered, and we will always be available to address future questions as they arise.

Printed Name of Person Obtaining Consent	Role in Research Study
Signature of Person Obtaining Consent	Date

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