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# PRESCRIBING EXERCISE INTENSITY FOR HEALTHY ADULTS USING PERCEIVED EXERTION

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## *ABSTRACT*

*Prescribing exercise intensity for healthy adults using perceived exertion. Rating of perceived exertion (RPE) is endorsed as a useful adjuvant for prescribing and monitoring exercise intensity. In this paper, I describe a rationale for the use of RPE and other exertional symptoms as an alternative to traditional exercise prescription procedures for healthy adults. Errors associated with using RPE for producing exercise intensity are discussed along with limitations with the use of $HR_{Reserve}$ as the standard for judging the accuracy of RPE for prescribing relative exercise intensity. The concept of preferred exertion is discussed as a prescription paradigm that is complementary to the use of perceived exertion and physiological indicators of relative exercise intensity. Important areas that have not received enough research attention are summarized.*

***KEYWORDS:*** *Rating of perceived exertion (RPE), Prescribing and Monitoring Exercise Intensity*

## INTRODUCTION

### Preferred Exertion, Exertional Symptoms, Exercise Adherence

Conventional training guidelines (2) for ensuring relatively risk-free gains in cardiorespiratory fitness and muscular strength are based on a large empirical literature. Fitness (defined by objective standards such as $VO_{2peak}$ or strength) can be increased andmaintained reliably by adults differing in age and initial fitness if the type, intensity, duration, and frequency of the exercise stimulus is optimized. However, recent estimates reveal that only 8-22% of U.S. adults participate in physical activities with sufficient intensity and regularity to satisfy conventional training guidelines for the improvement or maintenance of fitness (11). Population-based study (49) shows that more than twice as many adults will adopt a new routine of moderate activity (e.g., walking or gardening) than will adopt a fitness regimen. Moreover, the median dropout rate for adult fitness programs for both cardiopulmonary patients and asymptomatic adults approximates 45% (25), and the dropout rates for the typical studies on which current ACSM fitnessguidelines for healthy adults (2) were based ranged from about 25-35% (41). Injury, perceptions of excessive exertion demands, and lack of confidence in the ability to carry out a fitness program are commonly reported barriers to sustained physical activity (20,32). These observations have renewed attention to the potential usefulness of alternative approaches, such as the use of perceived exertion and exertional symptoms, for prescribing exercise and physical activity.

### Problems with Intensity Prescriptions

I have addressed the general problem of exercise adherence in detail elsewhere (20), but here it is emphasized that participants can adhere to an exercise program (i.e., attend the recommended number of sessions for the specified amount of time) but fail to comply with the prescribed intensity. Noncompliance can increase cardiovascular or orthopedic risks among some participant groups, can attenuate fitness adaptations, and can be aversive. Each of these factors can limit sustained participation and its outcomes.

Two specific, practical aspects of exercise intensity prescription are especially relevant. The first involves prescription errors that occur when exercise intensity is calculated from a training heart rate range based on either measured or age-predicted $HR_{Reserve}$ (i.e., maximum hear! rate - resting heart rate). The second involves errors of self-regulation by the exerciser that reduce compliance with a typical training intensity prescription once it is given.

**Limitations of Training HR**

Various indicators can be used for exercise intensity prescriptions (e.g., energy expenditure, % $VO_{2peak}$ and ventilatory or lactate responses), but relative heart rate reserve (%$HR_{Reserve}$) (31) is practical and is the most widely used approach. Mean rate prescriptions present some problems though. Evenwhen variability due to age, training status, and testing mode is accounted for, the standard deviation of measured heart rate maximum ($HR_{max}$) approximates11beats.$min^{-1}$ (35). When the more common procedure or age-predicted $HR_{max}$ (220 beats.$min^{-1}$ or 226 beats.$min^{-1}$- age) is used, even greater problems can occur. Based on a normal distribution, errors of 11 beats.$min^{-1}$ above or below a true maximum can be expected (35) in about 30% of the adult population. Heart rate is also altered by emotional states and medication. For these reasons, exclusive reliance on heart rate for testing and prescription can lead to large overestimates and underestimates of % $VO_{2peak}$ for some individuals. For example, an age-predicted prescription of 60% $HR_{Reserve}$ for 50-yr-old men will yield a training heart rate approximating a range as low as ~70% or as high as ~80% of actual maximum heart rate in about 30% of the cases. In about 5% of the cases, the training prescription will be as low as ~65% or as high as ~90% of true $HR_{max}$. These errors have been viewed as acceptable for use with groups (1,2), but clearly they are unacceptable for use with many individuals. Because perceived exertion is more closely linked in many circumstances with relative oxygen consumption than with relative heart rate (40.45,46), the subjective strain of a standardized prescription based on heart rate can vary widely also. Hence, the clinical observation is not surprising that some participants given age-predicted heart rate ranges frequently complain that the exercise intensity is too easy or too hard.

Limitations in heart rate prescriptions have been recognized for many years. Previous authors (9,13,41) have suggested using rating of perceived exertion (RPE) as an adjuvant to heart rate prescription. Reports show that RPE can better estimate $VO_{2peak}$ than HR and that using HR and RPE to predict voluntary working capacity is more accurate than using either measure alone (37,39). However, studies of how HR and RPE might be weighted to optimize a training stimulus with minimal individual variability in relative oxygen consumption or in compliance are not available.

Borg (6) proposed that a model: RPE x 10 = FIR could be effective, but several authors (9,27,41) have reported clinical observations that a correction factor of 20 to 30 beats.$min^{-1}$ must be added (i.e., RPE X 10 + 20 to 30 beats.$min^{-1}$ = HR) for RPE of 11-16 and heart rates within typical training ranges of 130-160 beats.$min^{-1}$. Burke (9) found that RPE of 11-16 corresponded to heart rates ranging from 144 to 174 during jogging in healthy adults from about 18-50 yr of age. Similarly, RPE between 10 and 15 or 16 usually correspond with exercise intensities between 50% and 75% of maximum METs during graded treadmill walking (28) or 50-85% of $HR_{Reserve}$ during level walking/jogging (2) (see Figure. 1).

**Problems of Self-Regulation**

There are random and motivated errors when a prescribed training heart rate range is self-regulated. Chow and Wilmore (13) found that during four daily 15-min sessions of self-paced treadmill jogging without an exercise prescription or feedback, adult males remained in a training heart rate range (60-70%' $HR_{Reserve}$) only 25% of the time.

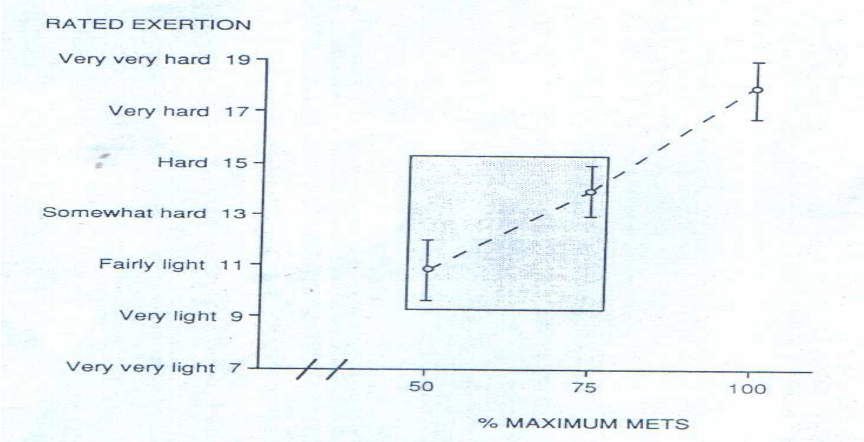


**Figure 1: Perceived Exertion (Mean ± Standard Deviation) and Relative Exercise Intensity during Treadmill Exercise (% maximum METs). The Linear Relationship between Exertion Rating and the Percent of Maximum Exercise Capacity Provides a Useful Monitoring tool for Exercise Testing.** ***Nate:*** **From Hanson (28, p. 24), Copyright 1984 by W. H. Saunders Company. Reprinted by Permission.**

Allowing subjects to periodically monitor pulse rate increased accuracy to 55%, whereas using RPE led to a similar accuracy of 48%. Average error for the heart rate monitoring group was 2.6 beats-min$^{-1}$ above the prescribed group mean, and the error for RPE was 5 beats-min$^{-1}$ below the mean prescription. We have observed (19) that the mean error between prescribed and attained target heart rate on the first day of field walking/jogging following a prescription (60% $HR_{Reserve}$) based on measured heart rate maximum during a graded treadmill test was +23 beats-mirr1 for control subjects and +18 beats-min$^{-1}$ for subjects given feedback about HR during the treadmill test..Subjects who attempted to produce a training heart rate based on RPE estimates from the treadmill test had a mean error of +3 beats.min$^{-1}$. The standard deviation was 19 beats.min$^{-1}$, but most subjects in the RPE group who overshot the training heart rate were still exercising below 75% of $HR_{Reserve}$. Each group was given feedback about heart rate errors after each of three daily field sessions. All groups decreased training heart rate errors equally across the three days. Similar findings have been reported by others (4,53).

An early study showed that subjects could reproduce a treadmill pace using RPE when HR was 150 beats.min$^{-1}$ or above and RPE was 12 or higher (51). At lower speeds and heart rates, perceived exertion was associated with large production errors. This finding might be explained by the mixing of modes between the trials, but the study illustrates important questions about problems that are inherent with using perceptual estimation tasks,like RPE, to produce an exercise pace contrasted with the useof RPE to produce a prescribed perceptual or physiological (e.g.. $VO_2$ or HR) response. Standard exercise prescription procedures titrate exercise intensity, usually at a constant pace, to yield a physiological or perceptual response indicative of optimal $VO_2$ for training adaptations and. in cardiopulmonary patients, indicative of low risk. This is opposed to producing a prescribed rate or pace and allowing physiological and perceptual responses to vary.

Estimation tasks allow the subject to assign numbers to a series of stimuli under the instruction to make the numbers proportional to the apparent magnitudes of the sensations of the stimuli. Production tasks require the subject to appraise the perception of a stimulus by producing an analog response that is proportional to the stimulus. Because physical exertion depends upon task production, it has been argued that reproduction of a prescribed exercise intensity will be more accurate following feedback during production trials than following RPE estimation trials. Moreover, it is expected that reproduction of an intensity will be more accurate if the estimation task is intramodal (i.e., the same activity mode is used for estimation and production) rather than inter-modal (i.e., the estimation task is a different mode of activity than the production task). Most studies using RPE to prescribe and monitor exercise intensity have used RPE estimation rather than RPE production tasks (38), and many have been intermodal (e.g., treadmill walking or cycling vs field jogging).

**The Accuracy of RPE as an Adjuvant to Relative Exercise Intensity**

When exercise intensity is quantified by oxygen consumption, heart rate, blood lactate, power output, or pace, the use of RPE may lead to underestimates of intensity when intramodal production is based on pace and/or when treadmill speed is high and grade is low (4,23,51). Production of exercise' intensity based on RPE estimates appears to be more accurate at higher intensities. The use of RPE from estimation tasks may overestimate intensity when intramodal or intermodal production is based on standard grade-incremented treadmill protocols (21); RPE was more accurate at 50% than 70% $VO_{2peak}$. Production of exercise intensity during field jogging/running from treadmill RPE can result in equivalent HR and velocity at an RPE that is about 2 units lower in the field (12). Three interday learning trials seem sufficient to reduce RPE production errors, compared with heart rate, to clinically acceptable levels in asymptomatic adult males (4,13,19,51,53).

Errors of production from cycling or treadmill RPE estimation approximate 10-15% for HR (12,13,19,21,26). Errors are greater below 50% and above 70% of $HR_{Reserve}$. Group mean errors for power output approximate 10-50 W and for $VO_2$ are less than 5% (21). Just-noticeable differences for grade-incremented treadmill orload-incremented cycling have not been clearly established, but reports suggest that they approximate 20 W (19,37,40). The errors for reproducing V02 from RPE at 50% and 70% $VO_{2peak}$ are not greater than the errors observed from the use of target HR (12,19,21,23,26).

**What is the Criterion for RPE Errors?**

Many studies have used % $HR_{Reserve}$(31) as the criterion for judging the accuracy of RPE production of a prescribed exercise prescription, based on the assumption that relative heart rate will best approximate the training goal of attaining a $VO_2$ that is optimal for increasing $VO_{2peak}$. There is limited evidence supporting a linear relationship between % $HR_{Reserve}$ and % $VO_{2peak}$ across exercise intensities (14). Recent evidence questions the validity of $HR_{Reserve}$ as a surrogate for relative oxygen uptake when applied to a population base. Wier and Jackson (54) have reported that a prescription based on % $HR_{Reserve}$ underestimated % $VO_{2peak}$ by about 5-10% at intensities between 50-60% $HR_{Reserve}$, but overestimated% $VO_{2peak}$ by about 4-8% at intensities between 80-85% $HR_{Reserve}$ in a large group of adult men –and women (see Figure 2). The concept of $HR_{Reserve}$ has been accepted by exercise professionals for 50% to 85% of $VO_{2peak}$ (1,2), but there is little empirical evidence for the relationship between % $HR_{Reserve}$ and % $VO_{2peak}$ at exercise intensities below 60% of capacity (14) where fitness and health adaptations will occur for much of the population.

For some segments of the population, % $HR_{Reserve}$ may represent an inaccurate index of relative exercise intensity for low and for high exercise intensities, and thus, an inappropriate criterion for determining the validity of RPE for exercise prescription. This is reinforced by a

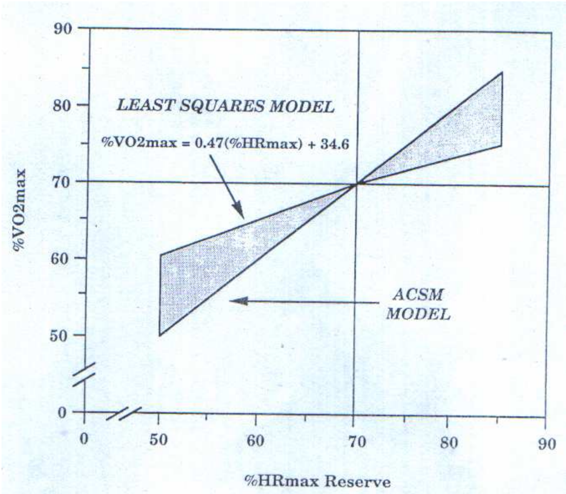


**Figure 2: Comparison of the Hypothetical Stepwise Relationship (i.e., slope = 1.0) Between % HR Reserve and % $VO_{2peak}$ Endorsed by the American College of Sports Medicine (ACSM) and Least Squares Regression Results (slope = 0.47) Observed for 930 men and Women. *Note:* From Wier and Jackson (54), Copyright 1992 by Williams and Wilkens. Reprinted by Permission.**

study(22) of 20 untrained college women. On cycle ergometry, nine subjects exceeded ventilatory threshold at 75% of $HR_{Reserve}$. This increased to 13 and 15 subjects at 80% and 85%, respectively, of $HR_{Reserve}$ and 70% and 75% of $VO_{2peak}$. Because 75% of $HR_{Reserve}$ is a commonly endorsed intensity prescription for college women, these findings suggest that exercise intensities, indicated by $V_e.VO_2^{-1}$, can be higher than indicated by heart rate when used with untrained subjects. Ventilatory and lactate thresholds have been associated with RPE of 13-15 (15.30.43,44) corresponding with subjective categories of “somewhat hard” to “hard” on Borg’s 6-20 category scale. These intensities may be aversive to some sedentary individuals.

There is consensus (.10,40.45) that RPE is dominated during low intensity exercise by local factors; but as the exercise intensity increases, central factors including sensations associated with increasing blood lactate and hyperventilation play a more significant role. Relative $VO_2$ and RPE typically correspond at all intensities (40,45) independently of exercise mode (46). Experimental manipulations of minute ventilation, blood lactate, blood pH, and blood glucose at unchanged levels of poweroutput or % $VO_{2peak}$can perturb the association of % $VO_{2peak}$ and RPE (43,47,48). The association of RPE with blood lactate does not appear to be affected by specificity of mode or training (29,50). A cross-sectional comparison of trained and untrained subjects during treadmill running (15) and randomized training studies of running and cycling (8,30) suggest that the association of RPE with % $VO_{2peak}$ is changed by training. Perceived exertion at both the lactate and ventilatory thresholds has not been changed by training despite the fact that lactate and ventilatory thresholds after training occur at a higher power output and a higher absolute and relative oxygen uptake. These studies indicate that perceived exertion appears more closely linked with blood lactate or $Ve.VO_2^{-1}$ than % $VO_{2peak}$ after training (8,15,29,30,50).

Collectively, these findings support Borg's original conception of RPE (5) as a subjective gestalt of sensory information associated with many physiological responses to exercise. Thus, errors of prescription using RPE (based on a relation with % $VO_{2peak}$) are likely to be more accurately accounted for by RPE's relation to several physiological indicators of exercise intensity other than HR or $HR_{Reserve}$. Dunbar et al. (21) recently reported on variations in heart rate, oxygen uptake, and power output when prescribed exercise intensities, estimated by RPE at 50% and 70% $VO_{2peak}$ on the treadmill or cycle ergometer, were subsequently produced using the same (intramodal) or alternative (intermodal) exercise tasks. The ranges of group mean errors for intramodal and intermodal production, respectively, were:(l-min$^{-1}$) (0.005 to -0.732), for heart rate (beats.min$^{-1}$) (-26.85 to 0.26), and for power output (W)[-48.07 to -7.31). When averaged across groups, less than a 2% difference was observed for producing oxygen uptake from RPE, although these errors approximate 20-25% when expressed as intra individual errors (R. J. Robertson, personal communication). Other studies (23,26) have shown acceptable errors of heart rate, oxygen uptake, and ventilation when intramodal production of intensity has followed RPE estimation during grade-incremented treadmill testing and acceptable errors of heart rate, blood lactate, and pace for an intramodal production from treadmill running to field running (12) (see Figure 3).

**Preferred Exertion**

There have been repeated calls for accelerated research on the roles of perceptions and preferences regarding the intensity of exertion as possible determinants of exercise behavior (16,20,32). High physiological strain, relative to perceived exertion, may increase risks for musculoskeletal and orthopedic injuries that can lead to inactivity (42). If inactive people select, or are prescribed, an intensity that is perceived as very effortful relative to their physiological responses, they may be less attracted to continued participation. Conversely, some individuals may prefer to exceed conventional prescriptions. In a recent 1-yr randomized exercise trial with middle-aged sedentary adults, similar adherence was observed for groups assigned to comparatively low (60-73% peak HR) or high (73-88% peak HR) intensities. However, the authors reported that each group selected intensities during the year that regressed toward a common intensity level accompanied by mean daily exercise RPE of 11.7 to 13.1 (33).

It is not known whether active and relatively inactive persons differ in their subjective and physiological responses to preferred levels of intensity during prolonged exertion. Most

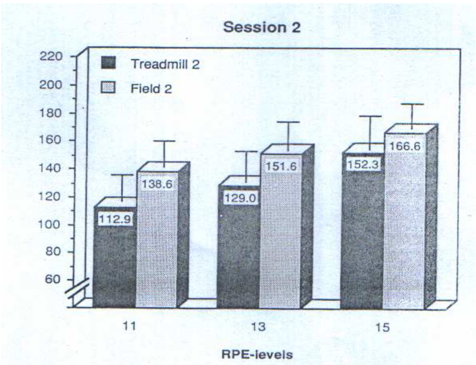


**Figure 3: The Obtained Heart Rates (in Beats.min$^{-1}$) at three RPE levels for Treadmill and Field Running. Mean Values ± Standard Deviations. *Note*: From Ceci and Hassmen (12, p. 735), Copyright 1991 by William & Wilkins. Reprinted by Permission.**

Studies of perceived exertion at self-selected exercise intensities have been of short duration ($\leq$20 min) and focused on production tasks following RPE estimation procedures (21,38,39,40,45,51). Bar-Or et al. (3) studied preferred power output during cycling in 70 middle aged (41-60 yr) men. Power output was increased 25 W every 2 min, at which time subjects indicated whether they would prefer the power output for 15 min of exercise. The power output preferred by active, lean subjects (~95 W) was higher compared with overweight, sedentary subjects (~85 W); but heart rate (~120 beats.min$^{-1}$) and the percentage of peak power output (~50%) at the preferred level did not differ between the groups. Farrell et al. (24) instructed trained male runners to run for 30 min at a "freely chosen pace" and compared responses with 30-min runs at fixed intensities of 60% and 80% of $VO_{2peak}$. The preferred intensity-approximated 75% $VO_{2peak}$ and ranged from 65-90%. Category ratings of perceived exertion during the preferred run initially averaged 9.2 and increased to 11.5. These ratings were between the mean RPE values of 8.8 and 12.3 for the 60% and 80% conditions. We have observed that when middle-aged men (45 ± 9 yr) were asked to select a treadmill speed at zero grade that was comfortable, they chose a speed eliciting ~65 ± 10% $VO_{2peak}$ and an RPE of 11.6 ± 2.2 (18).

We recently compared RPE, state anxiety, % $VO_{2peak}$, % ventilatory threshold, and blood lactate concentration in 11 physically active and 12 low active men (23 ± 3 yr) at self-selected power outputs (W) during 20 min of cycling (17). Activity history was verified by $VO_{2peak}$ and 7-d recall of vigorous exercise. Both groups reported increased RPE (11-14) across time, but RPE did not differ between the groups despite group differences in power output that approximated 25-50 W. No differences were found for blood lactate, and the groups did not differ on post exercise reports of exertional symptoms (52). Group-by-time interactions were observed for all other responses. The active group selected higher power outputs (~150-175 W) than did the inactive group (~125-130 W), but % $VO_{2peak}$ and % ventilatory threshold were lower for the active subjects during the initial 5-10 min. Percent $VO_{2peak}$ and % ventilatory threshold increased across time for the active subjects but did not change for the inactive subjects. During the early minutes of cycling, active subjects preferred an apparent warm-up strategy by selecting power outputs associated with lower percentages of ventilatory threshold and peak oxygen uptake. Both groups were cycling at ~60 ± 15% $VO_{2peak}$ at min 20 when RPE (Borg's category scale) was ~14 ± 2. State anxiety during cycling did not differ between the groups and did not change from pretest levels. However, the active subjects reported a significant reduction in state anxiety immediately after cycling. Our findings indicated that RPE at preferred intensities of exertion can dissociate from indicators of relative exercise intensitytypically linked with RPE during incline- or load-incremented exercise or intensity production tasks. Selection of higher relative intensities by our inactive subjects, despite RPE equal to the active subjects, suggests that reliance on physiological variables for exercise prescriptions, without consideration of RPE, may disregard important behavioral factors, such as anxiety reduction, that may be relevant for exercise adherence.

Morgan (36) reported that nine adult males, with unrecorded activity histories, preferred a mean power output of ~122 W following three, 5-min bouts of cycling at 50 W, 100 W, and 150 W. The mean preferred power output of his subjects is below the mean of the selected power outputs across the first 15 min of cycling for our active subjects (162 W) but comparable to our results for the inactive subjects (130 W). Morgan estimated from prior studies that the power output preferred by his subjects would approximate a category RPE of 11.5 ("neither light nor heavy") on Borg's early 1-20 category scale. The mean RPE for the first 15 min of cycling for our subjects was 12.2, which is between the verbal anchors of "fairly light" and "somewhat hard" on Borg's 6-20 scale.

Purvis and Cureton (44) reported that the % $VO_{2peak}$ of men and women at the ventilatory threshold was about 60 ± 8% with corresponding RPE values ~13 ± 1 and 14 ± 1, respectively. These values are similar to the values we observed for both groups of subjects at the 20th min of cycling. However, the power outputs selected by our inactive subjects were accompanied throughout the cycling bout by minute ventilations approximating 120% ± 10-15% of ventilatory threshold determined from the graded maximal cycling test. The % ventilatory threshold for our active subjects ranged from ~90-110% ± 10%. Future studies should determine the percentage of ventilatory threshold associated with changes in RPE and exertional symptoms including breathlessness (55) or discomfort during prolonged exercise.

**Exertional Symptoms**

Compared with the evidence supporting the accuracy of RPE for estimating and producing exercise intensity, little is known about the usefulness of other subjective responses to exercise for prescribing and monitoring exercise intensity. Self-report scales for angina pectoris and scales for dyspnea are recommended by ACSM (1) and arc commonly used in exercise stress testing. Their measurement properties and application are described elsewhere in this symposium. However, other exertional symptoms that might augment RPE have received little attention during the past 20 yr. Although the studies 1 have reviewed provide some support for using RPE to produce a prescribed exercise intensity, the psychophysical basis for RPE (5), and its empirical support, are most compelling for estimating the subjective intensity of incline- or load-incremented exercise. Few studies haveused velocity-incremented protocols at constant incline or load. Under many circumstances of prolonged exercise of a sustained intensity, RPE is known to uncouple from physiological indices of exertion to a degree not explained by drifts in oxygen consumption, heart rate, or ventilation (e.g., 34). How other subjective responses to prolonged exercise affect RPE or performance are largely unstudied and poorly understood. An early study by Weiser et al. (52) suggested that several clusters or factors could explain variation in subjective responses to exercise by young males immediately following a bout of submaximal cycling at ~55% of $VO_{2peak}$ to voluntary exhaustion (~36 ± 23 min). The factors are depicted in Figure 4.

Bayles et al. (4) applied descriptors from these factors and from temperature sensation and comfort scales to Borg's 6-20 category RPE scale as anchors for subject feedback during three field production trials following treadmill estimation trials at 40%, 60%, and 80% of $HR_{Reserve}$. Practice with or without RPE feedback was associated with small accuracy improvements (~5%) for producing the prescribed pace, but no learning effect for heart rate inaccuracy was observed. The authors reported that during the field trials when subjects were asked to produce the 60% intensity based on the RPE estimation trials, they uniformly selected paces and heart rates representative of the 80% estimation trials. These findings do not support (hat the use of exertional symptoms will augment the accuracy of RPE for estimation and production tasks, but they show that we know very little about how subjective responses to exercise intensity may moderate intensity production or preferred intensities of exertion during field exercise.

**What is Needed?**

There has been little scientific progress in understanding the clinical applications of RPE and other exertionalsymptoms during the past decade (39). I believe the following questions,in addition to returning us to Borg's (5) original conception of RPE as a clinical tool, need to be addressed in the future. We have spent the past decade continuing the search for the physiological mechanisms responsible for RPE and quantifying mean differences between prescribed and produced exercise intensity. More studies of physiological correlates of RPE during incline- or load-incremented protocols arc *not* needed. Figure 5 illustrates my view of more important questions: Who are the outliers? How can we teach them to more accurately estimate and produce a prescribed exercise intensity? What is the impact of RPE errors on inactivity or on risk of injury?

Most studies have used treadmill running or cycling modes at relatively high intensities, but walking, swimming, lifting, climbing, and leisure activities like gardening or yard- and housework at lower intensities have greater relevance for public health. Most studies have examined global (undifferentiated) and differentiated (e.g., chest vs legs) RPE, angina (7), and breathlessness, but many other exertional symptoms (e.g., chronic fatigue, lightheadedness, and soreness) may be equally relevant for understanding the adoption, maintenance, and enjoyment of physical activity.

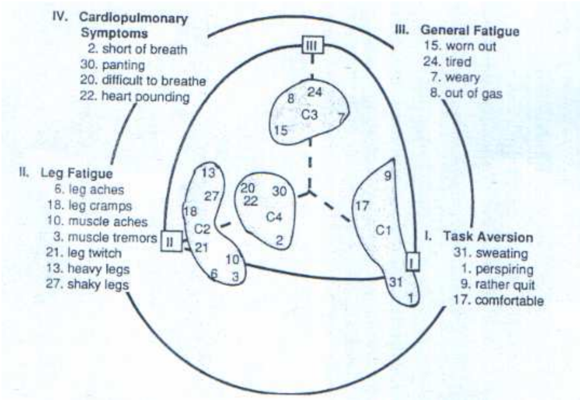


**Figure 4: Spherical Analysis Diagram of four Clusters of Exertional Symptoms at the end of a Cycling bout to Voluntary Exhaustion at ~55% of $VO_{2peat}$. *Note*: From Weiser et al. (52, p. 83), Copyright 1973 by American College of Sports Medicine. Reprinted by Permission.**

The typical approach used has employed Borg's category and category-ratio scales in laboratory or controlled field settings. Similar scales that can be implemented in a population base and validated for community or population use are needed. Most studies have sampled young to middle-aged Caucasian males. More studies are needed that sample females and other race and ethnic groups of differing education levels in different social and cultural contexts. Although RPE has been used extensively with cardiac patients (27), most of the production studies have sampled healthy, active subjects. More studies are needed of inactive children and adults andpersons with diseases such as obesity, respiratory disorders, and chronic fatigue syndrome. Most studies have been limited to RPE estimation during incline or load increments to maximal exertion. However, most field exercise is not incline- or load-incremented and is sub-maximal. More studies are needed using prolonged estimation protocols that increment speed or pace within a narrow range of inclines and loads. More studies of RPE during standardized games and during aquatic activities are needed.

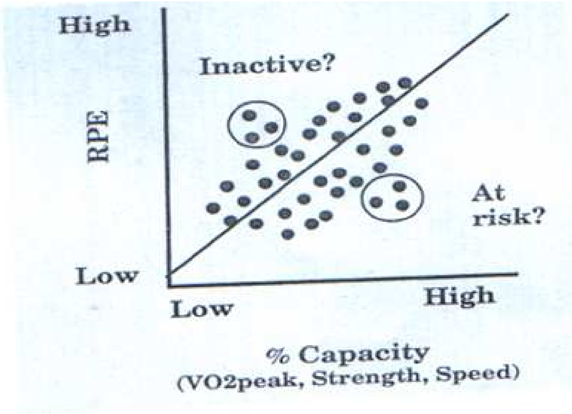


**Figure 5: Hypothetical Depiction of Outlier RPE Responders as a Function of Relative Exercise Intensity. A Focus only on the Group mean Relationship (i.e., the Slope and the Standard error) Obscures Individuals that Respond Atypically in Practically important ways that may Predispose them to Inactivity or Injury.**

More studies are needed at intensities below 60% $VO_{2peak}$, investigating physiological anchors other than % $HR_{Reserve}$, such as relative force, lactate or ventilator break points, and atypical pituitary and adrenal hormone responses. More studies are needed of prolonged sub-maximal physical activities that simulate occupational tasks and leisure activities. More studies are needed of protocols that permit subject selection of preferred intensities of exertion. If a preferred intensity of exertion selected by a person is reliable and is within expectedranges for RPE (e.g., 10-16 on Borg's 6-20 category scale) and relative tolerance for exercise (e.g., 40-75% $VO_{2peak}$ or maximum METs), it should be safe and heal promoting for most healthy adults. A preferred intensity of exercise also may better promote adherence than strict prescription based on more precise physiological criteria if those criteria conflict with a person's intensity preference. Hence, more studies are needed of how RF or exertional symptoms influence the adoption and maintenance of a physically active lifestyle.

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