Validation of the Pictorial Scale of Perceived Exertion for Children

Patrick D. Sells

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ABSTRACT

The purpose of this study was to develop a scale for children ages 6 to 10 years of age to identify various exercise intensities. Cartoon pictures of a person exercising with five numerical levels and verbal descriptors were presented as a visual reference to exercise intensity. Twelve children performed graded maximal exercise testing on a treadmill to establish baseline measures of perceived exertion, peak heart rate and maximal oxygen consumption (VO_2peak). Additionally, the subjects performed three exercise trials of intensity production and three trials of intensity estimation on two subsequent testing sessions.

The primary findings of the children produced three different intensities during production trials when intensity was expressed as VO_2 (17.54, 20.84, and 27.17 $ml \cdot kg^{-1} \cdot min^{-1}$) and %$VO_2$peak (47.4, 56.2, 73.3) at PSPEC 2, 3, and 4. The children exercised at three different intensities expressed as mean heart rates during production trials of 135.1, 142.4, and 158.3 bpm and mean %HRpeak (70.7, 74.6, and 82.9 percent) during the production trials. Estimation trial intensities ($ml \cdot kg^{-1} \cdot min^{-1}$) of 13.1, 18.84, and 27.64 were significantly different

($p < .05$) at PSPEC levels 2, 3, and 4 as were the intensities expressed at %VO2peak (35.3, 50.4, and 74.2 percent). Significantly different ($p < .05$) intensities were also observed when HR and %HRpeak were used to express intensity. The subjects exercised at a mean HR of 123.1, 135.8, and 157.2 bpm and 64.9, 71.1, and 82.3 and HRpeak for PSPEC levels 2, 3, and 4.

The results of the study establish that children between the ages of 6 and 10 years of age were capable of using the Pictorial Scale of Perceived Exertion for Children to produce different intensities during the production trials and to discern between intensities during estimation trials.

DEDICATION

This dissertation is dedicated to my wife, Terri. Her love, support, commitment, and sacrifice made it possible.

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CHAPTER I

Introduction

The application of Borg's (1971) Rating of Perceived Exertion (RPE) Scale has been varied in the past. Borg's scale was designed and used for middle-aged men and is based on the principle that a person can self monitor and evaluate feelings of stress, exertion, and discomfort pertaining to working muscles, joints, and the cardiopulmonary system. Ratings of Perceived Exertion can assist in delivering appropriate levels of exercise and can be used in a wide range of activities. Borg's scale consists of 15 points with verbal anchors progressing from 6 at the lowest level, or light, to 20 at the highest, or very, very, hard level. One of the underlying principles of the Borg scale is that each number on the scale should increase in a linear fashion and correlate with an individual's Heart Rate (HR) (Borg, 1971). Borg's 15-point category rating scale was introduced and developed to increase the linearity between an objective measure of intensity (HR), exercise intensity (power output), and perceptual ratings. Most research regarding the Borg scale involved adults. Lamb (1995) noted that exercise scientists have seldom considered using an alternative scale in adults or children.

Researchers have examined the ability of children to accurately perceive various and changing levels of exertion. As in adults, this relationship has been studied using physiological variables as objective measures of intensity. These variables include heart rate (HR), work output (W), percent of maximal oxygen consumption (%VO_2peak, %VO_2max), and blood lactate levels. There are several issues that have become apparent with research concerning children and RPE. The relationships between physiological variables and perceived exertion have varied in magnitude. Gillach, Sallis, Buono, Patterson, and Nader (1989) incorporated two methods of correlating HR and ratings of perceived exertion (RPE) and reported correlations ranging from $\underline{r}$ = 0.64 to 0.94 among children and Bar-Or (1977) has reported correlations ranging from r = 0.55 to 0.74 between HR and perceived exertion for children. Children have differed from adults when comparing ratings of perceived exertion (Bar-Or, 1977, Gillach et. al., 1989). Children tend to underrate exercise intensity at the same intensity relevant to body weight using the Borg scale compared to adults. A major weakness apparent in the literature is that children's heart rates do not correlate as strongly as adults with RPE values on the Borg scale (Lamb and Eston, 1997).

These aforementioned issues lend strong support for the development of a child specific exertion rating scale. Inconsistencies in research findings exist as to whether or not children over or underestimate ratings and the ratings differ by age groups (Bar-Or, 1977; Gillach, Sallis, Buono, Patterson, and Nader, 1989). Recent efforts have been taken in the direction of scale development for children (Williams, Eston, and Furlong, 1994) with improved results. Nystad, Oseid, and Mellbye (1991) attempted to clarify the intensity dimension of the original Borg scale by replacing its 9 descriptors ("hard", "very hard", "light", etc.) with stick-figures depicting various stages of fatigue. The subjects continued to have difficulty using the Borg scale to monitor their exercise intensity (after the inclusion of the stick figures). Prior to the appearance of the Children's Effort Rating Table (CERT) in 1994 (Williams, Eston, and Furlong), little attention had been directed to the practicality of a RPE scale for children. The CERT scale was developed with fewer responses, a smaller range of numbers and verbal descriptions chosen by children to describe their effort. The verbal descriptors vary from those of Borg (1971) in that the discriptors were selected to identify words children use to describe exertion.

Despite these attempts a recent review by Lamb and Eston (1997) indicates that future research of children and effort perception pay more attention to devising new instruments. This could allow physical educators/health promoters to begin to examine the usefulness of these new instruments in applying perceived exertion with students.

Purpose of the Study

The purpose of the present investigation is to collect validity evidence for the Pictorial Scale of Perceived Exertion for Children (PSPEC). The PSPEC is an effort perception rating scale that incorporates five cartoon pictures. The pictures depict various levels of exercise intensity to aid in the conceptualization and utilization of RPE in children (Appendix B). Physical educators and health professionals concerned with pediatric populations could utilize the scale to monitor and regulate exercise intensity.

Research Hypotheses

1. There is no difference in the mean heart rate and $\%VO_2$ between a production trial and an estimation trial at exercise intensities selected to elicit intensities similar to 35, 50, and 75%.

2. PSPEC ratings will distribute as a positive linear function of heart rate, % HRpeak, VO_2, and $\%VO_2$ to provide evidence of scale validity.
3. Children age 6-10 years will effectively regulate and modify their intensity based on the PSPEC scale.

Delimitations

The following delimitations were applied during this investigation:

1. Subjects selected attended a recreation program for home-schooled elementary age children at the Rutherford County YMCA in Murfreesboro, Tennessee. Additional subjects were recruited through personal acquaintance.

2. Only male and female subjects age 6 - 10 years on the day of the test were selected for the sample.

3. All measurements were made at the human performance laboratory at Middle Tennessee State University located in Murfreesboro, Tennessee.

4. Anthropometric and physiological data to be measured were delimited to height, weight, Body Mass Index (BMI), age, heart rate, VO_2peak, and ratings of perceived exertion.

5. The instructions and familiarization process presented to each subject were standardized in order to hold these variables constant.

Definition of Terms

For the purposes of this investigation, the following definitions will be used:

Anthropometry

The measurement of size, weight, and proportions of the human body. Anthropometry is operationally defined for the purposes of the present investigation as height in centimeters (cm), weight in kilograms (kg), Body Mass Index (BMI), and body composition based on a two-site skinfold measurement.

Maximal Oxygen Uptake *(VO_2peak), (VO_2max)*-

Leger (1996) states that maximal aerobic power corresponds to the maximal exercise intensity that can be sustained in steady state aerobiosis and coincides with a plateau in oxygen consumption level (VO_2) as exercise intensity increases. The plateau ($V0_2$max) is not always seen with children.

Operationally, $V0_2$max will be expressed in terms of the highest $V0_2$ value because it is possible that $V0_2$max is not reached. $V0_2$peak is the terminology that was used to indicate the highest levels of oxygen consumption.

Perceived Exertion

Perceived exertion as defined by Noble & Robertson (1996) is a method to determine the intensity of effort, stress, or discomfort felt during exercise.

Perceived exertion is defined operationally as ratings on the Pictorial Scale of Perceived Exertion for Children (PSPEC) selected during production and estimation trials.

Steady State

Steady state is defined operationally as an unchanging state of a given internal environment, but does not indicate that the internal state is completely normal.

Elementary School Age Children

For the purpose of this research, elementary school age children were defined operationally as boys and girls age 6 to 10 years.

CHAPTER II

Review of Literature

The following review of literature will be divided into three sections. The first section will discuss various issues regarding children and maximal oxygen consumption and exercise testing in children. The second section will address ratings of perceived exertion with regards to the history, development and application of RPE in adults. The final section will discuss the literature regarding ratings of perceived exertion and children

Maximal Oxygen Uptake in Children

The measurement of maximal oxygen uptake (VO_2max) is generally accepted as a highly reliable indicator of cardiorespiratory fitness in adults and children. Maximal oxygen uptake (VO2max) is the highest level of oxygen uptake and utilization an individual can attain. Studies have been conducted to examine VO_2max in children, which could be used as a measure of physiological stress to determine linearity of oxygen consumption and RPE. Noble and Robertson (1996) stated that the perceptual signals associated with VO_2 are mediated by the ventilatory drive used to support the aerobic system. As ventilatory drive increases due to increased aerobic energy requirements associated with exercise, so does the muscle tension involved with respiration. The increase in muscle tension is perceived as a signal of respiratory and metabolic exertion. Ratings of perceived exertion can be correlated with physiological variables, such as %VO_2max or %VO_2peak, to provide evidence that an individual can regulate exercise intensity and identify various levels of physical exertion.

Several indices of maximal effort have been used in research of VO_2max in adults. Among those, a plateau in VO_2 when plotted against work rate has traditionally been used to signify a true maximal effort during progressive, incremental exercise testing. This plateau is not always seen in continuous multistage tests, particularly with children (Armstrong, Williams, Balding, Gentle, & Kirby, 1991; Freedson & Goodman, 1993). The concept of the plateau is based on the supposition that at some point in a maximal exercise test the body's ability to transport and utilize oxygen will be reached. This results in the leveling off of the VO_2 slope when plotted against work rate. In the absence of a plateau, the highest VO_2 value obtained during a graded exercise test is usually referred to as VO_2peak.

Duncan, Mahon, Howe, and Del Corral (1996) indicated that the plateau concept has been challenged in recent years. They investigated the effect of exercise test duration and anaerobic capacity on VO_2max and the occurrence of a VO_2 plateau during treadmill exercise in 25 boys (10.4 ± 0.8 years). Ten of 35 subjects (28%) met the criterion for plateau on one protocol and 35% met the criterion on the other protocol. The difference between VO_2 values in the protocols was not statistically significant. Twelve subjects did not plateau on either protocol. All subjects reached the respiratory quotient (RQ) criteria of ≥ 1.0 or as an indicator of maximal effort. The results of this study lend evidence to the use of VO_2peak as a better indication than a plateau of maximal oxygen consumption in children. Similar results have been published in regards to plateau and non-plateau issues. Fenster, Freedson, Washburn, and Ellison (1989) published data on 18 schoolchildren who underwent maximal testing and 67% of the children demonstrated a plateau.

Armstrong, Welsman, and Winsley (1996) conducted a study to investigate whether a VO_2 plateau is required before VO_2peak can be considered an indication of maximal aerobic fitness in children. Eighteen girls and 17 boys (age 9.9 ± 0.4 years) participated in three treadmill tests to exhaustion administered one week apart. The first test was a discontinuous incremental protocol to voluntary exhaustion. Seven girls (39%) and 6 boys (35%) demonstrated a VO_2 plateau when changes of ≤ 2 ml· $kg^{-1}\cdot min^{-1}$ were evident with increased work loads on the first test, but no significant differences were found in the peak physiological data between those who demonstrated a plateau and those who did not. Mean VO_2peak values during tests two and three did not increase significantly above the level achieved in test one. Therefore, the authors concluded that a plateau does not have to be observed in order to consider VO_2peak as a maximal index of young children's aerobic fitness.

Other factors must also be taken into consideration with children and maximal aerobic performance. As children age and mature there are obvious changes in body mass. Therefore researchers have examined the effect of both body mass and maturation on VO_2peak. If body mass does influence VO_2peak then there is rationale for scaling VO_2peak to accommodate for differences in body size. Armstrong, Welsman, and Kirby (1998) examined the influence of gender and sexual maturation on the VO_2peak of 106 boys and 106 girls, (ages 12.2 ± 0.4 years). Sexual maturity was classified according to Tanner's (1962) indices of pubic hair and VO_2 peak was determined on a treadmill test. They removed the influence of body mass using a log-linear ANCOVA adjustment model. The authors concluded that a significant influence of maturation on VO_2peak of 12 year olds existed independent of body mass. The study also found the boys' VO_2peak was significantly higher ($p < 0.01$) than the girls'.

Welsman, Armstrong, Nevill, Winter, and Kirby (1995) examined the influence of different statistical modeling techniques on the interpretation of VO_2peak in groups of prepuberal children and adult males and females. Absolute VO_2peak increased with age in both males and females, largely reflecting the increase in body mass. They concluded that the data supporting the use of per-body-mass ratios had obscured our understanding of developmental changes in VO_2peak. Their findings are relevant to studies wishing to examine the functional changes in VO_2peak due to changes in body mass and used $ml \cdot kg^{-0.76} \cdot min^{-1}$ to express VO_2peak. However, VO_2peak expressed as $ml \cdot kg^{-1} \cdot min^{-1}$ is still appropriate when studies use VO_2peak to indicate functional capacity as opposed to tracking maturation and changes in performance.

Various research studies have been conducted to provide data representing the aerobic performance of children. Fenster, Freedson, Washburn, and Ellison (1989) tested 18 healthy school children between the ages of 6 and 8 years. A walking treadmill protocol was used and speed was based on the age of the child, coordination, and size. The mean VO_2peak was 44.1 ± 5.6 $ml \cdot kg^{-1} \cdot min^{-1}$ and VO_2peak ranged from 33.9 to 51.4 $ml \cdot kg^{-1} \cdot min^{-1}$. Welsman, Armstrong, Nevill, Winter and Kirby (1995) examined VO_2peak in boys (age 11.1 ± 0.4 years) in the United Kingdom. The boys (n=106) in the study had a mean VO_2peak of 52 ± 6 $ml \cdot kg^{-1} \cdot min^{-1}$ and the girls (n=106) had a mean VO_2peak of 44 ± 5 $ml \cdot kg^{-1} \cdot min^{-1}$. Tolfrey Campbell and Batterham (1998) used a cycle ergometer to test 45 prepubertal children (age 10.5 ± 0.7 years) prior to a 12-week intervention program. The results of the pretest yielded mean VO_2peak data ranging from 39.3 $ml \cdot kg^{-1} \cdot min^{-1}$ in trained girls to 50.7 $ml \cdot kg^{-1} \cdot min^{-1}$ for the boys. These values are comparable in range to the aforementioned studies, regardless of the testing device used (treadmill vs. cycle ergometer).

Similar results in regards to values for VO_2peak were found by Rowland and Boyajian, (1995), and Armstrong, Williams, Balding, Gentle, and Kirby (1991). Further, Armstrong, Williams, Balding, Gentle, and Kirby (1991) indicate that their results are comparable to those of Krahenbuhl et al., 1985 and Bar-Or, 1983. The data from these studies, when examined collectively indicate a range in VO_2peak from about 39 $ml \cdot kg^{-1} \cdot min^{-1}$ to 52 $ml \cdot kg^{-1} \cdot min^{-1}$. The subjects in these studies followed past tendencies in that boys have a progressive rise in VO_2peak from the age of 8 to 16 years when expressed as absolute (L/min) oxygen consumption (Armstrong & Welsman, 1994). Girls have a similar but less consistent trend. From age 8 to 13 years, girls VO_2peak appears to increase with chronological age (Armstrong & Welsman, 1994). When expressed relative to body weight, these differences appear to dissipate (Armstrong & Welsman, 1994). Armstrong and Welsman (1994) report that from age 10 years, male VO_2peak values are greater than those of similarly aged females. Additional data have been reported from children age 4 through 7 years. However, small sample sizes are a common limitation in studies within this population.

Normative data concerning maximal oxygen consumption for children under 8 years of age are limited; however, data have been published. Krahenbuhl, Pangrazi, Stone, Morgan and Williams (1989) reported that 6 to 8-year-old children's (N=80) estimated maximal aerobic power during submaximal running increased with age when expressed as

L/min. As in older children, these differences are not present when VO_2 is expressed relative to body weight. The mean VO_2peak values for 6, 7, and 8-year-olds were 41.8 ± 6.0, 44.0 ± 6.0, and 44.9 ± 7.4 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively. Shuleva, Hunter, Hester, and Dunaway (1990) reported mean VO_2max values for children 3-4 years and 5-6 years. The maximal values for were 44.5 ± 6.7 and 44.1 ± 6.0 $ml \cdot kg^{-1} \cdot min^{-1}$ for 3-4 and 5-6 year-olds. Cureton, Sloniger, Black, McCormick, and Rowe (1996) examined the metabolic determinants of the age-related improvement in 1-mile run/walk performance in boys and girls aged 7-17 and concluded that age-related changes in mile run/walk time should not be used to infer changes in VO_2peak.

Leger (1996) reviewed studies to evaluate the time required to reach steady state in children and recommends 2-minute stages and an overall test duration of between 6 and 12 minutes (Bar-Or, 1993; Rowland, 1993). Leger (1996) states that the unsolved questions concerning the most appropriate method to express VO_2 and VO_2max/VO_2peak seem to increase as research continues. Leger states that individual researchers need to be cognizant of these issues and select the tests, protocols, and units of expression that are best suited for the intent of their investigations.

Ratings of Perceived Exertion

A wide range of research has been conducted pertaining to perceived exertion. Noble and Robertson (1996) indicated that over 450 articles have been published on a variety of topics related to RPE over the past 25 years. Early research studies predominantly explored the relationship between perceived exertion and physiological variables. More recent research has focused on psychological factors that play a role in exertional ratings and on the accuracy of perceived exertion as a method of prescribing and controlling exercise intensity (Noble & Robertson, 1996). Throughout the history of perceived exertion, clinical applications in various medical settings and conditions have been a frequent research topic in the literature.

The perception of physical exertion deals with both physiological and psychological variables. Practical applications of perceived exertion related to exercise require an individual to report a subjective rating of effort using a numerical scale. The ratings reported are based on perceptions of both types of variables. Noble and Robertson (1996) stated that many scientists and laypersons take issue with the validity and objectivity of a measurement of subjective human response. The central issue relates to the ability to assign a qualitative measure on a scale to a subjective judgement. However, individuals routinely experience sensory stimulation such as temperature and muscular discomfort and these sensations can then be interpreted in one form or another. This interpretation of specific stimuli (changing exercise intensity) is commonly referred to as perception. The ability to measure the changes in discomfort associated with exercise has been studied by classical psychophysicists (Noble & Robertson, 1996). In order to make the required measurements of effort during studies, a scale was needed that described a range of senses. Psychophysicists developed scales with both beginning and end points and referred to these as thresholds. Variables were then studied in relation to achieving a threshold value. These scaling methods refer to the application of numbers to differentiate among events or objects, often associated with exercise intensity.

One method of psychophysical measurement is the method of magnitude estimation where the subject is presented with stimuli (changes in exercise intensity) and asked to assign a numerical value to describe the perceived magnitude of the stimulus. This technique allows the establishment of equal intervals, but does not assure interval level data between numbers with the presence of an absolute zero. These intervals could be ordinal regardless of the ratings on the scale having equal intervals (Noble & Robertson, 1996).

Numeric scales have been developed to allow people to rate their perceptions of exertion. The Borg 6 - 20 Rating of Perceived Exertion Scale (Borg, 1985) is considered to be the most well known and widely used measure of perceived exertion. Borg's scale was designed and used for middle-aged men and is based on the principle that a person can self-monitor and evaluate feelings of stress, effort, and discomfort pertaining to working muscles, joints, and the cardiopulmonary system. During exercise, an individual can assess his/her exertion relative to the numerical scale. This self-monitoring is commonly used to prescribe exercise in a clinical setting as well as regulate exercise intensity during exercise in non-clinical environments. Due to the influence of various drugs used by cardiac patients on the heart rate response to exercise, RPE can be used to prescribe exercise intensity. The perceptually based exercise prescription is determined by plotting RPE against VO_2 responses obtained during a graded exercise test. The RPE equivalent to the prescribed percentage of VO_2max is determined and exercise intensity is adjusted until the target RPE is produced (Noble & Robertson, 1996).

The initial scales developed by Borg evaluated the perception of exertion based on ratio scaling and revealed several methodological problems. Noble and Robertson (1996) indicated the importance of some specific aspects concerning the construction of the Borg scale. Borg rationalized that a perceptual scale with rating results closely aligned with heart rate would provide support for perceived exertion as a subjective indicator of physical strain (Noble and Robertson, 1996).

Borg originally constructed a 21-point graded scale with the objective being to align perceived exertion and pulse rate so that "the heart rate of a normal, healthy middle-aged man can be predicted if the RPE value is multiplied by 10; thus, RPE X 10 = HR" (Borg, 1971). However, this 21-point scale did not establish a linear relationship with pulse rate. In the early 1970s a 15 point category rating scale was introduced by Borg; the scale was developed to increase the linearity between an objective measure of intensity (HR), exercise intensity (power output), and perceptual ratings. The values on the scale were assigned verbal descriptors such as "no exertion at all" for a value of 6 or "maximal exertion" for a 20. Pandolf (1990) stated that the relationship to be expected from the Borg scale is a HR during exercise similar to 10 times the RPE value. Many studies have examined the linear relationship between RPE and HR with the 15-point scale, regardless of the fact that the prediction equation has not proven accurate (Noble & Robertson, 1996). However, the scale is applicable to prescribe exercise even though it can not be used to predict HR.

Ratings of perceived exertion can assist in delivering appropriate levels of exercise and can be used in a wide range of activities. The RPE scales (Borg, 1971; Borg, 1985) have been used extensively in exercise physiology laboratories, cardiac rehabilitation, health clubs and fitness centers. Most studies of RPE and scale development have excluded application of the Borg scale or alternative scales to children (Lamb and Eston, 1997). However, the need for additional scales warrant investigation, and if children could apply a rating scale devised for them, they could benefit from the same uses as adults.

Effort Perception in Children

The extensive use of RPE in adults has led to suprisingly limited research and use with children. Suggestions for a child specific effort rating scale would have to be preceded by examining the various physiological indicators of exercise intensity in children. Various studies have addressed this issue by investigating HR, oxygen uptake, (VO_2peak/VO_2max), ventilatory drive, blood lactate, and blood pressure. Lamb and Eston (1997) provide a historical perspective in a review article based on effort perception and children. In 1997, Lamb and Eston indicated that 7 articles had been published since 1990 dealing with the ability of children to apply ratings of perceived exertion effectively. Most of these studies involving children required subjects to use effort perception to regulate exercise intensity. This is commonly considered to be the production mode of perceived exertion and requires subjects to adjust the exercise load to match various experimenter set RPE values. These values are typically presented in a random order to the participants.

Bar-Or (1977) presented the first data concerning children's perception of exercise effort. Data were collected to represent the subjects RPE during continuous, incremental cycle ergometry. Results revealed that children in different age groups reported higher RPE's in relation to increased workloads. This was accomplished by charting RPE against heart rate (HR). The study also reported that children gave lower ratings of effort than adults at the same relative intensity. The one exception was found in the 7- to 9-year-olds; this group tended to overestimate exertion. Another study that used HR as a physiological variable to examine the relationship between objective measures of intensity and ratings of perceived exertion in children and adults was that of Gillach, Sallis, Buono, Patterson, and Nader (1989). Their reported findings are similar to those of Bar-Or (1977) in that both children and adults were able to distinguish physiological changes using RPE.

Gillach et al. (1989) tested 193 children (mean age = 11 years) and 188 adults (mean age = 36 years) to examine the relationship between children and adults and effort perception. The authors concluded children in this age group were as capable as adults in expressing RPE and that the absolute levels of RPE were not predictive of physiological strain as indicated by HR. A range of over 40 to 100 bpm was observed during the association of RPE to HR in both children and adults in this study. A range of this magnitude would have no predictive value in exercise prescription of clinical settings.

Ward, Jackman, and Galiano (1991) conducted a study to compare children ages 8-14 years (n = 17) to adults (n =

19) in their ability to execute various levels of exertion using the Borg 6 - 20 RPE scale and HR. Subjects were required to pedal at a controlled pace on a cycle ergometer or travel one 400m lap on a track at four RPE levels: 7, 10, 13, and 16. Reported results indicated that children were similar to adults by reproducing four incremental cycling intensities. The walk/run task results indicate that both groups overexerted compared to the criterion. Furthermore, children could only discriminate RPE 7 from other levels. The authors recommended that exercise prescriptions for children using self-paced intensity should be preceded by practice and that various modes of exercise be considered. The recommendation for practice was not supported by statistical analysis.

Gillach et al. (1989) make a convincing argument about the statistical analyses used in many studies attempting to validate a physiological response against RPE. Computing correlations for each individual's data and then taking the group mean produced very high correlations, ranging from 0.92 to 0.95. However, when correlating HR and RPE for the entire group at all powers simultaneously produced correlations ranging from 0.63 to 0.65. Lamb's (1995) data support that of Gillach et al. (1989) by showing that correlations calculated on all participant's data simultaneously reduced the validity of children's effort perceptions and makes the data look less meaningful. This information lends support to the need to develop a child specific effort rating scale.

A 1994 study of children's perception of exercise effort produced two papers concerned with the validity of a rating scale designed for use with children. The appearance of the Children's Effort Rating Table (CERT) (Williams, Eston, and Furling, 1994) was the first to attempt to establish the suitability of the RPE scale for children. The CERT scale consists of 10 points (ranging from 1 to 10) with verbal anchors deemed more appropriate for children than those of Borg. The verbal descriptors ranged from "Very, Very Easy" at level 1 to "Starting to Get Hard" at level 5 to " So Hard I am Going to Stop" at level 10. Williams et al. (1994) used a bench stepping protocol as the mode of exercise in the first attempt to validate the CERT. This application produced near perfect correlations ($\underline{r}$ = 0.99) between exertion level and HR among 8 to 9 year-old girls. A lower yet acceptable correlation ($\underline{r}$ = 0.73) was observed for 6 to 7 year-olds. The authors acknowledge that low and narrow ranges of intensity between approximately 70 to 80 % of HRmax (HR = 149 to 171 bpm) may have caused these correlations to be deceptively high.

A study by Lamb (1995) produced findings that are perhaps more credible. Children exercised over a broader range of HRs (107 to 210 bpm) and workloads (10 to 125W). Observed correlations between perceived exertion and objective effort ranged from moderate (r = 0.69) to moderately high (r = 0.80). Lamb (1997) states that when CERT is compared to Borg's RPE scale, the validity of CERT was an improvement. Additionally, Lamb states that any consideration of validity and reliability among children be accompanied by a regard for their ability to understand the chosen scale.

Reliability evidence also exists for CERT. Lamb (1995) used an intraclass correlation coefficient obtained from repeated measures analysis of variance. According to Lamb and Eston (1997) these findings are more credible than those using the interclass Pearson correlation. In his study of 9 - to 10 - year olds, the overall 7 day r value for RPE during cycle ergometry was 0.90, and 0.70 to 0.90 for specific intensities. Since the CERT scale was found to be reliable, (r = 0.91), Lamb concluded that under the stipulated conditions children could use their perceptions of effort to estimate actual physiological effort. This aspect is very important to establish if RPE is to be used effectively in the prescription of exercise in children.

Eston et. al. (1994) concluded that the CERT is a valid indicator of physiological effort during cycle ergometry, based on their study. The children ages 8 - 11 years were successful in perceiving experimenter applied changes in exercise intensity and reliably regulating their efforts. This ability to regulate effort was accompanied by a general underestimation of intensity. The objective effort produced at CERT levels 5, 7, and 9 were 13 to 18% lower than expected. This underestimation does not reflect the same findings of Ward and Bar-Or's 1990 study of overweight children (ages 9 to 15 years). Ward and Bar-Or's subjects overestimated efforts at low intensities and underestimated efforts at the highest intensity of the Borg Scale.

Recent data involving CERT in an exploratory study with children ages 4 to 8 years (Williams, Furlong, Hockley, & Mackintosh, 1993) provided additional insight. The subjects in this study were generally unable to regulate their efforts accurately during an incremental stepping task. The authors suggest that this may be due to children having little experience with exercise at various intensities. Discrepancies in estimation and varied exercise intensities indicate the need for further investigation using CERT in various populations.

At least one attempt has been made to assist children in their comprehension of RPE, although CERT was not used in the study. Nystad, Oseid, and Mellbye (1991) were the first to attempt to enhance their subjects' understanding of the Borg RPE scale by using stick figures depicting varying degrees of effort. According to Lamb (1997), no other researchers have attempted to do this. Results of the study did not indicate that the stick figures aided in the conceptualization of the Borg scale. However, the focus of the study was not intended to test the effectiveness of the scale with figures compared to a control. Subjects within the study had difficulties in using the scale to accurately assess their exercise intensity levels. The subjects had a tendency to perceive their exertion at levels higher than indicated by actual HR.

Robertson et al. (2000), presented evidence that children may choose words other than those on the Borg scale to describe intensity. "Tired" was chosen as the root word used with the recently proposed OMNI scale. In their study, Robertson et al. determined from 1582 verbal expressions that the word "tired" appeared 475 times in the primary descriptor pool. Robertson also indicated that the words "light" and "hard" (used on the Borg scale) were not chosen as the root words for the OMNI scale because the word "light' was not used by the children in the study and "hard" was used only 89 times.

Summary

Due to the research conducted regarding children's perception of physical effort, present levels of understanding are low. As indicated in the literature review, no concurrence exists on methodologies. This inconsistency, along with debates on the proper statistical analysis, makes interpretation of validity and reliability evidence confusing. Eston et al. (1994) indicated that the attempt to use effort perception scales in children is complicated in many regards. Young children have little experience with various exercise intensities; therefore, these children have an inability to exercise beyond brief, vigorous bouts. Lamb and Eston (1997) drew similar conclusions. They indicated that variables such as habituation, gender, activity level, maturity, and reading ability might influence children's effort perception and use of rating scales. Debate also exists on which physiological measure is best suited for testing and validating RPE's in children. Studies have primarily used HR and VO_2 as objective measures of effort.

Nystad et al. (1991) attempted to address children's comprehension of the Borg scale using stick figures. This is the only attempt of this nature (using pictures or art work) revealed in the current search of literature. Lamb and Eston (1997) indicated the need for more research to refine existing scales or to devise new instruments for the pediatric population.

Chapter III

Methods

Scale Development

The Pictorial Scale of Perceived Exertion for Children (PSPEC) was developed to provide professionals with a perceived exertion scale for use with children. The PSPEC scale was designed with fewer responses than previous scales, (i.e., 1 to 5) and incorporates cartoon pictures to depict various levels of exercise intensity (Appendix A). Five pictures were developed to illustrate an individual engaging in various levels of activity. The pictures focus on increasing amounts of perspiration, changes in complexion, and facial expression as visual cues to depict increasing intensity. The pictures were purposely designed without the presence of a specific modality, such as a bicycle, to increase the applicability of the scale to various modalities.

A pilot study was conducted to determine if elementary school age children could recognize the different intensities depicted in the pictures of the PSPEC. The students (N=20) were asked to rank the pictures from lowest to highest based on how tired they felt the person in each picture felt. The students were able to rank the pictures appropriately. Eighty-nine (89) percent of the students correctly labeled picture one, 74% correctly labeled pictures 2 and 4, 95% correctly labeled picture 3, and all students correctly labeled picture 5. This study supports that children between the ages of 6-10 could cognitively differentiate levels of tiredness from the PSPEC pictures.

The PSPEC incorporates verbal and numerical descriptors at all five points on the scale. The verbal descriptors used for the PSPEC were based on Robertson's (2000) OMNI scale. The descriptor ("Not tired at all" was assigned to the first picture. The descriptors "Getting more tired" and "Tired" were used for pictures two and three. "Really tired" and "Very, very tired" were assigned to pictures four and five, respectively.)

Familiarization Procedures

Due the unfamiliarity of the subjects with a laboratory setting and exercise testing, testing session one (TS1) began with procedures designed to make the subjects more comfortable in the environment. Instruments used in the study were explained and demonstrated to each subject in a manner that was age appropriate. Children were encouraged to ask questions and parents were encouraged to attend the familiarization and testing sessions. Each subject and his/her parents were provided with photographs of children being weighed, having skinfold measurements taken, and wearing the facemask used for metabolic testing during the familiarization process.

Subjects

Subjects consisted of 12 elementary school age students (7 male, 5 female) 6-10 years of age who attend recreational services at the Rutherford County YMCA in Murfreesboro, Tennessee and by convenience sampling. Table 1 (page 39) lists demographic data for the subjects. Subjects and parents/guardians were required to complete and return an informed consent (Appendix C and D) and were encouraged to seek further information regarding the study from the principal investigator. The proposed study was submitted for full review by the Institutional Review Board of Middle Tennessee State University (Appendix A) and all stated regulations and guidelines were followed. All subjects who agreed to participate in the study were allowed to, unless contraindications to exercise testing according to the guidelines set forth by the American College of Sports Medicine (ACSM, 1998) were present. No subjects were excluded based on contraindications. All potential subjects (parents) completed a health screening questionnaire (Appendix E) prior to participation in the study.

Anthropometric Measurements

Anthropometric data were collected during the initial testing session (TS1). Body composition was assessed using a two-site skinfold measurement (Slaughter, Lohman, and Boileau, Horswill, Stillman, Van Loan & Bemben, 1988). Skinfold site locations measured included the triceps and calf for boys and girls. Skinfolds were measured using a Lange caliper and were recorded in millimeters. Height in centimeters (cm) was measured using a Health-o-Meter stadiometer and weight in kilograms (kg) was measured using a Health-o-Meter weight scale (#400 DFK: Continental Scale Corp., Chicago, IL). Lean body mass and fat weight were expressed in kilograms and body composition was reported as a percentage of fat.

Testing Procedures

Each subject was tested on three separate occasions in the Human Performance Laboratory at Middle Tennessee State University. Prior to the initial testing session, subjects were provided with pre-test instructions. At the initial testing session (TS1) all subjects performed a maximal graded exercise test. Physiological data were collected and analyzed using a MedGraphics CPX/D Metabolic Measurement Cart in conjunction with a Quinton Q4000 electrocardiograph (ECG) monitor and Quinton Q55 treadmill.

Oxygen consumption was assessed using breath by breath spirometry and a Vacumed facemask with an adapter for the preVent pneumotach.

During TS1, the familiarization process was followed by the collection of anthropometric data. Verbal instructions were then given to each subject explaining all procedures. The PSPEC was discussed and explained to each subject prior to testing. The relation between the pictures on the scale and how tired the character appears to feel was the focus of the ratings of perceived exertion discussion. The facemask for the metabolic cart was then explained and fitted to the subject. The subject was informed that the test could and would be terminated when the subject indicated he/she had reached maximal effort. The subject was instructed to end the test by placing both hands on the forward support bar of the treadmill.

Baseline data were collected during a three-minute period prior to testing. During this three-minute period subjects sat in a chair adjacent to the treadmill and resting oxygen consumption was measured. Heart rate was monitored (ECG) and recorded upon placement in the chair and during the last 30 seconds of rest. During the last minute of the preliminary measurement time, subjects were shown the PSPEC and were instructed that they felt "not tired at all" while sitting in the chair and that "picture 1" on the PSPEC showed how tired they felt. The subjects were instructed to stand on the treadmill with their feet at each side of the belt. The belt was started at 1.0 MPH and 0 % grade and the subjects were instructed to begin walking on the treadmill. The subjects were allowed to walk at this pace for a brief period in order to establish stability, balance and a natural gait. Once these criteria were met, the testing session began immediately.

A treadmill protocol was utilized and is generally preferred to a cycle ergometer due to the greater attention span required for the cycle and children may have underdeveloped knee extensor muscle mass (ACSM, 1995). The protocol was as follows: the initial grade of the treadmill was set at 5% and was increased 2% every three minutes, speed remained constant at 2.0 miles per hour (MPH) this allowed the children to adapt easily to stage changes by not requiring a change in walking speed. All efforts that produced respiratory quotients above 1.0 were considered maximal efforts (Leger, as cited in Docherty, 1996).

When subjects reached a maximal effort and indicated they were ready to stop, the PSPEC scale was presented. Each subject was instructed that he/she felt "very, very tired" and were instructed that "picture five" was how tired he/she felt. At the termination of the exercise test, HR response was monitored via ECG while the subject engaged in an active recovery period of three to six minutes. Prior to leaving the facility, the subjects were given written documentation detailing the next scheduled testing session and a brief review of the PSPEC scale. Subsequent testing sessions were held at approximately the same time of day as the initial session.

The second testing session (TS2) and third testing session (TS3) were assigned in a counter-balanced fashion. One session used production trials (PT) and one an estimation trials (ET). During the ET each subject was randomly assigned three different exercise intensities that represented 35, 50, and 75 %VO_2peak attained during the maximal test of TS1. Each period of the discontinuous protocol was separated by a three-four minute period of recovery in which the subject was allowed to rest. Once each subject attained a VO_2 within 1.5 ml.kg.min^{-1} of the targeted intensity, the PSPEC was presented and a rating was indicated by the subject placing his/her finger on the desired picture. The ratings were taken in the same manner during all three bouts of the ET. The oxygen consumption values were then recorded based on 30 second averages. Total exercise time was noted to facilitate identification of HRpeak from recorded data. After recovering from TS2 the subject briefly reviewed the session and was informed of his/her scheduled time for test session 3 (TS3).

The PT included the random assignment of three exercise intensities depicted on the PSPEC scale (pictures 2, 3, and 4). Each subject was allowed to manipulate the speed and grade of the treadmill to the level that he/she felt elicited the assigned intensity from the PSPEC scale. This was accomplished by asking the subject if he/she needed to exercise harder or easier to feel as tired as the selected picture. The grade and/or speed of the treadmill was adjusted by the investigator according to the subject's request. This adjustment required some subjective interpretation of the subject's response. Initial treadmill speed and grade was constant for all three production trials. The grade was 5% and speed was 2.5 mph. Once the treadmill was adjusted, the subject was allowed to continue walking for one minute and given an opportunity to readjust the speed and/or grade. Once the subject indicated he/she was at the appropriate intensity the subject continued to walk and metabolic data were monitored to assess attainment of steady state. Once steady state criteria was met, physiological and PSPEC data were recorded, the treadmill was stopped and subject was moved to the down time activity area. Following the recovery period the same procedures were repeated for the second and third exercise bout of the PT.

Data analysis

All data analysis was conducted using SPSS (V9.0) statistical package. Means and standard deviations were calculated for the following: age, height, weight, body fat percentage, VO_2peak, maximal heart rate, %of VO_2peak and % of HRpeak. A repeated measures ANOVA was used to test for main effects for estimation and production trials. Paired comparisons t-tests (Bonferroni) were used to determine where significant differences occurred within production and estimation trials at three levels of the exercise intensity. Statistical data are presented in Tables 3 - 8 in Appendix F (page 69-71).

Chapter IV

Results

Subjects

The physical characteristics of all subjects are presented in Table 1. Males (n = 7) and females (n = 5) are combined as a total sample group.

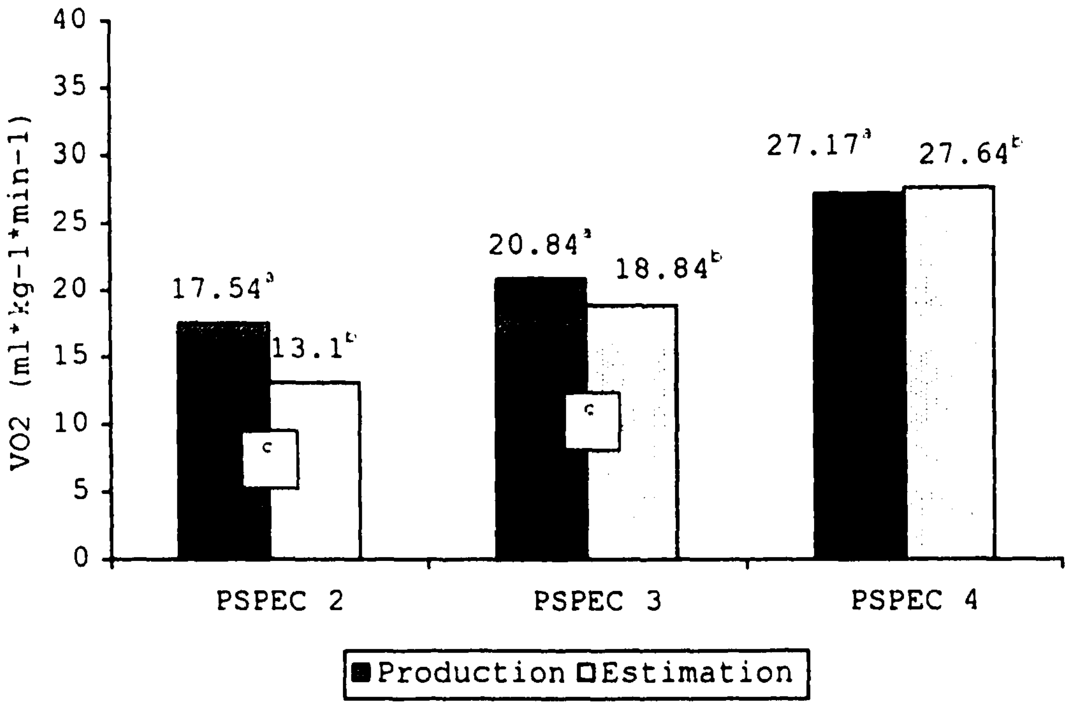
Table 1. Subject Characteristics.

Variable	Min	Max	M	SD
Age	6.0	10.0	7.8	1.64
Height (cm)	113.0	153.0	132.7	10.27
Weight (kg)	21.4	41.8	30.8	6.06
Percent Body Fat	12.8	34.1	21.6	5.33
VO_2peak ($ml*kg^{-1}*min^{-1}$)	25.7	59.0	37.5	8.60
Heart Rate peak	153.0	208.0	191.8	15.25

The VO_2 values for the three production and estimation trials are presented in Figure 1 and 2.

Figure 1.

Mean VO_2 for Production and Estimation Trial Intensities at PSPEC Levels 2, 3, and 4.

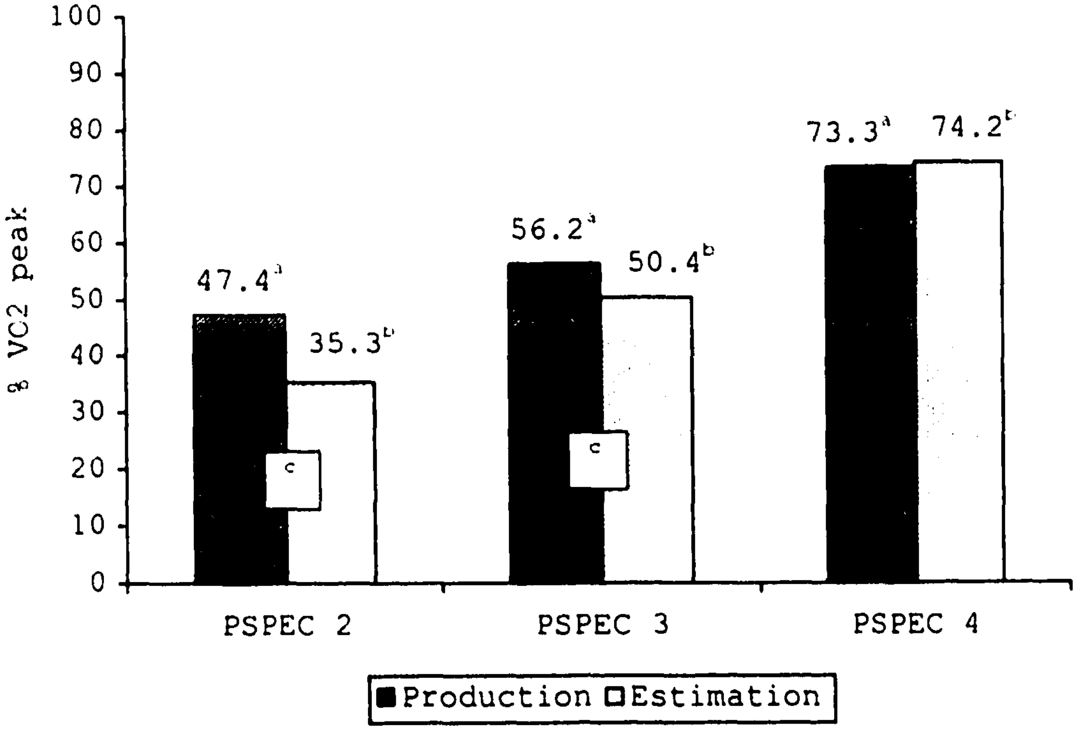


[a] Indicates a significant difference ($p < .05$) between the production intensities (VO_2) at PSPEC levels 2, 3, and 4.
[b] Indicates a significant difference ($p < .05$) between the estimation intensities (VO_2) at PSPEC levels 2, 3, and 4.
[c] Indicates a significant difference ($p < .05$) between production and estimation intensities at PSPEC levels 2, 3, and 4.

The production and estimation trial intensities expressed as a percentage of VO_2peak are illustrated in Figure 2.

Figure 2.

Fractional Utilization of VO_2 for Production and Estimation Trials.

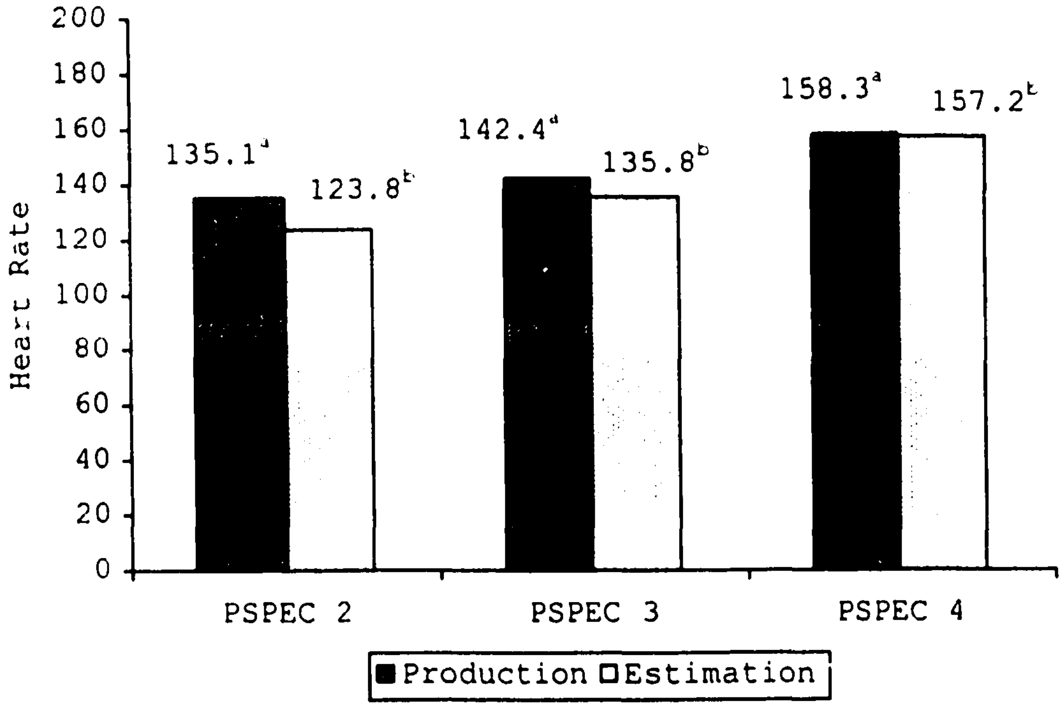


[a] Indicates significant ($p < .05$) difference of intensity (% of VO2peak) between production trials at PSPEC levels 2, 3, and 4.
[b] Indicates significant ($p < .05$) difference of intensity (% of VO2peak) between estimation trials at PSPEC levels 2, 3, and 4.
[c] Indicates a significant ($p < .05$) difference of intensity (% of VO2peak) between production and estimation trials at PSPEC levels 2, and 3.

The mean production and estimation trial heart rates are illustrated in Figure 3. Significant differences are noted where appropriate.

Figure 3.

Mean Heart Rates for Production and Estimation Trials.

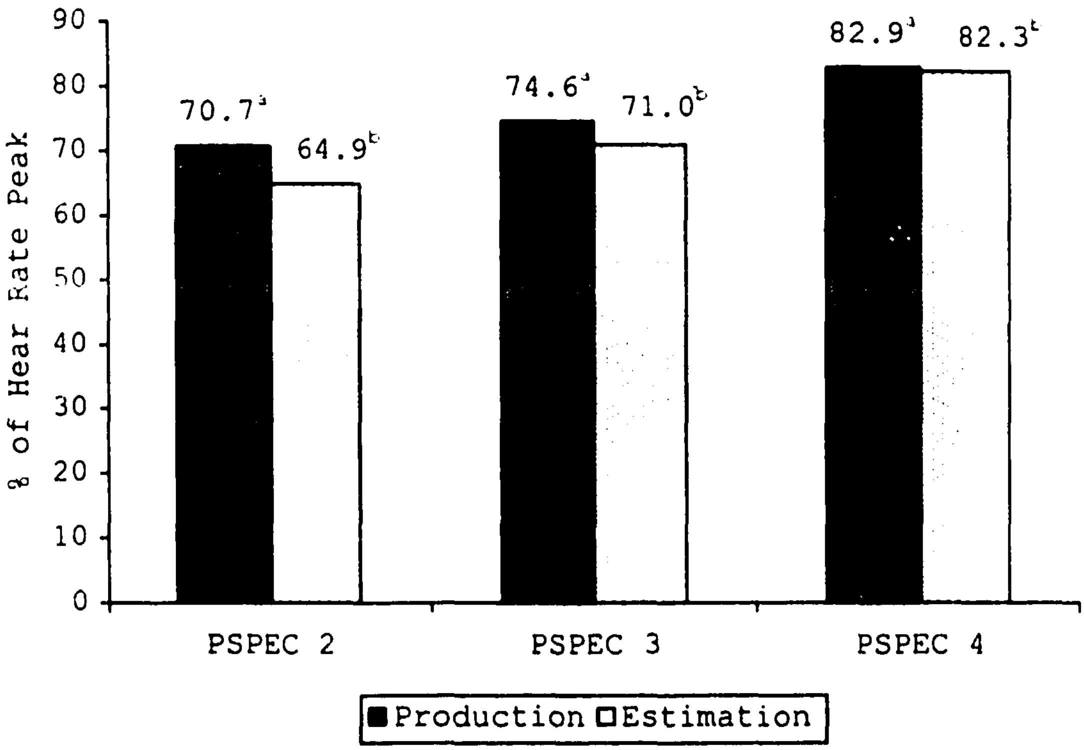


[a] Indicates significant ($p < .05$) difference of intensity (HR) between production trials at PSPEC levels 2, 3, and 4.
[b] Indicates significant ($p < .05$) difference of intensity (HR) between estimation trials at PSPEC levels 2, 3, and 4.

The production and estimation trial intensities expressed as a percentage of heart rate peak are illustrated in Figure 4.

Figure 4.

%HRpeak (bpm) for Production and Estimation Trials.

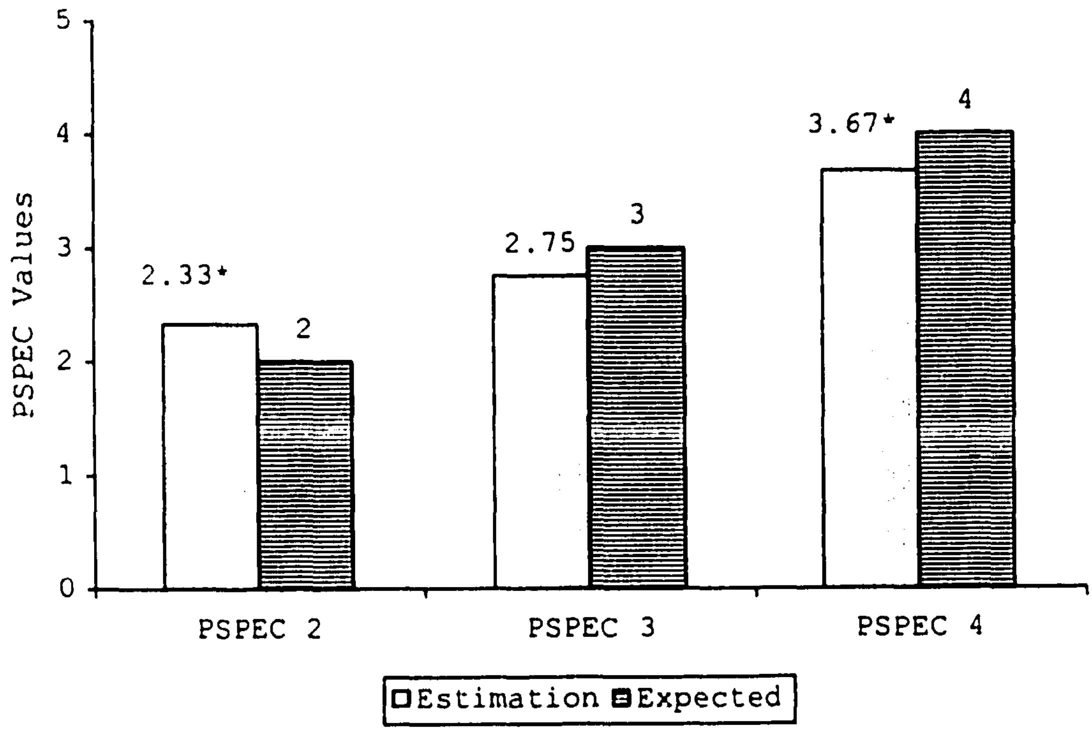


[a] Indicates significant ($p < .05$) difference of intensity (%HRpeak) between production trials at PSPEC levels 2, 3, and 4.
[b] Indicates significant ($p < .05$) difference of intensity (%HRpeak) between estimation trials at PSPEC levels 2, 3, and 4.

The mean PSPEC rating during estimation trials compared to the expected PSPEC values are illustrated in Figure 5.

Figure 5.

Estimation Trial PSPEC Scale Ratings and Expected Ratings.



* Indicates significant difference (p < .05).

Table 2.

Percentage of Expected Responses During Estimation Trials at PSPEC Levels 2, 3, and 4.

Estimation Trial	Unexpected Choice	Expected Choice	% Expected Choice
PSPEC 2	4	8	67
PSPEC 3	5	7	59
PSPEC 4	4	8	67

Chapter V

Discussion

The purpose of the present study was to validate the PSPEC scale. The validity of the PSPEC was examined by comparing physiological indications of intensity (VO_2peak, %VO_2peak, HR, and % HRpeak) at three randomly assigned levels of intensity for both production and estimation modes using the Pictorial Scale of Perceived Exertion for Children (PSPEC).

The first step in establishing the validity of the PSPEC was to examine the subject's ability to use the scale to regulate exercise intensity. This was accomplished by asking the subject to exercise at an intensity that he/she felt was appropriate for PSPEC levels 2 ("getting more tired"), 3 ("tired"), and 4 ("very tired"). Pictures 1 and 5 on the PSPEC scale were labeled with "Not tired at all" and "Very, very tired, respectively. The production of a different intensity at each level of the PSPEC would provide evidence that the children in the study could use the scale to produce varying exercise intensities. The mean VO_2 at each of the three trials during both production and estimation were compared using a paired comparisons *t*-test. The present study establishes that children (n=12) between the ages of 6 and 10 years of age (7.83 ± 1.64) were capable of using the PSPEC scale to produce different intensities during the production trials and could discern between intensities during estimation trials.

As illustrated in Figure 1 (page 40), the mean VO_2 relative to body weight ($ml \cdot kg^{-1} \cdot min^{-1}$) at PSPEC 2 for production trials was significantly different ($p < .05$) from the mean VO_2 at both PSPEC 3 and PSPEC 4. This difference remains significant when examining all combinations of paired comparisons. The Mean VO_2 increased from PSPEC 2 to 3 and continued this pattern from PSPEC 3 to 4. To further investigate the validity of the PSPEC, exercise intensities from production and estimation trials were also expressed as a percentage of VO_2peak. Figure 2 (page 41) illustrates that production trial intensities remain significantly different ($p < .05$) from one another when expressed using fractional utilization. The subjects in the present study produced different intensities using the PSPEC scale. These results differ from those reported for the CERT scale. Williams, Eston, and Furlong (1994) concluded that subjects in Grades 1 to 3 were generally unable to regulate effort accurately when attempting to produce two levels of intensity as requested. Based on the present results, the PSPEC appears to be an improvement in this regard.

The subjects exercised at an intensity of 47.4% of VO_2peak at PSPEC 2, 56.2% at PSPEC 3, and 73.39% at PSPEC level 4. These intensities indicate that the subjects produced intensities higher than expected (35% VO_2peak, 50% VO_2peak) at the lower levels of the PSPEC (2 and 3) but were close to the target intensity of 75% VO_2 peak at PSPEC 4.

The estimation trial data also indicate that the subjects exercised at three different intensities when examining oxygen consumption relative to body weight ($ml \cdot kg^{-1} \cdot min^{-1}$). Figure 1 (page 40) illustrates the mean VO_2 at each of the estimation trial levels as well as indicating that all three intensities are significantly different from one another. Estimation trial data for oxygen consumption expressed as fractional utilization are illustrated in Figure 2 (page 41). As in the production mode, all intensities remain significantly different whether expressed relative to body weight ($ml \cdot kg^{-1} \cdot min^{-1}$) or as a percentage of peak.

Previous research concerning children and RPE have reported using heart rates to indicate intensity. The subjects in the present investigation produced significantly different HR's at PSPEC levels 2, 3, and 4 in both production and estimation trials. Figure 3 (page 42) indicates that the mean heart rate (bpm) at PSPEC 2, 3, and 4 were 135.1, 142.4, and 158.3. These heart rates represent 70.2%, 74.6%, and 82.9% of HRpeak at PSPEC levels 2, 3, and 4. These data also indicate that the subjects exercised at higher than anticipated intensities during production trials when %HRpeak is the indication of intensity. The exercise intensities remain significantly different regardless of the method of expression (absolute HR or % of HRpeak). Heart rates from the estimation trials for PSPEC levels 2, 3, and 4 were 123.8, 135.8, and 157.3 bpm. These heart rates represent 64.85, 71.04, and 82.34 percent of HRpeak. Statistical tables are provided for all figures in Appendix F (page 69).

The findings of the present study are comparable to previous studies concerned with children's ability to produce different intensities using a perceived exertion scale. Bar-Or (1977) revealed that children in different age groups reported higher RPE in relation to increased workloads using a cycle ergometer. While using the Borg scale, Gillach, et al. (1989) tested 193 children (mean age = 11 years) and concluded that children were able to distinguish physiological changes using RPE. Ward, Jackman, and Galiano (1991) conducted a study to compare children ages 8-14 years to adults in their ability to execute various levels of exertion using the Borg 6 - 20 RPE scale and HR. The authors concluded that children were similar to adults by reproducing four incremental cycling intensities.

While most of the aforementioned studies did not involve child specific scales, the Children's Effort Rating Table of Williams et al. (1994) did use child specific scales. A bench stepping protocol was used as the mode of exercise in the first attempt to validate the CERT. This application produced near perfect correlations (r = 0.99) between exertion level and HR among 8 to 9 year Old girls. A lower yet acceptable correlation (r = 0.73) was observed for 6 to 7 year-olds. The authors acknowledge that low and narrow ranges of intensity between approximately 70 to 80% of HRmax (HR = 149 to 171 bpm) may have caused these correlations to be deceptively high. The present study found a similar occurrence. A range of HR intensity (70 - 82%) and a similar range of heart rate (135 - 158) occurred. Therefore, correlations were not used in the present study for this purpose.

The results of the t-test using PSPEC appear to validate the scale. Subjects in the present study were able to use the PSPEC scale to produce and report various intensities when using HR as the physiological measure of intensity. This evidence is reported in Figure 3 (page 42) and Figure 4 (page 43) for production and estimation trials.

When examined independently, physiological data from production and estimation trials indicate that children are able to use the PSPEC to regulate and identify different intensities. This leads to an examination of the consistency of data collected during these modes (production and estimation). If the PSPEC is a valid and reliable instrument, logic would suggest that the intensities produced across modes at each level would be similar. One would expect the VO_2 at PSPEC 2 in production to be the same as the VO_2 at PSPEC 2 in estimation. This assumption does not appear to be met in the present investigation. When comparing oxygen consumption values at PSPEC levels 2, 3, and 4 some interesting results are noted. Figure 1 (page 40) illustrates that the subjects produced significantly different intensities ($ml \cdot kg^{-1} \cdot min^{-1}$) at PSPEC levels 2 and 3 when comparing production and estimation trials. However, there was no significant difference at the highest intensity (PSPEC 4). The same relationship was consistent when intensity was expressed as a percentage of VO_2 peak, as illustrated in Figure 2 (page

41). This evidence suggests that the children in this study did not perceive the intensities the same between trials. The same relationship did not exist when exercise intensity was expressed as heart rates. There were no significant differences between production and estimation trial HR's whether expressed absolutely or as a percentage of HRpeak. The data for production versus estimation trial heart rates are illustrated in Figures 3 and 4 (pages 42 and 43) for absolute HR and % HR peak respectively. Although the heart rates are not significantly different, the heart rates were higher during the production trials at PSPEC levels 2 and 3 when expressed absolutely or as a percentage of HRpeak.

Correlations were run to further study the relationship between production and estimation trial intensities. Table 9 (page 72) indicates that significant correlations ($\underline{r}$ = 0.75, and $\underline{r}$ = 0.65) exist between the production and estimation trial VO_2 at PSPEC levels 3 and 4. However, these correlations would account for only a small amount of variance between modes (57% and 43%, respectively). There was not a significant correlation between modes at PSPEC 2. As seen in Table 10, 11, and 12 (pages 72-74), these correlations are not significant when the intensities are expressed as a percent of VO_2peak, as heart rates or as a percentage of HRpeak. This information would indicate that children in this study did not exercise at the same intensity during production and estimation trials.

During the estimation trial, the subject was asked to select a picture on the PSPEC scale that he/she felt represented his/her current exercise intensity. The investigator-assigned intensities for the three trials were 35, 50, and 75% of VO_2 peak. Once the subjects reached the assigned intensity (presented in a counter balanced order) based on metabolic cart analysis of VO_2, the subjects were anticipated to select PSPEC 2, 3, or 4 from the scale. Figure 5 (page 44) represents the mean PSPEC level indicated by the subjects during estimation trials at PSPEC levels 2, 3, and 4. The PSPEC rating selected at PSPEC 2 and 4 were significantly different ($p < .05$) from the anticipated selection. Table 2 (page 45) indicates that at the intensity set for PSPEC 2 (35% VO_2peak) during the estimation trial, 67% of the subjects indicated they felt like the PSPEC 2 picture. The subjects also selected the anticipated response 67% of the time at PSPEC 4. The intensity represented by PSPEC 3 seemed to be the level at which the greatest amount of variation occurred. The subjects selected the expected response 59% of the time.

These results suggest that the estimation mode of perceived exertion may be difficult for young children to understand or consistently identify. The results of this study would appear to support the position of Lamb and Eston (1997). In their review of effort perception and children Lamb and Eston stated:

> To reiterate our earlier comments, a reasonable and simple strategy (to address effort perception in children) would be to focus attention solely on examining how children perform during the production trials; how they respond during estimation trials is not important. If it can be firmly established that children are able to adjust their physical exertion in proportion to their perception of effort, for which some evidence exists, then there is genuine potential for applying this relationship to the physical education/health promotion environment (page 146)

The results of the production trials of the present investigation provide support for the use of the PSPEC as a tool for children to use to adjust (produce) their physical exertion in proportion to their perception of effort.

Conclusions

The results of the current study provide evidence that the PSPEC is a valid effort rating scale in production trials. The children in the study produced three different exercise intensities based on their perception of effort during discontinuous treadmill bouts. The intensities were different regardless of the physiological variable used to express intensity. Intensities were significantly different when oxygen consumption was expressed as $ml \cdot kg^{-1} \cdot min^{-1}$, or as a percentage of VO_2peak. However, oxygen consumption data gathered during production trials did not compare well to the expected levels of intensity when expressed as a percent of VO_2peak. The subjects in the study had a tendency to overproduce expected intensities at PSPEC 2 and 3.

Heart rates during production trials were also significantly different from one another when expressed as absolute values or as a percentage of HRpeak. Similar to the VO_2 data, the intensities increased with higher ratings on the PSPEC. The children in the study were inconsistent during their effort perception attempts during the estimation mode. This has been addressed previously (Lamb and Eston, 1997). The children in the study had more difficulty in estimation at PSPEC 3 than at PSPEC 2 and 4. The intensity represented by PSPEC 3 seemed to be the level at which the greatest degree of variation occurred. The subjects selected the expected response 59% of the time. This could be an indication that the perceptual signals used by the subjects to differentiate intensity were not strong enough. A greater difference in intensity between the PSPEC 2 and 3 may be needed to increase consistency in the use of the scale. The number of points on the scale could be confusing to children.

Recommendations

Recommendations for further use of the PSPEC scale should include studies with a larger number of subjects. Variables that influence effort perception in children should be examined with regards to the PSPEC. Other variables such as age, maturation, gender, reading ability, and activity level are examples of factors that may influence effort perception and should be further examined. Future research could seek to establish the optimal number of points. A three point scale might prove to be as or more valid as a five point scale.

The current research design did not include teaching children how to use the scale. The scale was simply anchored. No attempt was made to teach children how to identify levels 2, 3, and 4. Although not a traditional approach to investigating perceived exertion, teaching in this manner could address the differences between children's and adults' comprehension of effort perception. Teaching and anchoring the scale could further develop a better understanding, leading to a more accurate application in physical education/health promotion settings.

References

Armstrong, N., Williams, J., Balding, J., Gentle, P., & Kirby, B. (1991). The peak oxygen uptake of British children with reference to age, sex, and sexual maturity. European Journal of Applied Physiology, 62, 369-375.

Armstrong, N., Welsman, J., & Kirby, B. (1998). Peak oxygen uptake and maturation in 12-yr olds. Medicine and Science in Sports and Exercise, 30.165-169.

Armstrong, N., Welsman, J., & Winsley, R. (1996). Is Peak VO2 a maximal index of children's aerobic fitness? International Journal of Sports Medicine, 17, 356-359.

Armstrong, N., & Welsman, J., (1994). Aerobic fitness in children and adolescents. Exercise and Sport Sciences Reviews, 22, 435-476.

Bar-Or, O. (1977). Age related changes in exercise perception. In: Borg, G., (Ed.), Physical work and effort. Oxford: Pergamon Press.

Borg, G., 1971. The perception of physical performance. In Shepard, R. J., (Eds.), Frontiers of fitness, 280-94. Springfield, IL: Charles C. Thomas.

Borg, G., (1978). Psychological assessments of physical effort. In Proceedings of the 1978 international symposium on psychological assessment in sport, 49-57. Netanya, Israel: Wingate institute of physical education and sport.

Borg, G., (1985). An Introduction to Borg's RPE scale. Ithaca NY: Movement Publications.

Cureton, K. J., Sloniger, M. A., Black, D. M., McCormick, W. P., and Rowe, D. A., (1996). Metabolic determinants of the age-related improvement in 1-mile run/walk performance in youth. Medicine and Science in Sports and Exercise, 29, 259-267.

Duncan, G. E., Mahon, A. D., Howe, C. A., & Del Corral, P., (1996). Plateau in oxygen uptake at maximal exercise in male children. Pediatric Exercise Science, 8, 77-86.

Eston, R. G., Lamb, K. L., Bain, A., et al., (1994). Validity of a perceived exertion scale for children: A pilot study. Perceptual Motor Skills, 78, 691-697.

Fenster, J. R., Freedson, P. S., Washburn, R. A., & Ellison, R. C. (1989). The relationship between peak oxygen uptake and physical activity in 6 to 8 year-old children. Pediatric Exercise Science, 1, 127-136.

Freedson, P. S., & Goodman, T. L., (1993). Measurement of oxygen consumption. In T. W. Roland (Ed.), Pediatric Laboratory Exercise Testing. Champaign, IL: Human Kinetics.

Gillach, M. C., Sallis, J. F., Buono, M. J., Patterson, P., & Nader, P. R., (1989). The relationship between perceived exertion and heart rate in children and adults. Pediatric Exercise Science, 1, 360-368.

Krahenbuhl, G. S., Panrazi, R. P., Stone, W. J., Morgan, D. W., Williams, T., (1989). Fractional utilization of maximal aerobic capacity in children 6 to 8 years of age. Pediatric Exercise Science, 1, 271-277.

Lamb, K. L., (1995). "Ratings of effort during cycle ergometry": an examination of the validity of two effort rating scales. Pediatric Exercise Science, 7, 407-421.

Lamb, K. L., & Eston, R. G., (1997). Effort perception in children. Sports Medicine, 23, 139-148.

Leger, L., (1996). Aerobic performance. In D. Docherty (Ed.), Measurement in pediatric exercise science. Champaign, IL: Human Kinetics.

Noble, B. J., & Robertson, R. J., (1996). Perceived exertion. Champaign, IL: Human Kinetics.

Nystad, W., Oseid, S., Mellbye, E. B., (1991). Physical education for asthmatic children: the relationship between changes in heart rate, perceived exertion, and motivation for participation. In: Oseid, S., Carlsen, K. (Eds.). Children and Exercise XIII. Champaign, IL: Human Kinetics.

Pandolf, K. B., (1990). Advances in the study and application of perceived exertion. Exercise and Sport Science Review, 11, 118-58.

Robertson, R. J., (1982). Central signals of perceived exertion during dynamic exercise. Medicine and Science in Sports and Exercise, 14, 390-96.

Robertson R.J., Goss F.L., Boer, N.F., Peoples, J.A., Foreman, A.J., Dabayebeh, I.M., Millich, N.B., Balasekaran, G., Riechman, S.E., Gallagher, J.D., & Thompkins, T., (2000). Children's OMNI scale of perceived exertion: mixed gender and race validation Medicine and Science in Sports and Exercise, 32(2) 452-58.

Rowland, T. W., & Boyajian, A., (1995). Aerobic response to endurance exercise training in children. Pediatrics, 96(4), 654-658.

Sargeant, A. J., & Davies, C. T., (1973). Perceived exertion during rhythmic exercise involving different muscle masses. Journal of Human Ergol, 2, 3-11.

Shuleva, K. M., Hunter, G. R., Hester, D. J., & Dunaway, D. L., (1990). Exercise oxygen uptake in 3-through 6-year-old children. Pediatric Exercise Science, 2, 131-139.

Slaughter, M. H., Lohman, R.A., & Boileau, R. A., et. al. (1988). Skinfold equations for estimation of body fatness in children and youth. Human Biology, 60, 709-723.

Tanner, J. M., (1962). Growth at Adolescence. Oxford, UK: Blackwell.

Ward, D., & Bar-Or, O., (1990). Use of the Borg scale in exercise prescription for overweight youth. Canadian Journal of Sport Science, 15, 120-125.

Ward, D. S., Jackman, J. D., & Gallano, F. J., (1991). Exercise intensity reproduction: children versus adults. Pediatric Exercise Science, 3, 209-219.

Welsman, J. R., Armstrong, N., Nevill, A. M., Winter, E. M., & Kirby, B. J. (1995). Scaling peak V02 for differences in body size. Medicine and Science in Sports and Exercise, Williams, J. G., Furlong, B., Hockley, T. J., & Mackintosh, C., (1993). Rating and regulation of exercise intensity in young children. Medicine and Science in Sports and Exercise, 25.

Williams, J. G., Eston, R. G., & Furlong, B., (1994). CERT: A perceived exertion scale for children. Perceptual Motor Skills, 79, 1451-1458.

Appendix A

School of Nursing

P.O. Box 81
Middle Tennessee State University
Murfreesboro, Tennessee 37132
(615) 898-2437

To: Patrick D. Sells
MTSU Box 96

From: Susan R. Seager, Ed.D., R.N.
Chair, Institutional Review Board

Re: " The Pictorial Scale of Perceived Exertion for Children: A Developmental Study "

(IRB Protocol Number: 00-049)

Date: October 28, 1999

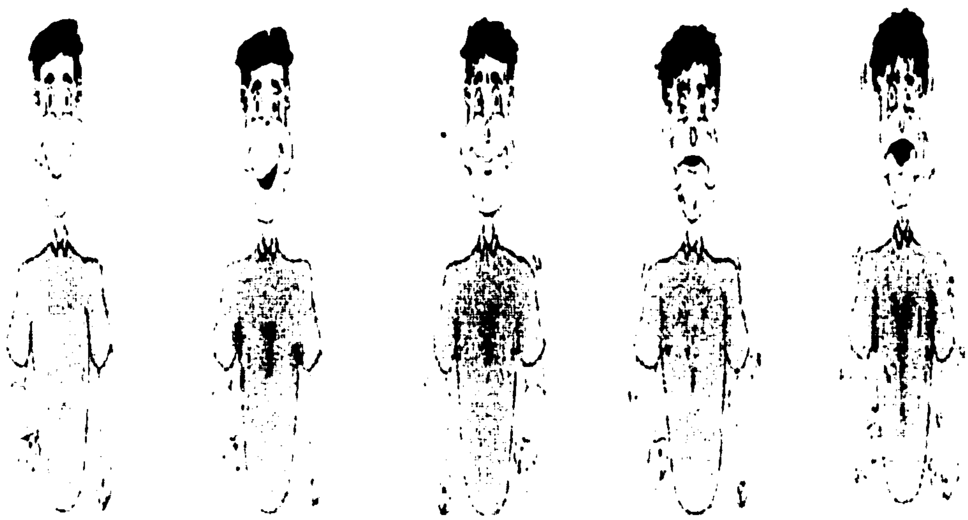
The above named human subjects research proposal has been reviewed and approved. This approval is for one year only. Should the project extend beyond one year or should you desire to change the research protocol in any way, you must submit a memo describing the proposed changes or reasons for extension to your college's IRB representative for review. Best of luck in the successful completion of your research.

CC: Tim Michael,PhD
Box 96

Appendix B

Pictorial Scale of Perceived Exertion for Children

PSPEC



Not Tired at All	Getting More Tired	Tired	Really Tired	Very Very Tired
1	2	3	4	5

Appendix C

Parental Consent for Participation
Development cf a Pictorial Scale of Perceived Exertion For Children

Principal Investigator:	Patrick D. Sells
Telephone Number:	(615)898-7087
Dissertation Chair:	Tim Michael, Ph.D.
Telephone Number:	(615)898-5547
	HPERS Dept. Middle Tennessee State University, Box 96

My son/daughter/ward has been asked to participate in a research study under the direction of Patrick D. Sells, a doctoral student at Middle Tennessee State University. The purpose of this research study is to develop a chart with pictures of someone exercising at different intensities. This chart may be used as a tool to help children understand differences in exercise intensity. The chart may also be used to assign specific exercise intensities during recreational and leisure time activities.

My child's participation in this study will last for approximately Three weeks and will be conducted at the Human Performance Laboratory at Middle Tennessee State University. During the course of this three-week timetable, my child will be scheduled to at least three testing sessions. Each testing session will last thirty or forty minutes.

During this study, each child will be instructed on all procedures prior to testing. Each child will undergo an exercise test that involves walking and running on a stationary treadmill. The first testing session on the treadmill is used to determine the child's maximum ability to perform exercise. The following sessions will not require a maximal effort of the child. During exercise testing, each child will be monitored with a Heart rate monitor, a blood pressure cuff, and will breathe into a device that collects and measures the expired air.

I understand that the research procedures described above may involve the following risks and/or discomforts. Risks to the child include those associated with short, intense bouts of exercise. Sweating, heavy breathing, and tired and/or sore muscles if the child is unaccustomed to exercise. The only foreseeable psychological stress expected is that associated with being exposed to a new environment. This will be addressed with a familiarization process that can include parents, children, and primary investigators.

As a result of his/her participation, the child and the parents/guardians will receive detailed information pertaining to the child's current level of fitness. Each child who participates in the study will receive a reward of a free pass to a child oriented play center. Results of each child's test will be fully explained and accompanied by practical information about how to apply the results. Others not associated with the study may be able to use the results. Pediatricians could use the scale to prescribe exercise to patients. Physical educators and other health professionals could use the chart in indicate desired levels of intensity for health benefits.

Participation is voluntary and I may refuse to let my child/ward participate without penalty or loss of benefits. I may discontinue his/her participation at any time without penalty. I also understand that the researcher has the right to withdraw him/her from participation in the study at any time. **My child/ward has may end his/her participation at any time without any penalty of loss of benefits.**

I AGREE TO ALLOW MY CHILD/WARD,

____,
name of child/ward

TO PARTICIPATE IN THIS RESEARCH PROJECT AND I WILL RECEIVE A COPY OF THIS CONSENT FORM.

____
PARENT/GUARDIAN SIGNATURE DATE

***PERSON OBTAINING CONSENT:**
I have explained to the above named individual the nature and purpose, the potential benefits and possible risks associated with participation in this research. I have answered any questions that have been raised and I will provide the parent/guardian with a copy of this consent form.

____
RESEARCHER'S SIGNATURE DATE

Appendix D

Child Assent For Participation
Development of a Pictorial Scale of Perceived Exertion For Children

Principal Investigator:	Patrick D. Sells
Telephone Number:	(615)898-7087
Dissertation Chair:	Tim Michael, Ph.D.
Telephone Number:	(615)898-5547
	HPERS Dept. Middle Tennessee State University, Box 96

We want to find the best way to help children like you learn more about exercise. We want you to help us learn about some pictures of people who are exercising

First, we will work with you to find out how tall you are and how much you weigh. Then you will get to visit Middle Tennessee State University and see where we will learn more about exercise. We will also work with your parents to make sure they know about what you are learning and doing. You and your parents can ask questions as often as you like and you do not have to do the exercise if you do not want to. You will exercise on a treadmill at MTSU on three different days and we will ask you questions and show you pictures about how hard you are exercising. You can ask questions at anytime.

I would like to know if you are interested in helping us learn about children and exercise. Please tell me if you want to do this by saying "yes" if you do or "no" if you do not want to.

Appendix E

Physical Activity Readiness Questionnaire

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and circle the yes or no opposite the question if it applies to your child.

1. Has your doctor ever said you have heart trouble?
   Yes NO

2. Do you frequently have pains in your heart and chest?
   YES NO

3. Do you often feel faint or have spells of severe dizziness?
   YES NO

4. Has a doctor ever said your blood pressure was too high?
   YES NO

5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
   YES NO

6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
   YES NO

7. Are you over age 65 and not accustomed to vigorous exercise?
   YES NO

If you answered **YES** to one or more questions...
If you have not recently done so, consult with your personal physician by telephone or in person before increasing your physical activity and/or taking a fitness test. If you answered **NO** to ail questions... If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for an exercise test.

Appendix F

Table 3.

Paired Comparisons of Production Trial VO2 for PSPEC levels 2, 3, and 4.

		Mean Difference	Std. Error	Sig.[a]
PSPEC 2 VS.	PSPEC 3	-3.300*	.751	.003
	PSPEC 4	-9.625*	1.086	.000
PSPEC 3 VS.	PSPEC 4	-6.325*	.615	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 4.

Paired Comparisons of Estimation Trial VO2 for PSPEC levels 2, 3, and 4.

		Mean Difference	Std. Error	Sig.[a]
PSPEC 2 VS.	PSPEC 3	-5.742*	.788	.000
	PSPEC 4	-14.542*	1.342	.000
PSPEC 3 VS.	PSPEC 4	-8.800*	.990	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 5.

Fractional Utilization of VO2 for Comparisons Between Production Trials.

% VO2peak @	% VO2peak @	Mean Difference	Std. Error	Sig.[a]
PSPEC 2	PSPEC 3	-8.804e-02*	.018	.002
	PSPEC 4	-.259*	.025	.000
PSPEC 3	PSPEC 4	-.171*	.016	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 6.

Fractional Utilization of VO2 for Comparisons Between Estimation Trials.

% VO2peak @	% VO2peak @	Mean Difference	Std. Error	Sig.[a]
PSPEC 2	PSPEC 3	-.151*	.016	.000
	PSPEC 4	-.389*	.025	.000
PSPEC 3	PSPEC 4	-.238*	.025	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 7.

Percent Heart Rate for Comparisons Between Production Trials.

% Heart Rate Peak @	% Heart Rate Peak @	Mean Difference	Std. Error	Sig.[a]
PSPEC 2	PSPEC 3	-3.868E-02*	.010	.009
	PSPEC 4	-1.22*	.013	.000
PSPEC 3	PSPEC 4	-8.236E-02*	.009	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 8.

Percent Heart Rate Peak for Comparisons Between Estimation Trials.

% Heart Rate Peak @	% Heart Rate Peak @	Mean Difference	Std. Error	Sig.[a]
PSPEC 2	PSPEC 3	-11.917*	4.024	.039
	PSPEC 4	-33.417*	3.757	.000
PSPEC 3	PSPEC 4	-21.500*	2.698	.000

* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Bonferroni.

Table 9

Correlations Between Production Trial and Estimation Trial VO_2.

	Correlation	Sig.
PSPEC 2	.381	.221
PSPEC 3	.748*	.005
PSPEC 4	.647*	.023

* Indicates a significant ($p < .05$) correlation between the intensity (VO_2) of production and estimation trials.

Table 10

Correlations Between Production Trial and Estimation Trial for $\%VO_2peak$.

	Correlation	Sig.
PSPEC 2	.865	-.056
PSPEC 3	.730	.112
PSPEC 4	.648	.147

* Indicates a significant ($p < .05$) correlation between the intensity (VO2) of production and estimation trials.

Table 11

Correlations Between Production Trial and Estimation Trial Heart Rates.

	Correlation	Sig.
PSPEC 2	.831	-.069
PSPEC 3	.229	.379
PSPEC 4	.743	.106

* Indicates a significant ($p < .05$) correlation between the intensity (VO2) of production and estimation trials.

Table 12

Correlations Between Production Trial and Estimation Trial Heart Rates (%HRpeak).

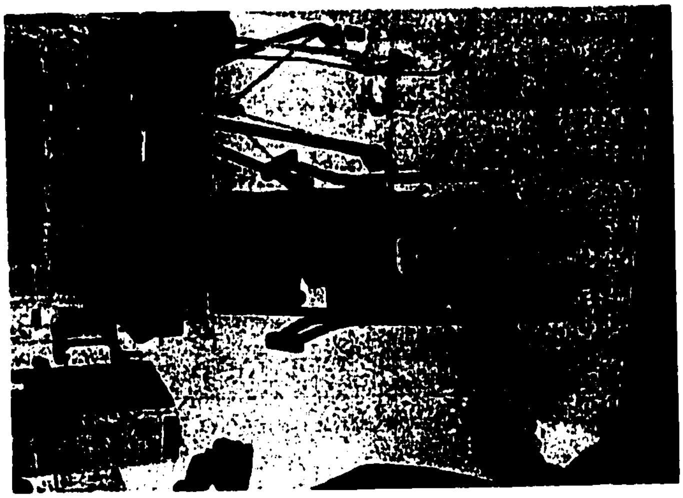
	Correlation	Sig.
PSPEC 2	.162	.614
PSPEC 3	.566	.055
PSPEC 4	.433	.160

* Indicates a significant ($p < .05$) correlation between the intensity (VO_2) of production and estimation trials.

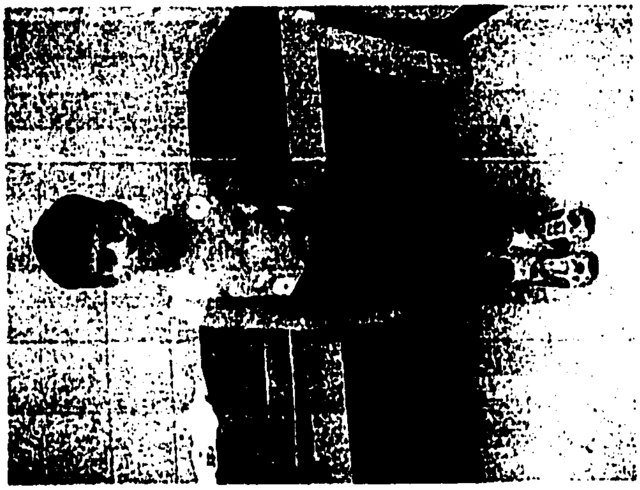
Appendix G

Familiarization Photographs

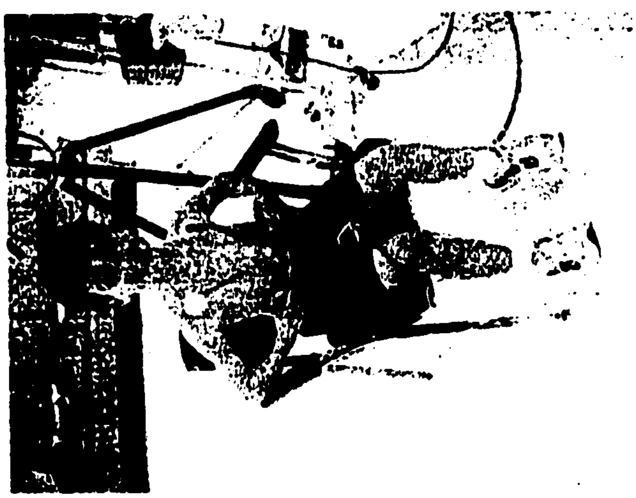
Skinfold measurements

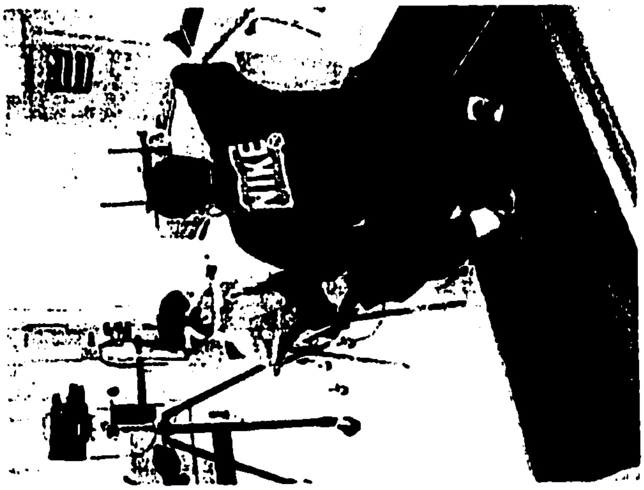


Trying on face mask

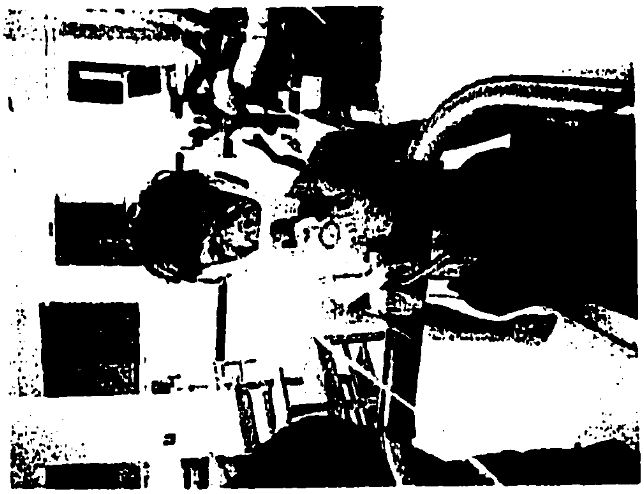


Electrode Boy!





All systems GO



Exercising