To the Graduate Council:

I am submitting herewith a thesis written by Stacy Nicole Scott entitled "The accuracy of the Progressive Aerobic Cardiovascular Endurance Run to estimate aerobic fitness in youth." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Kinesiology.

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We have read this thesis and recommend its acceptance:

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(Original signatures are on file with official student records.)

THE ACCURACY OF THE PROGRESSIVE AEROBIC CARDIOVASCULAR ENDURANCE RUN TO ESTIMATE AEROBIC FITNESS IN YOUTH

A Thesis Presented for the

Master of Science Degree

The University of Tennessee, Knoxville

Stacy Nicole Scott

May 2012

ACKNOWLEDGEMENTS

First, I would like to thank my major professor and advisor Dr. Dawn Coe. I am so thankful that you have shared your enthusiasm for research, working with children, and community involvement with me throughout my entire career at the University of Tennessee. Your dedication and guidance have been influential in helping me achieve both academic and personal goals. Thank you for giving me responsibilities and opportunities that have challenged me to grow as a student and professional while maintaining a "Play for Health" attitude.

I would also like to thank my committee members. Dr. Thompson, thank you for asking the tough questions and teaching me the value of practical application in our research. Dr. Bassett, your excitement for exercise physiology is contagious. Thank you for sharing it with me and helping me build upon my ideas.

Pam Andrews, Betty Carver, Emile Catignani, Jane Johns, and Lynnetta Holbrook, thank you for your support and assistance with my research and teaching responsibilities. I would also like to thank my fellow graduate students for all of your support. I am so grateful we've developed friendships beyond the classroom that will continue into our careers.

To my parents and sisters, thank you for setting a great example of hard work. I am so thankful that we were encouraged to be creative, independent, and use our problem solving skills.

Lastly, I would like to thank my participants. Thank you for giving me the opportunity to share my excitement for exercise and health with you. You've helped reveal just how much I enjoy teaching and working with children.

ABSTRACT

The FITNESSGRAM's Progressive Aerobic Cardiovascular Endurance Run (PACER) test is a commonly used field test to estimate peak oxygen uptake (VO_{2peak}) in youth. However, little research has been conducted to determine the influence of weight status on the accuracy of the equations used to estimate VO_{2peak}. **Purpose**: To assess the agreement between VO_{2peak} measured using indirect calorimetry during the PACER and estimated VO_{2peak} in normal weight and overweight youth and to determine the influence of weight status on the accuracy of estimated VO_{2peak} in 10-15 year old youth. **Methods**: The study included 101 participants that were classified as normal weight (n=78) or overweight (n=23) according to BMI percentiles for age and sex. Participants completed the PACER, a progressive, multistage, 20-meter shuttle run to volitional exhaustion. VO_{2peak} was measured during the PACER test using a portable gas analysis system (Oxycon Mobile, CareFusion, Inc.). Estimated VO_{2peak} values were calculated based on PACER performance using the Leger et al. and Mahar et al. equations. Paired samples t-tests were used to determine if significant differences existed between estimated and measured VO_{2peak}. Independent t-tests were performed to compare the normal weight and overweight groups. Accuracy was determined using Bland-Altman plots. **Results**: The Leger et al. (44.3 ± 4.6 ml•kg^{-1}•min^{-1}) and Mahar et al. (46.8 ± 4.8 ml•kg^{-1}•min^{-1}) estimated values were significantly lower than measured VO_{2peak} (49.0 ± 8.7 ml•kg^{-1}•min^{-1}) in the normal weight group. There were no significant differences between measured VO_{2peak} (38.8 ± 7.1 ml•kg^{-1}•min^{-1}) and predicted values (40.5 ± 2.5 and 38.2 ± 6.1 ml•kg^{-}

^{1}•min^{-1}; Leger et al. and Mahar et al., respectively) for the overweight group. For the normal weight group, the standard error of the estimate (SEE) was 5.44 ml•kg^{-1}•min^{-1} (Leger) and 5.33 ml•kg^{-1}•min^{-1} (Mahar). The SEE was 5.77 ml•kg^{-1}•min^{-1} (Leger) and 4.54 ml•kg^{-1}•min^{-1} (Mahar) for the overweight participants.

Conclusions: It appears that the prediction of VO_{2peak} from either equation based on PACER performance varies among weight status group and may be inaccurate for normal weight youth, but acceptable for overweight youth.

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CHAPTER I
INTRODUCTION

The increasing population of overweight children continues to be a public health concern in the United States. Body mass index (BMI) percentiles are statistically determined cut-points used to monitor children's growth status based on an age and sex-specific reference population (20). Children with a BMI at or above the 85^{th} percentile or 95^{th} percentile are classified as overweight or obese, respectively (44). Between 2009 and 2010, 31.8% of U.S. children, aged 2 through 19, were classified as overweight for age and 16.9% were classified as obese (45). Although the cut-points are not based on health risks, BMI is correlated with overfatness predisposing overweight and obese children to risk factors such as elevated blood pressure, dyslipidemia, and insulin resistance that negatively impact cardiovascular health (49).

High aerobic fitness, a reflection of cardiorespiratory function (14), may play a protective role in the cardiovascular health of overweight and obese children. Low aerobic fitness during childhood may predict the onset of cardiovascular disease in adulthood, while higher aerobic fitness is associated with risk reduction (22, 24). In youth, peak oxygen uptake or VO_{2peak} reflects the highest rate at which the cardiorespiratory system utilizes oxygen during exercise (14) and is considered to be an objective measurement of aerobic fitness (18). A valid assessment of aerobic fitness, measured by VO_{2peak} is important for properly interpreting cardiovascular function and subsequently determining health related risk.

Several methods can be used to assess aerobic fitness in children. In the laboratory, oxygen uptake, measured continuously through indirect calorimetry during graded exercise testing, is used to determine aerobic fitness. However this methodology requires sophisticated equipment and is not feasible for regularly testing large groups of children. For environments such as physical education classes or community settings, field tests can be used to estimate aerobic fitness. Field tests provide an affordable and practical alternative for testing large groups of children where VO_{2peak} is estimated based on a performance measure. The FITNESSGRAM's Progressive Aerobic Cardiovascular Endurance Run (PACER) is a maximal field test commonly used to assess aerobic fitness in large groups of children. The PACER test involves running 20-meter shuttles in time with music (14). As a progressive exercise test, the pace increases accordingly in one-minute stages until the running pace can no longer be maintained. VO_{2peak} during the PACER test is estimated using a regression equation developed by Leger et al. (27) based on age and the highest speed achieved at the end of the PACER test.

The PACER has been validated as a field test to estimate aerobic fitness in children of normal weight status. Estimated aerobic fitness from the Leger et al. equation (27) using age and final running speed of the PACER test correlates (r= .54-.87) with VO_{2peak} measured during the final stages of graded treadmill tests (9, 21, 29, 37, 57), maximal heart rate achieved during exercise testing (6, 23, 58), and with estimates from other field tests (1, 21, 39, 58). Two studies investigated the influence of weight status on performance during the PACER test. Ihasz et al. (23) compared the estimates of aerobic fitness from the PACER test and a modified shuttle test to measured oxygen consumption during treadmill testing and found no significant difference between estimated and measured aerobic fitness levels in overweight boys. Similarly, Suminski et al. (55) determined that weight status in Hispanic youth, did not affect the validity of the Leger et al. equation (27) for predicting VO_{2peak} in this population compared to VO_{2peak} measured during a treadmill test. The Leger et al. equation (27) was originally developed and validated in 1988 based on post-shuttle test VO_2 measurements, retroextrapolation techniques, and maximal speed attained during the 20-meter shuttle run. There is a correlation between VO_{2peak} estimated from the Leger equation and VO_{2peak} measured during a treadmill graded exercise test (GXT); however, some studies report that the Leger equation underestimates treadmill VO_{2peak} (21, 53). The exercise protocol may explain the underestimation of the Leger equation to predict VO_{2peak}. Since the equation was not developed based on treadmill measurements, Ruiz et al. (53) suggests that the difference between treadmill VO_{2peak} and Leger VO_{2peak} is due to the different exercise modalities comparing shuttle running to continuous, forward, motor driven treadmill locomotion. Due to advances in technology, oxygen uptake can be determined outside of the laboratory using a portable metabolic system to measure VO_{2peak} during field testing. Wearing a portable metabolic system during the PACER test to measure VO_{2peak} should be used as the criterion-related measure to validate the Leger equation (53), since it was developed using VO_{2peak} measurements obtained in the field via the Douglas Bag method. Only three studies have measured VO_{2peak} during the PACER test using a portable metabolic system. Melo et al. (42) compared measured VO_{2peak} during the PACER test to estimated VO_{2peak} from the Leger equation (27) and found estimated VO_{2peak} to be significantly different than measured values in 8 to 10 year old children (r = 0.88, d = 4.7, $p < 0.05$). Ruiz et al. (53) reported a lower correlation (r = 0.59; p < 0.01) between estimated and measured VO_{2peak} during the PACER test in twenty-six girls aged 13 through 19 years. More recently, Mahar et al. (34) measured VO_{2peak} during the PACER and during a treadmill GXT in 15 to 16 year olds. However, no study has been conducted that investigates the accuracy of the PACER run to determine aerobic fitness in overweight children.

Utilizing a portable metabolic system to measure VO_{2peak} during the PACER test will aid in determining the accuracy of the PACER test and Leger et al. equation to estimate aerobic fitness in overweight youth. The validation of the PACER test in this population would enable researchers and educators to accurately estimate aerobic fitness in overweight youth and thus, determine aerobic fitness level, and associated health risk implications. Therefore, the purpose of this study is to determine the accuracy of the PACER to estimate aerobic fitness in overweight and obese youth aged 10 to 15 years.

Research Question #1: To assess the agreement between VO_{2peak} measured during the PACER and estimated VO_{2peak} derived from the PACER test in normal weight and overweight/obese youth.

Research Question #2: Does accuracy of the PACER differ among normal weight and overweight/obese youth 10 to 15 years old?

CHAPTER II
LITERATURE REVIEW

INTRODUCTION

The Progressive Aerobic Cardiovascular Endurance Run (PACER) is a multi-stage 20-meter shuttle run used as a maximal field test to estimate aerobic fitness. Routinely performed in physical education classes or community settings, the PACER test has been administered in 37 countries and published data exists for over 400,000 children aged 6-19 years (46). Although, the PACER test has been established as a reliable and valid field test of aerobic fitness (4, 30, 36, 58), few studies have addressed the influence of weight status on predicting aerobic fitness in children. Equations developed by Leger et al. (27) and Mahar et al. (34) are the two most commonly used equations to estimate VO_{2peak} from PACER performance that have been tested against other field estimates of VO_{2peak} and also treadmill or cycle tests of VO_{2peak} performed in the laboratory (27, 34). Children are placed in fitness categories based on the estimated values; therefore, the accuracy of the equations is critical for appropriate classification. Further research is necessary to determine the influence of weight status on the accuracy of predicting aerobic fitness from assessments in the field, specifically the PACER or 20-meter shuttle run.

The purpose of this literature review is to highlight the importance of aerobic fitness assessments in youth and the influence of weight classification on predicting aerobic fitness levels. Because accuracy of aerobic fitness assessments is imperative in determining aerobic fitness levels, this literature review also examines previous research on measuring and estimating aerobic fitness in youth.

AEROBIC FITNESS

Definition and Importance

Aerobic fitness reflects the ability of cardiorespiratory system to transport oxygen during strenuous exercise (51) and is an important element in overall health-related physical fitness (18). Aerobic fitness assessments should be conducted in a manner such that the cardiovascular and pulmonary systems are pushed to their functional limits (52) to determine peak exercise response, uncover deficiencies, or evaluate performance. In adults, maximal oxygen uptake (VO_{2max}) is the highest rate at which active tissue can take up and utilize oxygen for energy during strenuous exercise (14, 51) and is used as an objective measure of aerobic fitness. In pediatric literature, peak oxygen uptake (VO_{2peak}) is used to represent peak aerobic fitness compared to VO_{2max} in adults (18). Several factors known to influence VO_{2peak} include sex, age, fat free mass, and fat mass (15).

Aerobic Fitness in Overweight and Obese Youth

Aerobic fitness is an important element of health-related fitness. Low aerobic fitness is considered an independent risk factor for cardiovascular disease. Children with low aerobic fitness are at a greater risk for developing cardiovascular disease risk factors including hypertension, dyslipidemia, diabetes, and obesity (14, 18), (24, 31). Currently, 31.9% of U.S. youth (2-9 y) are considered overweight and 16.9% obese based on BMI for age and sex (45). Overweight and obese children tend to have lower relative aerobic fitness levels compared to their normal weight counterparts (24).

Comparing peak aerobic fitness across children of different weight status is dependent VO_{2peak} is expressed. Absolute VO_{2peak}, expressed as liters of oxygen per minute ($L \bullet min^{-1}$), also represents the highest rate at which oxygen uptake occurs in active tissue; however, it does not account for differences in body mass (32). Overweight and obese children have increased total body mass which includes excess fat mass or metabolically inactive tissue. To account for differences in body size (14), peak oxygen uptake is commonly expressed relative to body mass in milliliters of oxygen per kilogram of body mass per minute ($ml \bullet kg^{-1} \bullet min^{-1}$) (51). VO_{2peak} can also be scaled relative to milliliters of oxygen per kilogram of fat mass or fat free mass when body composition values are available (2). However, scaling to fat mass or fat free mass may introduce bias when comparing VO_{2peak} values between individuals of different age, sex, and body composition (2). Expressing peak aerobic fitness is most commonly reported as relative VO_{2peak} ($ml \bullet kg^{-1} \bullet min^{-1}$) allowing for comparison longitudinally and across studies (2). Johnson et al. (24) suggests that improving or maintaining aerobic fitness may reduce overweight and obesity rates and decrease the prevalence of cardiovascular disease risk factors.

ASSESSMENTS OF AEROBIC FITNESS

In the 1950's, research involving fitness testing in U.S. youth reported that American youth were less fit than their European counter parts (25). This ignited further research in pediatric exercise testing and the development of the President's Council on Youth Fitness, American Alliance for Health, Physical Education and

Recreation Youth Fitness Test, and later the concept and practice of health-related fitness (63). Since then, health-related fitness testing, specifically aerobic fitness assessment in the pediatric population has become common practice in educational, wellness, and clinical settings. Although fitness testing is conducted in a similar manner for adults and children, for example treadmill and cycle testing, it is critically important to choose a test protocol that is physically and developmentally appropriate for the pediatric population. Test administrators should also consider the suitability of test location (laboratory or field-based) and availability of pediatric sized equipment for participant safety and comfort (52).

Laboratory Testing

The measurement of VO_{2peak} is commonly performed in a laboratory or clinical setting with progressive workloads applied during a cycle ergometer or treadmill graded exercise test (GXT) until the child can no longer continue. Cycle ergometer protocols may require the participant to maintain a set pedaling cadence, specific stage duration, or increases in work rate (52). The McMaster cycle protocol is one of the standard maximal, cycle aerobic fitness tests (47); initial workload and incremental increase is determined by the participant's height and pedal cadence remains constant throughout the test. If a maximal exercise test is not appropriate, a submaximal cycle test, such as the Physical Working Capacity test (PWC_{170}) can be administered to estimate VO_{2peak}. For the PWC_{170}, initial workload is set according to the child's weight and successive workloads are determined by the heart rate (HR) response from the prior stage. Once

HR is ≥ 165 beats•min^{-1}, the test is complete; VO_{2peak} is then estimated using heart rate extrapolation techniques (37).

Although cycle protocols may be safer and less intimidating for the pediatric population, local muscle fatigue, instead of cardiorespiratory limitations may cause the participant to reach volitional fatigue prematurely. Research indicates VO_{2peak} is about 10% higher measured during a treadmill GXT compared to a cycle test due to increased amounts of active muscle tissue during walking and running (8, 52). The Bruce treadmill protocol and the modified Bruce protocol are reported to be the most commonly used treadmill GXTs (52). The Bruce protocol begins at a speed of 1.7 miles per hour (mph) with a 10% grade and increases in both speed and grade at 3- min intervals. The modified Bruce protocol starts at a speed of 1.7 mph with a 0% grade and increases in both speed and grade at 2-min intervals (12). Cumming et al. (12) conducted a study involving 327 participants (7 -14 y) to provide physiologic data and endurance time norms. The mean VO_{2peak} values were reported across four age groups were 40.2$\pm$ 0.4 (7 y), 36.5$\pm$ 5.3 (9-11 y), 35.2$\pm$ 3.2 (11-12 y), and 37.7$\pm$ 3.5 ml•kg^{-1}•min^{-1} (13-14 y). The Cumming et al. study provides the most comprehensive set of norms for aerobic fitness in terms of subject age. Several of aerobic fitness evaluations and norms utilizing the Bruce protocol or other treadmill GXTs for pediatric exercise testing in the laboratory are well documented in the literature (52, 54).

Field Testing

VO_{2peak} measured in the laboratory or clinical setting during a treadmill GXT is considered the criterion method for assessing aerobic fitness. Although ideal, laboratory testing requires sophisticated equipment, well-trained staff, and can be time consuming since tests are performed one at a time. Field tests of aerobic fitness provide an affordable and practical alternative for testing large groups of children. There are several field tests of aerobic fitness, among them some of the most common include the Cooper 12-minute run/walk, the 6-min run, the one-mile walk, the one-mile run, and the PACER test, all of which have been validated and used for testing children and adolescents (10, 28, 60).

The Cooper 12-minute run/walk and the 6-min run estimate aerobic fitness based on distance covered over the allotted amount of time (10, 28). Correlations of the Cooper 12- minute run/walk with measured VO_{2peak} range from r=0.20 to r=0.90 (57) indicating a wide degree of variability. This could be due to the fact that both of these field tests require high subject motivation, the ability to self-pace running speed, and maintain a near-maximal speed throughout the duration of the test (57).

The one-mile walk and run pose similar limitations in requiring maximal subject effort and appropriate pacing to achieve an accurate estimation of VO_{2peak}. Children may not be willing to maximally exert themselves the entire test which could potentially confound the results (57, 58); however, the one-mile walk and one-mile run are occasionally used as aerobic fitness assessments as a part of the FITNESSGRAM test battery (60, 61). Both tests are used to estimate VO_{2peak} based on sex, age, and the amount of time it takes to cover one mile; additionally the walk test includes body weight and heart rate at the end of the test in estimating aerobic fitness (60). Reliability coefficients ranging from 0.47 to 0.91 have been reported for the one-mile walk in youth 10 to 18 years old (14). Beets and Pitetti (5) reported reliability coefficients for the one-mile run of 0.66 and 0.77 for boys and girls 13 to 18 years old. The validity of predicting VO_{2peak} from one-mile walk or run performance has been evaluated against VO_{2peak} determined during treadmill exercise. A validity coefficient of 0.84 with the associated standard error of the estimate of 4.5 $ml \cdot kg^{-1} \cdot min^{-1}$ was reported by McSwegin et al. (40) for the one-mile walk. Studies involving the one-mile run have recorded validity coefficients ranging from 0.60 to 0.90 for children (14).

Research supports the PACER test as one of the better field assessments of aerobic fitness (46, 57, 58) and is the recommended test of the FITNESSGRAM battery (60). The PACER involves running 20-meter shuttles, keeping pace with timed audio signals playing from a soundtrack. The PACER starts at a moderate speed of 8.5 $km \cdot hr^{-1}$ and progressively becomes faster each minute, requiring maximal effort only in the final stage of the test. Similar to the other field tests, the PACER requires minimal equipment and is easily administered. In contrast to the other field tests, the PACER requires less space, maximal exertion only in the final stage, and can be conducted outdoors or indoors (60). The accuracy of aerobic fitness field testing is important, especially because of the associated health implications of high or low aerobic fitness levels.

Because the PACER is one of the most widely used assessments (46), its reliability, validity, and application will be further discussed in this review.

PROGRESSIVE AEROBIC CARDIOVASCULAR ENDURANCE RUN (PACER)

The 20 meter shuttle run (20- MST) was developed by Leger and Lambert (26) to simulate a treadmill graded exercise test increasing one MET per stage (29). VO_{2peak} is estimated based upon the highest speed attained, corresponding to the number of completed stages, and the participant's age. More recently, the 20-MST has been adopted as the FITNESSGRAM's PACER with the addition of background music on an audio CD. Participants perform 20-meter shuttles set to a cadence, increasing each minute, until the participant can no longer continue, or fails to cover the 20-meter distance within the allotted time on two consecutive shuttles.

Reliability

In adults, Leger and Lambert (26) found the 20-MST to be a reliable field test of aerobic fitness. On two separate occasions, the 20-MST was performed and immediately upon completion four, twenty-second samples of expired gases were collected via the Douglas Bag method to determine VO_{2max}. Leger and Lambert (26) reported strong test-retest reliability for the estimation of VO_{2max} ($r= 0.98$; SEE= 2.0 $ml•kg^{-1}•min^{-1}$). The reliability of the 20-MST or PACER test has been demonstrated in children as well. Leger et al. (27) reported a correlation coefficient of 0.89 for test-retest reliability in 139 children, 6 to 16 years old based on VO_{2peak} determined from the equation. Liu et al. (29) conducted the PACER to assess the test-retest reliability among American students aged

12-15 years. Twenty students (12 males and 8 females) performed the PACER twice, one week apart. The investigators reported an intraclass correlation coefficient of 0.93 and no significant difference between mean laps completed at trial one and trial two (T_1= 47.80± 20.3 vs. T_2 = 55.55± 22.4 laps; $p \geq .13$). This finding is similar to other PACER reliability studies reporting interclass coefficients of 0.81 and 0.90 for laps completed (6, 37). More recently, Beets, Pitetti, and Fernhall (6) and McVeigh et al. (41) investigated reliability of peak heart rate (HR_{peak}) recorded during multiple PACER trials; both reporting no significant difference between mean HR_{peak} obtained between trials, reliability coefficients were 0.78 and 0.69, respectively.

Validity

The PACER test has become one of the most commonly used field tests of aerobic fitness in youth (36). Comparisons to a treadmill GXT have been made to determine the validity of the PACER as an aerobic fitness assessment. Van Mechelen et al. (57) investigated VO_{2peak} measured during a treadmill GXT compared to PACER performance from the number of laps completed in 12 to 14 year old adolescents (n= 82) and found that 57% of the variance in VO_{2peak} could be explained by performance on the PACER. Similarly, in a small, non-Caucasian sample (n= 10), Mahoney (37) found significant positive correlations between treadmill VO_{2peak} and number of laps completed on the PACER for boys (r= 0.83) and girls (r= 0.76). Boreham et al. (9) also investigated the validity of PACER performance using treadmill GXT as the criterion for determining VO_{2peak} in 14 to 16 year old adolescents and reported a slightly higher correlation (r= 0.87) between estimated and measured VO_{2peak}. In their study, boys (n= 23) averaged 81.7$\pm$15.9 laps completed and VO_{2peak} measured was 53.3$\pm$5.9 ml•kg^{-1}•min^{-1} and girls (n= 18) completed 50.4$\pm$12.5 laps and measured VO_{2peak} averaged 42.6$\pm$5.8 ml•kg^{-1}•min^{-1}.

To further validate the PACER test as an aerobic fitness assessment, researchers have monitored HR during both the PACER and a treadmill GXT to compare participant effort and peak heart rates (HR_{peak}) elicited from each test. Voss and Sandercock (59) reported that the PACER elicits maximal effort in 11 to 16 year olds. Using HR_{peak} greater than 185 beats•min^{-1} to indicate maximal effort, Voss and Sandercock reported a mean HR_{peak} of 196 beats•min^{-1} (95% CI; 194 – 198 beats•min^{-1}) to conclude that maximal effort was achieved. McVeigh et al. (41) found no significant difference between HR_{peak} achieved during the PACER (boys = 203 beats•min^{-1}; girls = 201 beats•min^{-1}) and treadmill GXT (boys = 200 beats•min^{-1}; girls = 204 beats•min^{-1}) in 13 to 14 year-old youth. Boreham et al. (9) reported similar maximal heart rates ranging from 190 to 213 beats•min^{-1} during a treadmill GXT compared to a range of 190 to 214 beats•min^{-1} during the PACER test in a sample (n= 41) of 14 to 16 year old adolescents.

It is important to compare validity evidence to other aerobic fitness tests when evaluating the utility of the PACER test. From a study conducted by Vincent et al. (58) HR at the completion of the PACER and 1- Mile Run show a moderate correlation (r= 0.82) in fifth grade elementary students. The investigators reported no significant difference between mean HR_{peak} upon completion of the PACER (195$\pm$14 beats•min^{-1})

versus the 1-Mile Run (191$\pm$23 beats•min^{-1}). Results reported by Chun et al. (11) show high inverse correlations (r= -0.73 for boys, -0.80 for girls) between the PACER laps and 1-Mile run time; supporting the PACER as a comparable field test of aerobic fitness. In one study, in which participants performed the PACER, a 6-minute run test, and a treadmill GXT, VO_{2peak} was more highly correlated with the PACER test than the 6-minute run (*r*= 0.76 vs. 0.63) (57). Although not statistically different, Van Mechlen et al. (57) discussed the advantages of conducting the PACER test over the 6-minute run because of the PACER's resemblance to a treadmill GXT and higher subject motivation. The PACER has also been compared to the PWC_{170}, a submaximal cycle test. In a small sample (n= 18), Mahoney (37) reported a significant correlation between PACER laps and VO_{2peak} from a treadmill GXT (*r*= 0.83, boys; *r*= 0.76, girls) but no significant relationship between the PWC_{170} and VO_{2peak} or the PWC_{170} and PACER laps. Boreham et al. (9) also reported significant correlations between treadmill VO_{2peak} and PWC_{170} performance (*r*= 0.84) and between treadmill VO_{2peak} and PACER laps (*r*= 0.84).

Regression Equations

The 20-MST or PACER test was first used as a field test to estimate aerobic fitness in adults by Leger and Lambert in 1982 (26) and later tested for children in 1988 (27). The investigators used regression analysis to develop an equation that predicted VO_{2peak} based on performance during the PACER and the participant's age. Youth (n=188, 8-19y) performed the test to volitional fatigue and immediately upon completion, expired gases were collected using the Douglas Bag Method to establish the oxygen recovery curve and determine VO_{2peak} (26, 27). A regression analysis yielded age (y) and maximal speed attained ($km{\bullet}h^{-1}$) in the final stage of the test to be significant predictors (r= 0.71; SEE= 5.9 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$) of VO_{2peak}[equation: VO_{2peak} ($ml{\bullet}kg^{-1}{\bullet}min^{-1}$) = 31.025 + 3.23 (($km{\bullet}h^{-1}$) – 3.248 (years) + 0.1536 ($km{\bullet}h^{-1}$)(years)] (27). More recently, FITNESSGRAM (61) has updated the prediction equation to also include number of laps completed, BMI ($kg{\bullet}m^2$), and gender (0 for girls, 1 for boys) [equation: VO_{2peak} ($ml{\bullet}kg^{-1}{\bullet}min^{-1}$) = 41.77 + 0.49(laps) – 0.0029(laps)^2 – 0.62(BMI) + 0.35(gender•age)].

Validity of the Regression Equations

Several studies (27, 30, 37)have supported the utility of the Leger et al. equation to estimate VO_{2peak} from PACER performance. However, a wide range of variability exists among the accuracy of VO_{2peak} values estimated from the equation. Leger et al. developed and validated the original equation in 1988 in a sample of 188 boys and girls ages 8 to 19 years. In 2011, Mahar et al. (34) developed a new equation to estimate VO_{2peak} from PACER performance that is now used in the latest edition of the FITNESSGRAM software (60). From a total sample of 244 youth (10–16 years old), 174 participants were used for the development and validation of the new equation and 70 participants for cross-validation. The total number of laps completed was recorded following the PACER test and VO_{2peak} was determined from a treadmill GXT for each participant. A multiple regression analysis yielded PACER laps, gender, age, and BMI to be significant predictors of VO_{2peak}. After cross-validation, VO_{2peak} estimated (44.1 $\pm$6.9 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$) from the FITNESSGRAM equation was significantly correlated (r = 0.75, SEE = 6.17 $ml \cdot kg^{-1} \cdot min^{-1}$) to measured VO_{2peak} (43.9 $\pm$9.5 $ml \cdot kg^{-1} \cdot min^{-1}$). Although, the updated FITNESSGRAM software utilizes the new equation (34), this change has not been reflected in the most recent FITNESSGRAM manual (60); therefore, the Leger et al. equation is still widely used and supported.

Because the PACER involves running and is a multistage progressive fitness test, VO_{2peak} values estimated from PACER performance are most often compared to those measured in the laboratory during a treadmill graded exercise test (GXT) (4, 9, 27, 29). Lui et al. (30) cross-validated the Leger et al. equation in a sample of forty-eight 12 to 15 year olds and reported no significant difference between laboratory measured VO_{2peak} (49.97 $\pm$7.59 $ml \cdot kg^{-1} \cdot min^{-1}$) and PACER estimated values (48.72 $\pm$5.72 $ml \cdot kg^{-1} \cdot min^{-1}$) and a significant correlation of 0.72. Barnett et al. (4) reported similar results in Chinese students (n= 55; 12 to 17 years old). The correlation between estimated and measured VO_{2peak} was 0.72 and a standard error of 5.4 $ml \cdot kg^{-1} \cdot min^{-1}$; investigators also reported a significant correlation (0.74) between measured VO_{2peak} in the laboratory and maximal speed attained from the PACER. However, a lower correlation (r= 0.54) was reported between VO_{2peak} estimated from the Leger et al. equation and compared to values measured during a treadmill GXT by Armstrong et al. (3) for 11-14 year old males.

More recently, Winsley (62) examined the validity of the Leger et al. equation in youth 5 to 16 years old. VO_{2peak}, estimated from PACER performance, was not significantly different than VO_{2peak} measured during a treadmill GXT. However, Winsely (62) reported an underestimation (-3.0 $ml \cdot kg^{-1} \cdot min^{-1}$) of VO_{2peak} in boys and overestimation (1.0 ml•kg^{-1}•min^{-1}) in girls that could result in a potential error ranging between -19.0 to 13.0 ml•kg^{-1}•min^{-1} for boys and -9.0 to 11.0 ml•kg^{-1}•min^{-1} for girls. The equation has also been tested in 132 Japanese children. Matsuzaka et al. (38) reported no significant difference between VO_{2peak} predicted from PACER performance using the Leger et al. equation compared to direct measurement during a treadmill GXT for boys or girls (52.5 $\pm$5.7 vs. 54.2 $\pm$6.2 ml•kg^{-1}•min^{-1}, 46.4 $\pm$6.9 vs. 46.7 $\pm$6.7 ml•kg^{-1}•min^{-1}; predicted vs. measured for boys, girls; respectively).

The Influence of Weight Status

While the accuracy of the Leger et al. prediction equation has been validated in various populations (9, 37, 38) and in several age groups (41, 42) only two studies have addressed the influence of weight status on the accuracy of the equation. Suminski et al. (55) tested the validity of the Leger et al. equation in a sample of Hispanic youth where 64.8% (n=81) were normal weight and 35.2% (n=44) were overweight according to BMI-for-age and sex. There was no significant difference for either normal or overweight groups between VO_{2peak} values measured during a treadmill GXT and estimated from the PACER, with the difference between measured and estimated being 0.62 ml•kg^{-1}•min^{-1} for the normal weight group and 1.07 ml•kg^{-1}•min^{-1} for the overweight group. Ihaz et al. (23) conducted a study to determine whether a modified PACER would improve the prediction accuracy. Normal weight (n=16) and overweight (n=15) participants completed the PACER test, a modified PACER (15m), and a treadmill GXT. Although VO_{2peak} was significantly higher in the normal weight group (44.6+4.7 vs.

$39.4{+}3.7$ ml•kg^{-1}•min^{-1}), there were no significant differences between estimated VO_{2peak} and actual VO_{2peak} for either protocol. Additionally, there were there no significant differences in HR_{peak} across the three tests for either group. It appears that weight status does not affect the validity of the Leger et al. equation to predict VO_{2peak} when compared to measured values attained during a treadmill GXT.

While the Leger et al. equation appears accurate, despite the range of correlation coefficients, researchers argue whether the criterion-related validity of the Leger et al. equation has truly been examined (42, 53). Ruiz et al. (53) suggests the variability of the prediction equation could be due to the physiological differences of forward locomotion in treadmill running and the start-stop pattern of shuttle running. To test the accuracy of the prediction equation, VO_{2peak} measured via indirect calorimetry during the PACER is more ecologically valid than comparing estimates VO_{2peak} obtained during a treadmill GXT, since the equation was developed from measured values upon completing the PACER using the Douglas Bag Method (42). Currently, the three studies (33, 42, 53) involving youth that have used portable gas analyzers to obtain measured VO_{2peak} values during the PACER indicate varying degrees of accuracy and agreement between equations to estimate aerobic fitness from the PACER performance.

In studies conducted by Ruiz et al. (53) and Melo et al. (42), VO_{2peak} was measured while participants performed the PACER test for comparison against predicted values; however, these were not tested against values from a treadmill GXT.

In a sample of 48 adolescents (14 -15 y), mean VO_{2peak} measured during the PACER (47.1 $\pm$8.1 ml•kg^{-1}•min^{-1}) was significantly different than the mean VO_{2peak} (41.5 $\pm$5.2 ml•kg^{-1}•min^{-1}) estimated from the Leger et al. equation (53). The mean difference of 5.5 ml•kg^{-1}•min^{-1} reported by Ruiz et al. (53) is similar to the 4.7 ml•kg^{-1}•min^{-1} reported by Melo et al. in a sample of 8 to 10 year old children.

A study conducted by Mahar et al. (36) investigated the criterion related validity of the PACER as an assessment of aerobic fitness and the accuracy of the prediction equation by measuring VO_{2peak} during the PACER compared to a treadmill GXT in youth (n = 40) 15 to 16 years old. VO_{2peak} measured during the PACER was highly correlated (r = 0.84) with measured values from the treadmill GXT and mean values did not differ significantly (d = 1.4 ml•kg^{-1}•min^{-1}; p = 0.17). For the cross-validation of the Leger et al. equation, Mahar et al. (33) reported a correlation of 0.77 and SEE of 10.1 ml•kg^{-1}•min^{-1} between the estimated value and VO_{2peak} obtained during the PACER.

These researchers (36, 42, 53) caution the use of the Leger et al. prediction equation to estimate VO_{2peak} and note that estimations of group VO_{2peak} may be reasonable, however the accuracy of individual values is unacceptable. Both Melo et al. (42) and Ruiz et al. (53) reported an over-prediction in less fit participants and an under-prediction in more fit participants when compared to VO_{2peak} measured during the PACER. If this is the case, less aerobically fit children could be classified inappropriately and necessary interventions may be neglected.

CRITERION REFERENCE STANDARDS

The FITNESSGRAM employs criterion- referenced standards to evaluate paricipants' of aerobic fitness levels against the level necessary for good health (63). For health-related fitness testing, the criterion- referenced standard is established at the point where the participant is fit enough to be free of potential health risks and for children and adolescents the likelihood of becoming a healthy adult.

Zhu et al. (63) recognized the importance of accurate classification and its impact on an individual's perception of his or her health. Using data from the National Health and Nutrition Examination Survey (NHANES) and studies conducted by the National Center for Health Statistics (NCHS) aerobic fitness data was collected for a nationally representative sample of approximately 3300 students, aged 12-18 years (17). Students performed a submaximal treadmill test until a heart rate of 75% - 90% of age-predicted maximum was elicited then HR was extrapolated to predict VO_{2peak}. For boys, VO_{2peak} slightly increased with age from 12 to 15 (42 to 46 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$) and decreased with age for girls from 12 to 18 (39 to 37 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$) (17). Researchers developed age- and gender- specific percentiles of aerobic fitness for U.S. youth aged 12-18 years from the NHANES and NCHS studies that were used to develop the health and fitness criterion-referenced standards for the FITNESSGRAM test battery (63).

Classification Accuracy of the PACER Test

The FITNESSGRAM has established standards of aerobic fitness, in which children are classified into one of three categories (Healthy Fitness Zone (HFZ), Needs

Improvement - some risk (NI- some risk), Needs Improvement – higher risk (NI- higher risk) based on VO_{2peak} estimated from PACER performance (60). Using scores from the youth NHANES fitness data, changes in aerobic fitness that occur from childhood to adulthood, and adults aerobic fitness values associated with cardiovascular disease risk, Cureton developed the cut-off scores for the HFZ standards to indicate the level of aerobic fitness associated with reduced risk of disease and mortality (13, 63).
These scores have been supported by further research of aerobic fitness and health- risk factors in children (61).

The reliability of the (HFZ) standards for aerobic fitness have been documented in the literature where youth performed the PACER test on two or more occasions and were classified in the HFZ, NI- some risk, or NI- higher risk. In a sample of 165 boys and 76 girls, Beet and Pitetti (5) found that 81% of boys and 79% of girls were classified the same on both occasions. In a study conducted by Mahar et al. (35), 89% of 10 to 11 year olds (n = 213) were consistently classified after performing two PACER tests. The results from these studies indicated the PACER's ability to reliably classify fitness in youth.

A few studies have investigated aerobic fitness classification and PACER performance. The potential of misclassification, HFZ or Needs Improvement Zone (NIZ) , depends upon the accuracy of the Leger et al. and FITNESSGRAM equations. Mahar et al. (36) examined the criterion-referenced validity by comparing the fitness category associated with the participant's estimated VO_{2peak} to the appropriate zone for the measured VO_{2peak}. Using the Leger et al. equation a total of 36% of participants were placed in the wrong category. The FITNESSGRAM prediction equation slightly improved the classification with 17% of participants inaccurately placed in the HFZ and 13% in the NIZ (36). Although the majority of youth are classified in the appropriate aerobic fitness category, the error of a false-positive (and unfit individual classified as fit) may be critical to the development of a plan or prescription to either maintain or improve an individual's aerobic fitness as it relates to health and disease risk (13, 63). Because the equations tend to overestimate VO_{2peak} in unfit youth, the child's weight status may also influence the classification and potentially lead to a false-positive error. Although the standards shifted the focus to health, instead of performance, additional research is needed to address the validity of the HFZ standards as it relates to aerobic fitness classification and PACER VO_{2peak} estimated from either equation.

SUMMARY

The PACER test is an easily administered, practical, and affordable field-based aerobic fitness assessment. Because of the popularity and prevalent use of PACER test it is critical that test administrators are aware of potential errors in predicting VO_{2peak} in order to provide participants with the most accurate results regarding their aerobic fitness level. Further research is needed to determine the influence of weight status (normal weight or overweight) on the accuracy of the equations used to predict VO_{2peak} and how the accuracy may affect fitness classification.

CHAPTER III
MANUSCRIPT

ABSTRACT

The FITNESSGRAM's Progressive Aerobic Cardiovascular Endurance Run (PACER) test is a commonly used field test to estimate peak oxygen uptake (VO_{2peak}) in youth. However, little research has been conducted to determine the influence of weight status on the accuracy of the equations used to estimate VO_{2peak}. **Purpose**: To assess the agreement between VO_{2peak} measured using indirect calorimetry during the PACER and estimated VO_{2peak} in normal weight and overweight youth and to determine the influence of weight status on the accuracy of estimated VO_{2peak} in 10-15 year old youth. **Methods**: The study included 101 participants that were classified as normal weight (n=78) or overweight (n=23) according to BMI percentiles for age and sex. Participants completed the PACER, a progressive, multistage, 20-meter shuttle run to volitional exhaustion. VO_{2peak} was measured during the PACER test using a portable gas analysis system (Oxycon Mobile, CareFusion, Inc.). Estimated VO_{2peak} values were calculated based on PACER performance using the Leger et al. and Mahar et al. equations. Paired samples t-tests were used to determine if significant differences existed between estimated and measured VO_{2peak}. Independent t-tests were performed to compare the normal weight and overweight groups. Accuracy was determined using Bland-Altman plots. **Results**: The Leger et al. (44.3 $\pm$4.6 $ml \cdot kg^{-1} \cdot min^{-1}$) and Mahar et al. (46.8 $\pm$4.8 $ml \cdot kg^{-1} \cdot min^{-1}$) estimated values were significantly lower than measured VO_{2peak} (49.0 $\pm$8.7 $ml \cdot kg^{-1} \cdot min^{-1}$) in the normal weight group. There were no significant differences between measured

VO_{2peak} (38.8 $\pm$7.1 ml•kg^{-1}•min^{-1}) and predicted values (40.5 $\pm$2.5 and 38.2 $\pm$6.1 ml•kg^{-1}•min^{-1}; Leger et al. and Mahar et al., respectively) for the overweight group. For the normal weight group, the standard error of the estimate (SEE) was 5.44 ml•kg^{-1}•min^{-1} (Leger) and 5.33 ml•kg^{-1}•min^{-1} (Mahar). The SEE was 5.77 ml•kg^{-1}•min^{-1} (Leger) and 4.54 ml•kg^{-1}•min^{-1} (Mahar) for the overweight participants.

Conclusions: It appears that the prediction of VO_{2peak} from either equation based on PACER performance varies among weight status group and may be inaccurate for normal weight youth, but acceptable for overweight youth.

INTRODUCTION

Aerobic fitness is a health-related fitness component associated with cardiovascular disease risk factors and other health outcomes during childhood (16) and adulthood (7). Children with low aerobic fitness are at a greater risk for developing cardiovascular disease risk factors including hypertension, dyslipidemia, diabetes, and obesity (14, 18). Currently, 31.9% of U.S. youth (2-19 y) are considered overweight and 16.9% obese based on BMI for age and sex (45). The aerobic fitness levels of overweight and obese youth are usually lower compared to their normal weight counterparts (24). Improving or maintaining aerobic fitness may reduce overweight and obesity rates and improve their cardiovascular disease risk profiles (16).

Peak oxygen consumption (VO_{2peak}) reflects the ability of cardiorespiratory system to transport oxygen during strenuous exercise (51) and is considered to be an objective measure of aerobic fitness in youth (53). Because of the related health implications, affordable, non-invasive field tests providing an estimate of VO_{2peak} have been developed and included in youth fitness evaluations.

The FITNESSGRAM's Progressive Aerobic Cardiovascular Endurance Run (PACER) is a multi-stage, 20-meter shuttle run frequently used in physical education classes or community settings to estimate VO_{2peak} and classify aerobic fitness level. There are two equations commonly used to estimate VO_{2peak} from PACER performance. In 1988, Leger et al. (27) developed an equation that predicts VO_{2peak} in youth based on the participant's age and maximal speed attained in the final stage of the test. More recently, Mahar et al. (34) developed an equation that includes number of laps completed on the PACER, body mass index (BMI), age, and gender. The most recent FITNESSGRAM software (web-based, version 9.2), applies the Mahar et al. equation. However, previous versions still in service utilize the Leger et al. equation.

Although, the PACER test has been established as a valid and reliable field test of aerobic fitness (4, 30, 36, 58), few studies have addressed the influence of weight status on predicting VO_{2peak} in children. Since aerobic fitness values tend to be lower in overweight children compared to values seen in normal weight children (24), the accuracy of predicting VO_{2peak} may be influenced if the child is overweight.

As a part of the FITNESSGRAM test battery, children are placed into one of two fitness categories, Needs Improvement (NI) or in the Healthy Fitness Zone (HFZ), based on the estimated VO_{2peak} values that are compared to criterion-referenced standards. Therefore, the accuracy of the equations is critical for appropriate classification. Melo et al. (42) reported that VO_{2peak} was over-predicted in less fit participants and under-predicted in more fit participants compared to VO_{2peak} measured via indirect calorimetry during the PACER. If this is the case, less aerobically fit children could be classified inappropriately and necessary interventions may be neglected. The error of a false-positive (an unfit individual classified as fit) may be critical to the development of a plan or prescription to either maintain or improve an individual's aerobic fitness as it relates to health and disease risk (13, 63).

Therefore, the purpose of this study is to assess the agreement between VO_{2peak} measured during the PACER and estimated VO_{2peak} in normal weight and overweight youth and to determine the influence of weight status on the accuracy of VO_{2peak} estimated from the PACER.

METHODS

Subjects

Participants were recruited from the Knoxville, TN community via flyers, word-of-mouth, and discussion forums. The sample included 101 youth, 56 boys (12.4 ± 1.6 y) and 45 girls (13.0 ± 1.7 y) that volunteered for the study. Participants were “apparently healthy” (without diagnosed disease or illness) and free of any orthopedic issues that may limit running performance. Written parental permission and participant assent were obtained prior to data collection. The study was approved by the Institutional Review Board at the University of Tennessee, Knoxville.

Procedures

All participants were required to fast at least 4 hours prior to testing. Height (to the nearest 0.1 cm) and weight (to the nearest 0.01 kg) were measured, and body mass index was calculated (BMI; $kg \bullet m^{-2}$). Participants with a BMI < 85th percentile for age and sex were classified in the normal weight group (n=78). Due to the low number (n = 2) of participants classified as underweight (BMI < 5th percentile for age and sex), underweight and normal weight groups were combined. Participants $\geq$ 85th percentile were classified in the overweight group (n=23) (44). Blood pressure was measured prior to the aerobic fitness assessment. Body composition was assessed using air displacement plethysmography (BOD POD; COSMED USA Inc., Concord, CA), and child specific-equations were used to estimate thoracic gas volume (19).

PACER Test

The PACER test was administered according to guidelines in the FITNESSGRAM & ACTIVITIYGRAM *Test Administration Manual* (43). Participants ran 20-meter shuttles back and forth between cones. The initial speed began at 8.5 $km \cdot h^{-1}$ and progressively increased by 0.5 $km \cdot h^{-1}$ each minute. Running pace was kept in time with signals played from an audio CD player; the same CD and CD player were used throughout the study. Participants were encouraged to run as long as possible, and testing was stopped when the participant reached volitional fatigue or could not maintain the required pace for two consecutive shuttles. Using the Children's OMNI Scale (56), participants were asked to report their peak rating of perceived exertion (RPE_{peak}) upon stopping the test.

The PACER test was conducted in a recreational gymnasium on a wooden floor or in a spacious hallway on a smooth tile surface. If needed, a researcher ran alongside participants to aid with pacing. A single researcher conducted all of the PACER tests and all participants received verbal encouragement from the researcher.

Physiological Measurements

During the PACER test, heart rate was monitored continuously via telemetry (Polar T31 coded transmitter) and inspired and expired gases were analyzed breath-by-breath with the Oxycon Mobile respiratory exchange gas analysis system (CareFusion, Inc., San Diego, CA) (50). Before each test, the gas analyzers were calibrated using a certified calibration gas mixture (4% CO_2, 16%O_2; CareFusion, Inc.) as well as gas flow and volume using the automatic volume calibration unit. Subjects were fitted with a Hans Rudolph, 8900 series nasal and mouth breathing mask (Hans Rudolph Inc., Kansas City, US) and vest containing the portable device. To determine if peak effort was achieved, at least two of the following criteria had to be fulfilled: (1) peak heart rate (HR_{peak}) greater than or equal to 195 beats per minute, (2) peak respiratory exchange ratio (RER_{peak}) greater than or equal to 1.05, or (3) subjective signs of fatigue (excessive sweating, dyspnea, unsteady gait, etc.) (48). HR_{peak} was recorded as the highest value in the final completed stage. VO_{2peak} and RER_{peak} values were averaged over the last 30-seconds of the final completed PACER stage.

Prediction Equations

For comparison purposes, VO_{2peak} was estimated from the PACER test using both the Leger et al. and Mahar et al. equations. [Leger et al. (27) equation: VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) = 31.025 + 3.23 (($km \cdot h^{-1}$) – 3.248 (years) + 0.1536 ($km \cdot h^{-1}$)(years)] (27). [Mahar et al. (34) equation: VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) = 41.77 + 0.49(laps) – 0.0029(laps)^2 – 0.62(BMI) + 0.35(gender •age)].

Data Analysis

Means and standard deviations were calculated for all variables. Independent t-tests were performed to compare participant characteristics and data collected from the

PACER test (HR_{peak}, RER_{peak}, $VO_{2peak,}$ RPE_{peak}, Leger estimated VO_{2peak}, and Mahar estimated VO_{2peak}) between the normal weight and overweight groups.

Paired samples t-tests were used to determine if significant differences existed between estimates of VO_{2peak} and measured VO_{2peak}. The error in predicting VO_{2peak} from the Leger equation and the Mahar equation was described for each group by the standard error of the estimate (SEE). Bland- Altman plots were constructed to assess agreement between VO_{2peak} estimated from both equations and VO_{2peak} measured during the PACER.

The Healthy Fitness Zone (63) criterion referenced standards currently used in the FITNESSGRAM test battery were used to classify VO_{2peak} values as Needs Improvement (NI) or in the Healthy Fitness Zone (HFZ). The percentage of youth who were inaccurately classified based on estimated VO_{2peak} values was also calculated.

Statistical analyses were performed using SPSS version 19.0 (IBM, SPSS Inc., Chicago, IL). An alpha value of $p \leq 0.05$ was assumed to show statistical significance.

RESULTS

Participant characteristics are presented in Table 1. Independent t-tests indicated weight, BMI, and percent body fat were significantly greater in the overweight participants compared to the normal weight group. Means and standard deviations for the variables assessed during the PACER test are presented in Table 2. There were no significant differences in HR_{peak}, $RER_{peak,}$ and RPE_{peak} between groups. However, measured VO_{2peak} and the number of PACER laps completed were significantly lower in the overweight group. Also, both the Leger et al. and Mahar et al. predicted VO_{2peak} values were significantly lower in the overweight group (40.5 and 38.2 $ml \cdot kg^{-1} \cdot min^{-1}$) compared to predicted values in the normal weight group (44.3 and 46.8 $ml \cdot kg^{-1} \cdot min^{-1}$).

TABLE 1. Participant characteristics [Mean (SD)]

Variables	**Normal Weight** (n=78)	**Overweight** (n=23)	**Total** (n=101)
Age (y)	12.7 (1.6)	12.5 (1.6)	12.6 (1.6)
Height (cm)	155.2 (12.4)	156.7 (10.2)	155.6 (11.9)
Weight (kg)	46.3 (10.9)	64.6 (14.7)**	50.5 (14.1)
BMI ($kg \cdot m^{-2}$)	18.9 (2.1)	26.1 (4.6)**	20.5 (4.2)
Body Fat (%)	15.9 (8.1)	31.3 (9.3)**	19.4 (10.5)

** Significantly different from normal weight group; $p \leq 0.01$

TABLE 2. Variables assessed during the PACER test [Mean (SD)]

Variables	**Normal Weight** (n=78)	**Overweight** (n=23)	**Total** (n=101)
HR_{peak} ($b \cdot min^{-1}$)	195 (15)	195 (10)	195 (14)
RER_{peak}	1.1 (0.1)	1.1 (0.1)	1.1 (0.1)
RPE_{peak}	7.7 (1.4)	7.8 (1.4)	7.7 (1.4)
Measured VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$)	49.0 (8.7)	38.8 (7.1)**	46.7 (9.4)
PACER Laps	41 (18)	26 (10)**	37 (17)

** Significantly different from normal weight group; $p \leq 0.01$

Measured and predicted VO_{2peak} values for both weight groups are included in Table 3. In the normal weight group, there was a significant correlation between measured VO_{2peak} and Leger predicted VO_{2peak} (r= 0.78, $p < 0.01$) and between measured VO_{2peak} and Mahar VO_{2peak} (r= 0.79, $p < 0.01$). Significant correlations were also found between measured VO2peak and predicted values for the overweight group [r= 0.61, *p*

< 0.05 (Leger); r= 0.78, $p < 0.01$ (Mahar)]. For the normal weight group, VO_{2peak} estimated from both the Leger et al. and Mahar et al. equations were significantly lower than measured VO_{2peak}. In the normal weight youth the Leger et al. equation yielded a SEE of 5.44 ml•kg^{-1}•min^{-1}. The SEE for the Mahar et al. equation was slightly better in the normal weight group (5.33 ml•kg^{-1}•min^{-1}). For the overweight participants, there were no significant differences between measured VO_{2peak} and predicted values from either equation. The SEE for the Leger et al. equation was 5.77 ml•kg^{-1}•min^{-1} and 4.54 ml•kg^{-1}•min^{-1} for the Mahar et al. equation. For the total sample, the Leger et al. equation significantly underestimated VO_{2peak} and the SEE was 5.77 ml•kg^{-1}•min^{-1}. The Mahar et al. equation also significantly underestimated VO_{2peak} and the SEE was 5.26 ml•kg^{-1}•min^{-1} for the groups combined.

TABLE 3. Measured and estimated VO_{2peak} values for each group [Mean (SD)]

Group	**Measured VO_{2peak}** (ml•kg^{-1}•min^{-1})	**Leger VO_{2peak}** (ml•kg^{-1}•min^{-1})	**Mahar VO_{2peak}** (ml•kg^{-1}•min^{-1})
Normal Weight (N=101)	49.0 (8.7)	44.3 (4.6)**	46.8 (4.8)**
Overweight (n=23)	38.8 (7.1)	40.5 (2.5)	38.2 (6.1)
Combined (n=78)	46.7 (9.4)	45.3 (4.5)**	44.8 (6.2)**

** Significantly different from measured VO_{2peak}; $p \leq 0.01$

The Bland-Altman plots for both equations are presented for the normal weight (Figure 1) and overweight (Figure 2) groups. The plots show that the Leger et al. equation results in VO_{2peak} values that are 4.77 ml•kg^{-1}•min^{-1} lower (for normal weight) and 1.69 ml•kg^{-1}•min^{-1} higher (for overweight) than values measured via gas analysis during the PACER. The Mahar et al. equation estimates VO_{2peak} values that are 2.25

ml•kg^{-1}•min^{-1} and 0.60 ml•kg^{-1}•min^{-1} lower than measured values for normal weight and overweight groups, respectively.

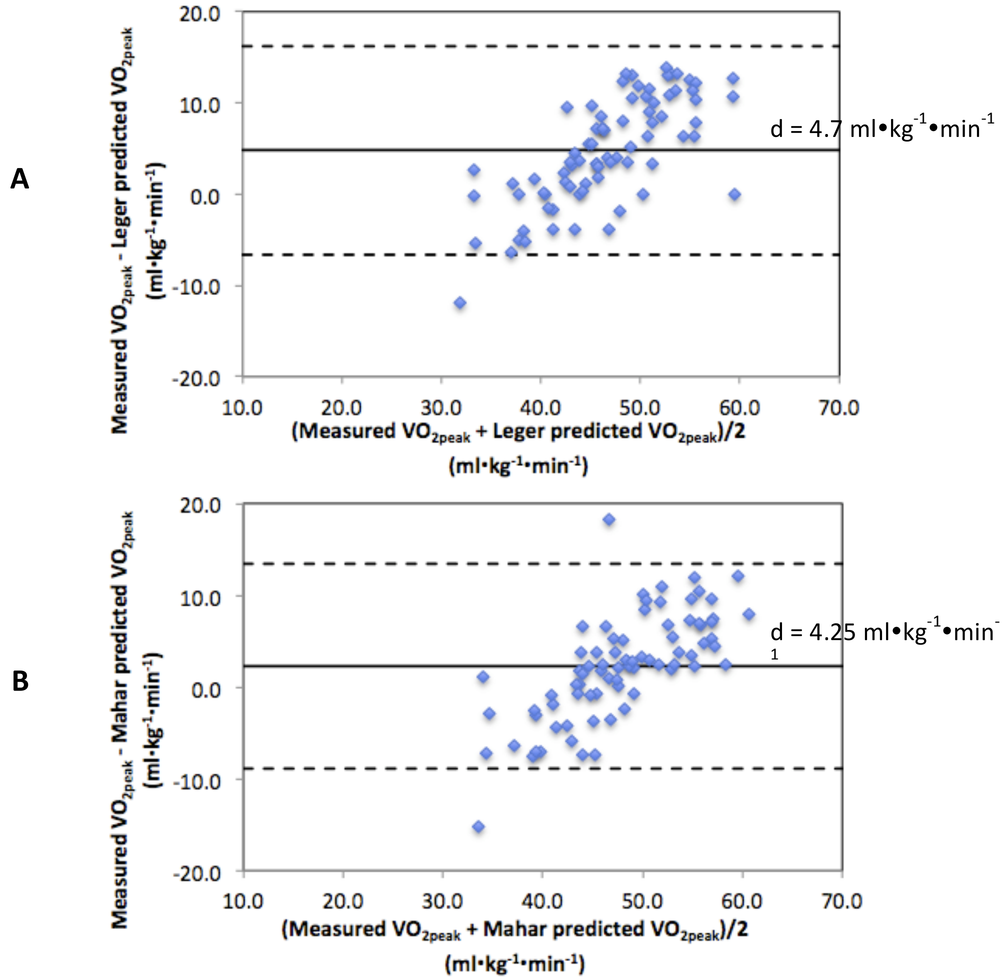

FIGURE 1. Bland Altman plots depicting agreement between measured VO_{2peak} and (A) Leger predicted VO_{2peak} and (B) Mahar predicted VO_{2peak} for normal weight participants.

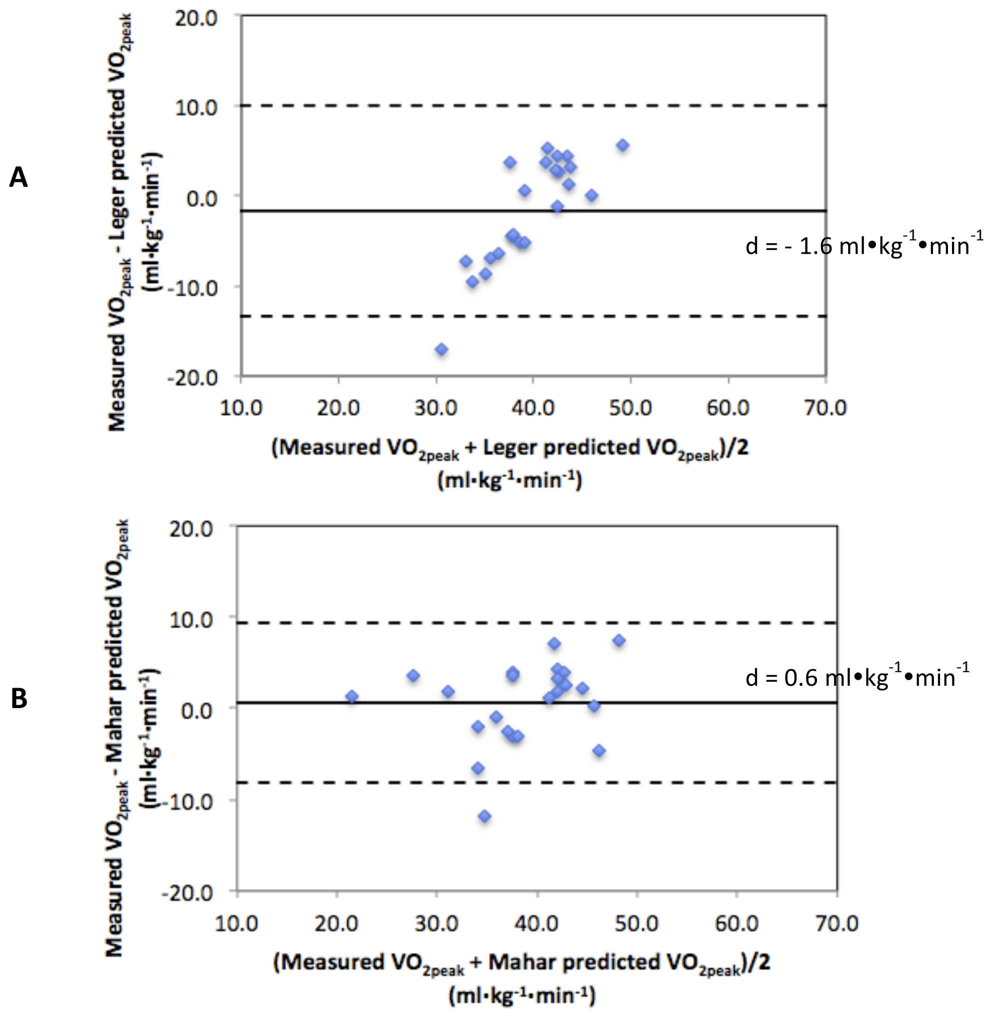

FIGURE 2. Bland Altman plots depicting agreement between measured VO_{2peak} and (A) Leger predicted VO_{2peak} and (B) Mahar predicted VO_{2peak} for overweight participants.

From the total sample, 76.2% of participants' measured VO_{2peak} values fell at or above HFZ threshold. A greater percentage of overweight youth (52.2%) fell in the NI category using measured VO_{2peak} values compared to the normal weight group (15.4%). When participants were classified based on VO_{2peak} estimated from the Leger et al. equation, it was determined that 12.8% of normal weight and 21.7% of overweight youth were classified inappropriately. This error decreased slightly when children were classified based on the Mahar et al. equation; however, 12.8% of normal weight and 17.4% of the overweight children were still misclassified.

DISCUSSION

VO_{2peak} values estimated from PACER performance using the Leger et al. equation and the Mahar et al. equations are commonly compared to VO_{2peak} values measured during a treadmill GXT. Researchers argue that comparing predicted values to treadmill VO_{2peak} values does not truly test the validity of the equations (42, 53). Ruiz et al. (53) suggests the error associated with the prediction equation could be due to the physiological differences of forward locomotion in treadmill running and the start-stop pattern of shuttle running. Therefore, in the current study, VO_{2peak} was measured via indirect calorimetry during the PACER to assess both equations and the influence of weight status on the accuracy of predicting VO_{2peak}.

From the results, it appears that the prediction of VO_{2peak} from PACER performance in youth varies among weight status groups using both the Leger and Mahar equation. Although there is a significant correlation between measured VO_{2peak} and predicted VO_{2peak} values for both groups, individual estimations may not be appropriate for normal weight youth. The results indicate that both the Leger and Mahar equations significantly underestimate VO_{2peak} in normal weight youth; however, there was no significant difference between measured and predicted VO_{2peak} values for overweight youth.

Previous studies have also found that the Leger equation underpredicts VO_{2peak} in more fit youth. Ruiz et al. (53) reported VO_{2peak} values of 47.1 ml•kg^{-1}•min^{-1} (measured during the PACER) and 41.5 ml•kg^{-1}•min^{-1} (Leger estimated) in 14 and 15 year old youth that are similar to the 46.7 ml•kg^{-1}•min^{-1} (measured) and 43.4 ml•kg^{-1}•min^{-1} (Leger estimated) values of the current study. In younger participants (8-10 y), Melo et al. (42) also reports an underestimation of VO_{2peak} with the Leger equation and reported a SEE of 4.7 ml•kg^{-1}•min^{-1} for the Leger et al. equation, which is slightly lower than values in the present study (SEE = 5.77 ml•kg^{-1}•min^{-1}; combined groups).

Other studies have reported that VO_{2peak} is overestimated in less fit youth (42, 53, 63). However, these comparisons were made against VO_{2peak} values determined during a treadmill GXT. Our results indicate no significant difference between estimated and measured VO_{2peak} values for overweight youth. Compared to VO_{2peak} measured while the participants performed the PACER, both the Leger and Mahar equations appear to be accurate in predicting VO_{2peak} for overweight youth. In a sample of Hispanic youth, Suminski et al. (55) reported no significant difference between VO_{2peak} values measured during a treadmill GXT and estimated from the Leger equation in overweight participants (d=1.07 ml•kg^{-1}•min^{-1}). This is similar to the mean difference (d) in the current study of -1.69 ml•kg^{-1}•min^{-1} between VO_{2peak} measured during the PACER and the Leger et al. estimated value.

The accuracy of estimating VO_{2peak} from either prediction equation is crucial for determining the participant's appropriate fitness classification. The FITNESSGRAM has established standards of aerobic fitness, in which children are classified into the HFZ or NI category based on their age, sex, and VO_{2peak} estimated from PACER performance using either the Leger or Mahar equation. If the estimated VO_{2peak} value does not reflect the child's actual VO_{2peak} there is potential for a classification error. In the present study, 12.8% of normal weight, 21.7% of overweight, and 15.0% of all participants were misclassified based on estimations of VO_{2peak} from the Leger et al. equation. For the whole sample, 7.0% were classified into the HFZ based on the Leger estimate when their measured VO_{2peak} was not in the HFZ. VO_{2peak} estimated with the Mahar et al. equation slightly decreased the error with 12.8% of normal weight, 17.4% of overweight, and 13.9% of the total participants classified incorrectly. However, the Mahar estimate resulted in 8.9% of participants classified within the HFZ when their measured VO_{2peak} was in the NI category. In a field setting, these youth could have potentially been overlooked for an aerobic fitness intervention due to misclassification.

Strengths of the present study include the moderate sample size and a similar number of boys and girls within each group (normal weight: 44 boys, 34 girls; overweight: 12 boys, 11 girls). Future investigations regarding the influence of weight status and the accuracy of the Leger et al. and Mahar et al. equations are needed across various race/ethnicities and different age groups. An additional strength of the study is the measurement of VO_{2peak} during the PACER; using portable gas analyzers provides high criterion related validity for comparing measured and estimated values. Although efforts were made to oversample children with a BMI greater than or equal to the 85th

percentile, the small sample of overweight participants is a limitation of the study. Also, each participant completed a single PACER test; multiple assessments would reveal the reliability of PACER performance and estimating VO_{2peak} in this sample. However, all participants met at least two of the established criteria to verify that peak effort was achieved and a reliable measure of VO_{2peak} was obtained. In addition, previous research indicates that a single test is adequate due to high test-retest reliability of the PACER (30, 60).

In conclusion, both the Leger and Mahar equations provide acceptable estimations of VO_{2peak} for overweight youth but significantly underestimate VO_{2peak} in their normal weight counterparts. For both groups, VO_{2peak} values predicted from the Mahar equation resulted in a smaller mean difference and SEE than the Leger equation. Improving VO_{2peak} estimations for weight status groups should be explored in future research as well as developing strategies to minimize fitness classification error. Test administrators should be cautious when classifying youth aerobic fitness levels based on the predicted values, since error classification is associated with both equations. Until more accurate estimations are available, administrators and educators should promote the importance of healthy aerobic fitness levels for all youth and provide effective programming to improve and maintain aerobic fitness for every student.

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APPENDICES

APPENDIX A
Peak Exercise Responses

TABLE 4. Ability of the PACER to elicit peak exercise responses in youth
Participant Characteristics [Mean (SD)]

	Boys (n=20)	Girls (n=25)	Total (n=45)
Age (yr)	12.7 (1.6)	12.7 (1.8)	12.7 (1.7)
Weight (kg)	49.0 (13.8)	52.7 (16.6)	51.1 (15.4)
Height (cm)	157.7 (15.0)	153.7 (11.2)	155.5 (13.0)
Body Mass Index (kg•m2)	19.3 (2.7)	22.0 (5.6)	20.8 (4.7)
Body Fat (%)	12.8 (6.4)	28.8 (9.3)*	21.5 (11.4)

* Significantly different from boys, P < 0.05

TABLE 5. Ability of the PACER to elicit peak exercise responses in youth
Peak Values during Treadmill GXT and PACER [Mean (SD)]

	HR_{peak} (b•min^{-1})		RER_{peak}		VO_{2peak} (ml•kg^{-1}•min^{-1})		RPE_{peak}	
	Treadmill GXT	PACER	Treadmill GXT	PACER	Treadmill GXT	PACER	Treadmill GXT	PACER
Boys	196 (9.3)	199 (6.7)	1.11 (0.08)	1.10 (0.04)	51.0 (6.7)	52.6 (7.4)	8.6 (0.96)	8.6 (1.3)
Girls	197 (8.4)	196 (10.3)	1.14 (0.08)	1.13 (0.09)	40.1 (7.9)*	40.5 (8.9)*	8.2 (1.1)	8.0 (1.3)
Total	197 (8.7)	197 (8.9)	1.13 (0.08)	1.12 (0.08)	45.0 (9.1)	45.9 (10.2)	8.4 (1.1)	8.3 (1.3)

* Significantly different from boys, *P* < 0.05

APPENDIX B
Validation Parameters

TABLE 6. Validation parameters of estimated VO_{2peak} values by group [Mean (SD)]

	Measured VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$)	**Leger et al. VO_{2peak}** ($ml \cdot kg^{-1} \cdot min^{-1}$)	**t**	**r**	**d**	**SEE**
Normal Weight	49.0 (8.7)	44.3 (4.6)**	7.23*	0.78**	4.77	5.44
Overweight	38.8 (7.1)	40.5 (2.5)	-1.36	0.61*	-1.69	577
Combined	46.7 (9.4)	45.3 (4.5)**	5.16*	0.79**	3.30	5.77
	Measured VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$)	**Mahar et al. VO_{2peak}** ($ml \cdot kg^{-1} \cdot min^{-1}$)	**t**	**r**	**d**	**SEE**
Normal Weight	49.0 (8.7)	46.8 (4.8)**	3.50*	0.79**	2.25	5.33
Overweight	38.8 (7.1)	38.2 (6.1)	0.63	0.78**	0.60	4.54
Combined	46.7 (9.4)	44.8 (6.2)**	3.45*	0.83**	1.87	5.26

* Significantly different from measured VO_{2peak}; $p \leq 0.01$

APPENDIX C
Parental Permission

Appendix B

Parental Permission Form

Permission for Child to Act as a Subject in a Research Study

The accuracy of the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to estimate aerobic fitness in youth.

Principal Investigator:

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Faculty Advisor:

Dawn P. Coe, Ph.D.
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University of Tennessee
Knoxville, TN 37996-2700
(865) 974-0294
dcoe@utk.edu

1. INTRODUCTION:

Your child is being given the opportunity to participate in this research study because s/he is apparently healthy and in the age range of 10 – 15 years. Your child will participate in exercise testing to determine aerobic fitness. Your child's participation in this research study is voluntary. Please read this permission form carefully and take your time making your decision to allow your child to participate. As the study staff discusses this permission form with you and your child, please ask him/her to explain any words or information that you or your child do not clearly understand. The nature of the research study, risks, and other important information about the research study are listed below.

The purpose of this research study is to determine how fit your child is using an exercise test commonly used in physical education classes.

The study will take place in the Applied Physiology Laboratory (APL) located at 1914 Andy Holt Avenue, Room 309 in the Health, Physical Education, and Recreation building (HPER) on the University of Tennessee, Knoxville campus.

Your child's participation in this study will involve one visit to the APL in the HPER building; the visit will last approximately two hours.

2. PROCEDURES TO BE FOLLOWED:

Blood Pressure Assessment
A cuff will be placed around your child's arm and air will be inflated into the cuff to determine your child's resting blood pressures.

Height and Weight
Your child's standing and seated height and body weight will be measured.

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Waist Measurement
A tape measure will be used to measure the distance around your child's waist.

Body Composition
During visit one, we will measure your child's body composition (the amount of muscle and fat) using the BOD POD. Your child will be asked to change into a swimsuit or athletic shorts and will then sit inside a chamber (BOD POD). Your child will need to sit very still and breathe normally for a few minutes during the testing.

Aerobic Fitness Test

Shuttle Run: Progressive Aerobic Cardiovascular Endurance Run
The purpose of this test is to estimate your child's fitness level. The Progressive Aerobic Cardiovascular Endurance Run (PACER) test is a shuttle run test that is used in many physical education classes. The test involves running 20-meter "laps" with music played from a CD. It starts with a slow jog and each minute your child will increase their pace. The test will end when your child cannot finish two laps in time with the music. Your child will perform this test in a gymnasium or hallway in the HPER building. The test will end when your child asks to stop or when your child is no longer able to continue safely. Your child may ask to stop the test at any time. During the test, your child's heart rate will be monitored using a belt around his or her chest. Your child will also wear a mask covering his/her mouth and nose to assess how much oxygen your child's body is using to make energy. Although your child's mouth and nose are covered with the mask, your child will still be able to breathe normally and talk during the test. Your child will also be asked how hard s/he feels that s/he is working during the test using a 0-10 scale. If your child has any pain or any abnormal response to the exercise test, the test will be stopped immediately. If s/he wishes to stop at anytime, your child can either ask to stop the test or simply stop running.

3. RISKS ASSOCIATED WITH PARTICIPATION:

Every effort will be made to minimize any discomforts or risks.

There are potential risks associated with the PACER test that may include lightheadedness, chest discomfort, leg cramps, falling, muscle sprain/strain, and abnormal blood pressure; these risks are similar to those of a physical education class. Additionally, there are some very rare (<1%) risks that include: irregular heart rates/rhythms, heart attack, stroke or death. This aerobic fitness test is a standard assessment used in pediatric exercise physiology laboratories and is safe for apparently healthy youth (no chronic diseases or health conditions). Personnel trained in first aid and pediatric CPR will be available during all testing sessions and emergency equipment (AED) will be readily available at all times to provide onsite care in the event of an emergency. A trained investigator will be conducting the exercise tests.

There is minimal risk associated with the heart rate monitors. The investigator will properly fit the Polar belt and apply anti-chaffing balm to your child before testing. Your child will only wear the belts during the exercise test (3-12 minutes) reducing the chances that irritation will occur.

4. BENEFITS ASSOCIATED WITH PARTICIPATION:

Your child will receive complimentary fitness testing and the results of these tests as a participant of the research study. Your child's participation in this research study may provide additional information regarding exercise testing and aerobic fitness in youth.

5. CONFIDENTIALITY:

All of your child's paper research records will be stored in locked file cabinets and will be accessible only to research personnel.

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All of your child's electronic research records will be computer password protected and accessible only to research personnel.

Your child's research records will be located on the University of Tennessee, Knoxville campus and will be labeled with a code. A master key that links your child's name with the code on your research record will be maintained at the local investigative site.

Your child will not be identified in any presentations or publications based on the results of the research study.

6. **PAYMENT FOR PARTICIPATION:**

Your child will receive a gift (approximately $7 value) for volunteering to be a part of this research study when all activities have been completed.

7. **TREATMENT FOR INJURY:**

You and your child are not waiving any legal rights or releasing the University of Tennessee, or its agents, from liability for negligence. In the event of physical injury resulting from research procedures, the University of Tennessee has not budgeted funds for compensation either for lost wages or for medical treatment. Therefore, the University of Tennessee does not provide for treatment or reimbursement for such injuries. No compensation will be available for any ancillary expenses incurred as a result of research related physical injuries, additional hospital bills, lost wages, travel expenses, etc.

If your child suffers a research-related injury, your study investigator will provide first aid and/or CPR no charges will occur care provided at the research site.

You and/or your insurance carrier will be billed for the costs of offsite care associated with the medical treatment of a research-related injury.

Additionally, no compensation will be available to subjects for any non-physical injuries that may be incurred as a result of research participation, such as exposure to criminal or civil liability, or damage to their reputation, financial standing, or employability.

8. **QUESTIONS:**

If you have any questions about this study, you may contact Dawn P. Coe, Ph.D. at (865) 974-0294. You may contact the Office of Research Compliance Officer at 865-974-3466 if you have any questions about your child's rights as a participant in this research study or your child's rights as a research subject.

9. **VOLUNTARY PARTICIPATION:**

Your child's participation in this research study is completely voluntary. Your child may choose not to participate or to drop out of the research study without any penalty or loss of benefits to which your child is otherwise entitled.
There is no direct cost to you for your child to participate in this research study. As a result of traveling to campus for the two visits, you will incur expenses related to your travel. We will provide you with a parking pass that can be used after 3pm to reduce the parking cost. If you decide to make your appointment before 3pm, you will be responsible for parking costs either at a garage or a parking meter on campus.

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10. PERMISSION OF SUBJECT:

You have read or have had read to you a description of the research study as outlined above. The investigator has explained the research study to you and has answered all the questions you have at this time. You knowingly and freely choose to allow your child to participate in the research study. A copy of this permission form will be given to you for your records.

____
Printed Name of Research Subject

______________________________ ________ ________
Signature of Parent/Guardian **Date** **Time**

____
Email Address of Parent/Guardian

____
Printed Name of Person Obtaining Permission

______________________________ ________ ________
Signature of Person Obtaining Permission **Date** **Time**

In my judgment, the subject or the legally authorized representative has voluntarily and knowingly given permission and possesses the legal capacity to give permission to participate in this research study.

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APPENDIX D
Subject Assent

Appendix C
Assent Form and Script

Assent Script

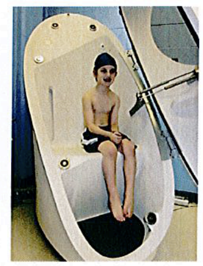
- ☐ Hello, my name is (insert name of researcher). I am a researcher and I study kids, activity, and body weight. Your mom, dad, guardian, etc. said it would be ok for you to help us out with some of these things. We are going to be doing some things for the next two hours. I will explain what you will be doing during this time, and if you have any questions about what I am talking about, please ask.

- ☐ We will start doing measurements in this room (APL) and in about forty-five minutes we will go downstairs to the basketball gym (HPER building) or to a large hallway.

- ☐ First, I will see how tall you are and how much you weigh. I will also measure around your belly.

- ☐ Next, I will take your blood pressure (show cuff). This cuff will be put around your arm, and I will put air into the cuff and it will become tight on your arm. Then, I will slowly let the air out. If it starts to hurt, I will take the cuff off.

- ☐ Next, I will ask you to put on this swimsuit and have you sit in this machine (BOD POD) I will need you to sit really still and breathe normally for about five minutes and we will do this two times. If you get uncomfortable in the machine, please let us know and we can stop the test and let you out of the machine.



- ☐ The next thing you are going to do is an exercise test. The purpose of this test is to see how strong your heart and lungs are.
    - o First we will put a belt around your chest, this belt will tell me how many times your heart beats. If the belt becomes uncomfortable tell me and I will fix it.

    - o Field Test PACER: We will go downstairs to the basketball gym (or hallway) for the shuttle test. This will be similar to something you would do in P.E. class at school. I am going to set up cones in the gym for you to run back and forth between. First, I will put a mask on you to see how much air you breathe in and out while you are running. If you become uncomfortable with this mask, please let me know and I will fix it. For this test music will be playing, we will listen to it first, so you will know what to do. We will start the music when you are ready, when the music starts playing you will start running. Try to get to the other cone before you hear the "beep". Each minute the music will "beep" three times to warn you that the music will get faster. I want you to run back and forth between the cones until you feel to tired to keep going. Tell me if you feel too tired, you will be able to stop and rest whenever you need to.

- ☐ Do you have any questions at this time? Please let me know if you become uncomfortable at any time or if you want to stop being in the study.

- ☐ Do you want to do this with me today?

Assent Form

The accuracy of the Progressive Cardiovascular Endurance Run (PACER) test to estimate aerobic fitness in overweight youth.

☐ The assent discussion was initiated on ____________(date) at _________ (time).

The information was presented in age-appropriate terms.

The minor: ____(Subject's Name)

☐ Agreed to take part in the study on _______________(date) at ____________ (time).
☐ Declined to take part in the study. The minor declined for the following reason(s):

____

● ●

☐ An assent discussion was not initiated with the minor for the following reason(s):

- ☐ Minor is physically incapacitated
- ☐ Minor is cognitively or emotionally unable to participate in an assent discussion
- ☐ Minor refused to take part in the discussion
- ☐ Other____

RESEARCHER/DESIGNEE STATEMENT: I hereby certify that I have discussed the research project with the research participant and/or his/her parent(s) or legal guardian(s). I have explained all the information contained in the permission document, including any risks that may be reasonably expected to occur. I further certify that the research participant was encouraged to ask questions and that all questions were answered.

____
Researcher/Designee Printed Name

______________________________ ______________ ______________
Researcher/Designee Signature Date Time (AM/PM)

____
Minor Subject Printed Name

______________________________ ______________ ______________
Minor Subject Signature (10-15 years) Date Time (AM/PM)

EXPEDITED REV.
OCT 6 2011 INITIALS B.Y.
UTK IRB
FWA 6629

APPENDIX E
Recruitment Flyers

Want to Know Your Fitness Level?

Are you a 10 to 15 year old boy or girl?

If so, you may qualify for a research study done by the University of Tennessee looking at youth weight status and aerobic fitness!

Qualifications

10-15 year old boy or girl
Apparently Healthy
(no diagnosed disease or health condition)
No Illness or Injuries

This study will involve two visits (2 hrs & 1 hr) to the exercise physiology lab at the University of Tennessee to complete a shuttle run and treadmill test to determine your fitness level!

Please contact
Stacy at (865) 974-5091
or aerobic@utk.edu

Want to Know Your Fitness Level?

Are you a 10 to 15 year old boy or girl?

If so, you may qualify for a research study done by the University of Tennessee looking at youth weight status and aerobic fitness!

Qualifications

10-15 year old boy or girl
Apparently Healthy
(no diagnosed disease or health condition)
No Illness or Injuries

This study will involve one visit (1.5 hrs) to the exercise physiology lab at the University of Tennessee to complete a shuttle run and determine your fitness level!

Please contact
Stacy at (865) 974-5091
or aerobic@utk.edu

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APPENDIX F
Institutional Review Board Approval

THE UNIVERSITY of TENNESSEE
Institutional Review Board
Office of Research
1534 White Avenue
Knoxville, TN 37996-1529
Phone: 865.974.3466
Fax: 865.974.7400

June 29, 2011

IRB#: 8584-B

Title: The accuracy of the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to estimate aerobic fitness in youth.

Stacy N. Scott
Kinesiology, Recreation, and Sport Studies
309 HPER Bldg.
Campus

Dawn P. Coe
Kinesiology, Recreation and Sport Studies
338 HPER Bldg.
Campus

Your project listed above was reviewed by the University of Tennessee, Knoxville IRB and has been granted **Conditional Approval** pending receipt of approval letters from participating organizations. The following conditions of approval will be in effect upon receipt of those letters of approval.

This approval is for a period ending one year from the date of this letter. Please make timely submission of renewal or prompt notification of project termination (see item #3 below).

Responsibilities of the investigator during the conduct of this project include the following:

1. To obtain prior approval from the Committee before instituting any changes in the project.
2. To retain signed consent forms from subjects for at least three years following completion of the project.
3. To submit a Form D to report changes in the project or to report termination at 12-month or less intervals.

The Committee wishes you every success in your research endeavor. This office will send you a renewal notice (Form R) on the anniversary or your approval date.

Sincerely,

Brenda Lawson

Brenda Lawson
Compliances

VITA

Stacy Nicole Scott was born on March 18, 1988 to David and Donna Scott. In May 2006, she graduated from Houston High School in Germantown, Tennessee. In the fall of 2006, she moved to Knoxville, Tennessee to begin her undergraduate education at the University of Tennessee. From 2006 to 2010 she was an active sorority member of Alpha Omicron Pi. She graduated in May of 2010 with a Bachelor's degree of Science in Education with a concentration in Exercise Science. A "Volunteer for Life", Stacy decided to continue her education at the University of Tennessee. Since the fall of 2010, she has worked as a Graduate Teaching Associate in the Physical Education Activity Program and will graduate in May of 2012 with a Master of Science degree in Kinesiology, with a concentration in Exercise Physiology. Stacy hopes to pursue a career in the field of exercise physiology working with children and promoting physical activity through a healthy lifestyle.