THE PREDICTIVE VALIDITY OF
A NINE MINUTE RUN TO PEAK $\dot{V}O_2$
IN CHILDREN AGED 11-14

A Thesis Presented

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ABSTRACT

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Thirteen boys and 12 girls were assessed for peak $\dot{V}O_2$ and the distance covered in a 9 min run (yds). Wt (kg), ht (cm), and age were also examined. Individual data for the boys and girls were substituted into predictive equations to predict peak $\dot{V}O_2$ developed by Baldwin (1983) and Kreun (1984), respectively. A dependent t-test, r, and % error were the statistical treatments utilized to determine validity. Four equations were found to be valid due to the nonsig diff (P>0.05) between the actual and predicted peak $\dot{V}O_2$ ($L.min^{-1}$ & $ml.kg.min^{-1}$). Baldwin's (1983) equation that utilized wt (kg) and the 9 min run (yds) to predict peak $\dot{V}O_2$ ($ml.kg.min^{-1}$) in boys resulted in an r of 0.86 and a % error of 1.46. Two other equations (Baldwin, 1983) that predicted peak $\dot{V}O_2$ ($L.min^{-1}$) were also valid, resulting in an r of 0.98 and % errors of 2.40. Each equation utilized the 9 min run (yds) and wt (kg), with ht (cm) being added to the second equation. Validity was also shown for only one equation developed by Kreun (1984) for girls. This equation utilized the 9 min run (yds) to predict peak $\dot{V}O_2$ ($L.min^{-1}$) and resulted in an r of 0.53 and a % error of .16.

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CHAPTER I

INTRODUCTION

There exists a need for a valid and reliable distance run field test for children that will become neither an economical impossibility nor a time-consuming burden for the administrator. A quick, simple, and accurate distance run test that requires no special equipment or knowledge has implications for application by physical educators and those involved with youth sports. Large numbers of children could be tested in a relatively short period of time with nominal preparation time required from the tester. Instructors could easily assess the cardiorespiratory training segment of their unit or program. A child who is found to possess a high peak $\dot{V}O_2$ also might be channeled towards sound coaching techniques that would continue to develop his/her physiological and psychological capabilities without being subjected to the stress of high-level competition that leads to burn out at an early age.

In the past, peak $\dot{V}O_2$ has been obtained individually in a laboratory setting through either the use of a bicycle ergometer (Mocellin, Lindemann, Rutenfranz, & Sbresny, 1971) or treadmill (Krahenbuhl, Pangrazi, Peterson, Burkett, & Schneider, 1978). To date, the most valid and reliable method for determining maximal oxygen consumption ($\dot{V}O_2max$) is the uphill running treadmill test (Froelicher, Brammell, Davis, Noguera, Stewart, & Lancaster, 1974; McArdle, Katch, & Pechar, 1973). This method, however, is not practical when viewed from a motivational, financial or time economy standpoint when dealing with children.

Finally, there is no universally accepted field test at the present time. Authors such as Burke (1976) and Disch, Frankiewics, and Jackson (1975), agreed that the running distances over 600 yards (yds) are more highly correlated with $\dot{V}O_2$max values obtained in the laboratory. Doolittle and Bigbee (1968) felt that the 12 minute run-walk test was a better indicator of the $\dot{V}O_2$max values in adolescent boys while Jackson and Coleman (1976) showed that the 9 minute run-walk test was more valid. The American Alliance of Health, Physical Education, Recreation and Dance (AAHPERD, 1980) felt that the mile run and the 9 minute run were valid field tests of cardiorespiratory conditioning and included both of these tests in their Health Related Physical Fitness Test Manual (AAHPERD, 1980). The manual also includes both the 12 minute and 1.5 mile run as alternatives for testing due to their popular appeal and current use.

Purpose

Determining the maximum volume of oxygen ($\dot{V}O_2$max) that a child can take in, transport and utilize during exercise can yield valuable information. Numerous authors (Doolittle & Bigbee, 1968; Jackson & Coleman, 1976; Krahenbuhl, Pangrazi, Burkett, Schneider, & Peterson, 1977; Krahenbuhl et al., 1978) have attempted to establish a field test that highly correlates to a laboratory determined $\dot{V}O_2$max in children. The purpose of this study was to validate the ability of a 9 minute run-walk test to predict the peak $\dot{V}O_2$ in boys and girls from the ages of 9 - 14.

Delimitations

Children aged 9 - 14 comprised the sample that was studied. Most of the boys and girls were obtained from an ongoing study at the University of Wisconsin - LaCrosse, LaCrosse, Wisconsin. In addition, a number of these children were participants in a fitness program, "Fit Kids," at State Road Elementary School, LaCrosse, Wisconsin. Other subjects were actively involved in track and field, swimming and/or gymnastics within the LaCrosse area.

A volitional maximal effort by the subject was the determined end point of the treadmill test. In order for accurate expired gas calculations to be made, it was necessary for the subject to complete the last minute of maximal exercise in the collection period.

Only those subjects that completed both the maximal treadmill test and the 9 minute run-walk were included in the results of this study.

Limitations

The subjects participating in this study were not obtained randomly. Most were actively involved in athletic programs such as YMCA swimming, gymnastics and school track and field programs. Therefore, a relatively homogenous sample of active children resulted. On this basis, the sample may not be representative of the more heterogenous population of children ranging in age from 9 - 14. Application of the resulting data is limited to a similar sample tested.

The results of this study are also limited by the subjects' motivation, knowledge and experience in using proper pacing techniques.

To administer the treadmill and 9 minute run-walk test, it was necessary to schedule the testing sessions at times when the University of Wisconsin - LaCrosse fieldhouse was free from athletic contests and practices. These limited time periods were not always convenient for the subjects due to other commitments.

Assumptions

The following assumptions were made in this study:

The subjects put forth equal maximal efforts in both the treadmill test and the 9 minute run-walk.

The subjects maintained the same level of fitness, health and fatique between the treadmill test and 9 minute run-walk test.

The recorders utilized during the 9 minute run-walk offered equal encouragement and motivation to all subjects.

The subjects had not eaten two hours previous to testing.

The subjects had not engaged in strenuous physical activity on their scheduled testing day prior to peak $\dot{V}O_2$ testing.

Definition of Terms

Maximal aerobic power - the highest oxygen uptake that any one individual can attain on any given day during exhaustive work while breathing at sea level.

Maximal heart rate - the peak heart rate achieved during the maximal treadmill test.

Maximal oxygen uptake ($\dot{V}O_2max$) - the maximum amount of oxygen taken in, transported and utilized by the body during strenuous, exhaustive work on the treadmill. It is expressed in either liters per minute ($L.min^{-1}$) or milliliters per kilogram of body weight per minute ($ml.kg.min^{-1}$). $\dot{V}O_2max$ is synonymous with peak $\dot{V}O_2$.

Nine minute run-walk - students performed a run-walk as fast as individually possible around an indoor 220 yd track for nine minutes. The total yardage covered by each individual was recorded to the nearest cone passed by the subject. Each cone passed (4) represented 55 yards.

Peak $\dot{V}O_2$ - the highest oxygen uptake elicited from the treadmill test. It is expressed in either $ml.kg.min^{-1}$ or $L.min^{-1}$. Peak $\dot{V}O_2$ will be used throughout this study.

Respiratory exchange ratio (R) - the volume of carbon dioxide produced by the body per volume of oxygen utilized ($\dot{V}CO_2/\dot{V}O_2$).

Volitional test - the subject chooses the end point of the test based upon his/her subjective indications of fatigue such as rapid breathing and local (leg) or general body fatigue.

CHAPTER II

REVIEW OF LITERATURE

Introduction

It has been agreed by exercise physiologists that maximal oxygen uptake ($\dot{V}O_2max$) is the greatest determinant of cardiorespiratory fitness (Astrand & Radahl, 1977). Assessing $\dot{V}O_2max$ in a school setting through accurate laboratory techniques would be costly, time consuming and most impractical for mass testing. Attempts have been made to develop an accurate field test that highly correlates with $\dot{V}O_2max$ values obtained through more sophisticated and reliable methods.

This chapter will examine the history of the development of field tests as predictors of $\dot{V}O_2max$, as well as the predictor variables used for the determination of $\dot{V}O_2max$, and the direct and indirect methods of measuring $\dot{V}O_2max$ in children.

History

Countless methods have been developed to determine the maximal aerobic power of individuals. Exercise protocols have been developed on both the bicycle ergometer and the treadmill with the result that the maximal treadmill test generally yields greater $\dot{V}O_2max$ values than does the bicycle ergometer (Boileau, Bonen, Heyward, & Massey, 1977; McArdle et al., 1973; Wiley & Shaver, 1972). Astrand (1971) believed that the treadmill should be utilized in studies with children less than 12 years of age due to the localized leg fatigue that forces children to end a bicycle ergometer test before they have reached their $\dot{V}O_2$max.

With the treadmill generally agreed upon as being the best instrument, the protocol utilized became the next consideration. A variety of protocols were tested in adults to determine which protocol elicited the highest values (Froelicher et al., 1974; Glassford, Baycroft, Sedgwick, & Macnab, 1965; McArdle et al., 1973). The results showed slight differences in the mean $\dot{V}O_2$max values with the continuous treadmill eliciting the highest $\dot{V}O_2$max values over the discontinuous treadmill test, and over both the continuous and discontinuous bicycle ergometer tests (McArdle et al., 1973). In contrast, however, Taylor, Buskirk, and Henschel (1955) elicited a higher $\dot{V}O_2$max with a discontinuous protocol. In agreement with Taylor et al. (1955) was Froelicher et al. (1974) who compared the Taylor protocol (1955) to the Bruce, Kusumi, and Hosmer (1973) and Balke and Ware (1959) protocols. Froelicher and his co-workers (1974) found that a greater mean maximal oxygen consumption was obtained when the Taylor et al. (1955) protocol was used.

In dealing with children, a study was conducted which compared the use of continuous and discontinuous treadmill protocols for the determination of $\dot{V}O_2$max values in children (Skinner, BarOor, Bergsteinova, Bell, Royer, & Buskirk, 1971). From their results it was found that either the Skinner or Bruce (Bruce et al., 1973) protocol could be utilized due to the very small difference in the $\dot{V}O_2$max values obtained.

Bonen, Heyward, Cureton, Boileau, and Massey (1979) utilized the continuous (Skinner) protocol in their study of predicting $\dot{V}O_2$max in 7 - 15 year old boys. These authors utilized a sample of 39 boys for cross validation of their prediction equations for $\dot{V}O_2$max. Their prediction of $\dot{V}O_2max$ was based upon $\dot{V}O_2max$ ($L.min^{-1}$), maximum heart rate, and height in centimeters, and was valid: $r = 0.97$, and $r = 0.87$, for $L.min^{-1}$ and $ml.kg.min^{-1}$, respectively.

As with other protocols, the Bruce protocol (Bruce et al., 1973) was first used with adults (Froelicher et al., 1974) and then with children (Cumming, Everatt, & Hastman, 1978). Cumming and his associates (1978) felt that the Bruce protocol was better for children than the Balke protocol. It was believed that the Balke protocol led to boredom in the subjects due to the length of time spent on the treadmill and were critical of the steepness of the incline before exhaustion. These authors were also critical of the Taylor protocol. For children, Cumming and his co-workers (1978) felt that the required running speed of 6.5 miles per hour (mph) was too fast to be used on those less than 11 years of age. In conclusion, these authors recommended that the Bruce protocol be used in testing fit, cooperative children.

In a study of children 8 years of age, Krahenbuhl and his associates (1977) suggested that when using the Bruce et al. (1973) protocol, time on the treadmill is a more valid predictor of $\dot{V}O_2max$ ($ml.kg.min^{-1}$) in both boys and girls.

Variables Used to Predict $\dot{V}O_2max$

Age, weight, resting heart rate and an 880 yd run performance were used to predict a $\dot{V}O_2max$ value in women 20 - 40 years of age by Bell and Hinson (1974). A correlation of $r = -0.689$ resulted when these variables were related to measured $\dot{V}O_2max$. Von Dobeln, Astrand, and Bergstrom (1967) also used age to make corrections in the Astrand and Rhyming (1954) nomogram. Astrand (1960) estimated that there still existed a 10% error when predicting $\dot{V}O_2max$ from the nomogram based upon a submaximal bicycle test. Based upon these results, Von Dobeln and his associates (1967) created a prediction equation based upon submaximal heart rate, maximal heart rate and age in male building workers aged 30 - 60. They felt that their equation was the best predictor of $\dot{V}O_2max$ compared to the Astrand-Rhyming (1954) nomogram.

Results are also found in the literature when children were used as subjects. Matsui, Myasita, Miura, Kobayashi, Hoshikawa, and Kamel (1972) used a prediction equation based on weight of Japanese youth that resulted in a correlation of 0.88 when weight was correlated with a cycling/running $\dot{V}O_2max$. Boe (1982) used the performance time of the maximum treadmill test along with height, age and weight of 8 - 12 year old girls to predict $\dot{V}O_2max$. When performance time and height were the variables used to predict the $\dot{V}O_2max$, a correlation of 0.84 resulted when compared to the actual treadmill $\dot{V}O_2max$ in $L.min^{-1}$.

<u>$L.min^{-1}$</u>

Height, age, heart rate and weight were used to predict $\dot{V}O_2max$ in boys 7 - 15 by Bonen and others (1979). The heart rate used in the equations was taken from the treadmill test during the third minute when the grade was 10% and a speed of 3.5 mph was used. Based on heart rate, $\dot{V}O_2$, and height, a correlation of 0.95 was found when $\dot{V}O_2max$ was expressed as $L.min^{-1}$. If heart rate, $\dot{V}CO_2$, $\dot{V}O_2$ ($ml.kg.min^{-1}$) and age were used, a correlation of 0.62 resulted. In their final equation, Bonen et al. (1979) utilized age, height, and weight to predict $\dot{V}O_2max$ in both $L.min^{-1}$ and $ml.kg.min^{-1}$. The multiple correlations were 0.94 and 0.52, respectively.

Ribisl and Kachadorian's (1969) prediction equation for middle age men was based upon a two mile run, age and weight. When the $\dot{V}O_2max$ was expressed in ml.kg.min^{-1}, a multiple correlation coefficient of 0.85 resulted.

Teenagers, both male and female, were investigated by Wells, Scrutton, Archibald, Cooke and De La Mothe (1973). Regression equations were formulated for $\dot{V}O_2$max using L.min^{-1}. When the treadmill $\dot{V}O_2$max and body weight were correlated, an r of 0.67 and 0.86 resulted for boys and girls, respectively. Fat free body weight and the treadmill $\dot{V}O_2$max (ml.kg.min^{-1}) were then studied and correlations of 0.70 (boys) and 0.96 (girls) were observed.

Others have also examined the relationship between $\dot{V}O_2$max and body composition. Welch, Riendeau, Crisp, and Isenstein (1958) reported that when $\dot{V}O_2$max in college men was correlated to body weight (kg) and fat free weight (kg), correlation coefficients of 0.69 and 0.65, respectively, resulted. Buskirk and Taylor (1957) also examined a similar group of college age men. These authors reported correlation coefficients of 0.63 and 0.85 for body weight (kg) and fat free weight (kg), respectively, to $\dot{V}O_2$max in L.min^{-1}.

Field Tests

Numerous field tests have been developed to predict $\dot{V}O_2$max outside the laboratory setting. These tests have been attempted for all age groups at various distances. A discussion of these tests follows.

Twelve Minute Run-Walk

Perhaps the most widely recognized field test for predicting $\dot{V}O_2$max is Cooper's 12 minute run-walk test (Cooper, 1968). Cooper's subjects consisted of 115 male army officers that ranged in age from 17 - 52 years.

The prediction of a 12 minute run-walk to an actual treadmill $\dot{V}O_2max$ resulted in a correlation of 0.897.

Most of the literature published agrees with Cooper's findings. Burke (1976) reported a similar result (r = 0.90) using a treadmill $\dot{V}O_2max$ test and the 12 minute run-walk test with male college students. Doolittle and Bigbee (1968) studied 153 ninth grade boys. Again a correlation coefficient of 0.90 resulted with the actual $\dot{V}O_2max$ obtained from a bicycle ergometer test. Jackson and Coleman (1976) examined the predictive validity of the 12 and 9 minute run-walk tests. In their co-ed sample of 47 elementary school children (grades 4 - 6), they, too, found significant zero-order correlations for both the 12 (0.82 - boys; 0.71 - girls) and 9 (0.82 - boys; 0.71 - girls) minute run-walk tests and the treadmill $\dot{V}O_2max$ values when expressed in $ml.kg.min^{-1}$.

<u>Twelve Minute Run</u>

Although the correlation reported was lower than the others previously mentioned, Maksud and Coutts (1971) also found a significant relationship (r = 0.65) in 20 young college men when a treadmill $\dot{V}O_2max$ and the 12 minute run-walk were utilized. Results similar to Maksud and Coutts (1971) were obtained by Kearney and Byrnes (1974) when they studied diversified groups of college males. Correlations for $\dot{V}O_2max$ of 0.80 (nonathletes), 0.64 (physical education majors) and 0.28 (cross-country runners) resulted from the 12 minute run-walk and a $\dot{V}O_2max$ test on the bicycle ergometer. The low correlation obtained for the cross-country runners is explained by the fact that the homogenous group of runners were not used to cycling.

The AAHPERD's <u>Health Related Fitness Testing Manual</u> (1981) also advocates the use of the 12 minute run due to its popularity. In addition, the 12 minute run has a reputation as a valid indicator of cardiorespiratory fitness.

Two Mile Run

The 2 mile run was used for comparison by Katch and Henry (1972) to $\dot{V}O_2max$ expressed in $ml.kg.min^{-1}$. With a controlled pace administered by a cyclist riding alongside the runner, 35 college men ran the 2 mile distance. Correlated with a $\dot{V}O_2max$ ($ml.kg.min^{-1}$) treadmill test, the correlation coefficient of -0.55 was obtained.

Higher correlation coefficients of 0.85 and 0.86 were reported by Ribisl and Kachadorian (1969) in their study of young and middle-aged men, respectively. These authors' correlations were based upon the relationship between a treadmill $\dot{V}O_2max$ and a 2 mile run.

Nine Minute Run-Walk Test

One study supports the use of the 9 minute run-walk to predict $\dot{V}O_2max$ values in elementary school children ages 10 - 12 (Jackson & Coleman, 1976). They found that both the 9 and 12 minute run-walk tests were significantly correlated with $\dot{V}O_2max$ ($ml.kg.min^{-1}$). Due to the extra 3 minutes of exercise in the 12 minute run and the motivational factors involved, these authors recommended the use of the 9 minute run-walk test for this age group.

Based upon this information, the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) now includes the 9 minute run in their AAHPERD Health Related Physical Fitness Test Manual (1981) as a means of measuring cardiorespiratory fitness. This organization feels that the 9 minute run provides the same information as the longer distance runs.

One Mile Run

When a variety of groups of college males were studied (non-athletes, physical education majors and cross-country runners), Kearney and Byrnes (1974) elicited significant correlations between actual and predicted $\dot{V}O_2max$ for only one group. The correlation resulting from a bicycle ergometer $\dot{V}O_2max$ ($ml.kg.min^{-1}$) and a mile run by physical education majors was 0.59. Although the results for the non-athletes and cross-country runners were found to be nonsignificant, the actual correlation coefficients were not given in their published study.

Krahenbuhl and others (1978) found that in primary school children, the highest correlations between the 1600 meter pace and $\dot{V}O_2max$ ($ml.kg.min^{-1}$) were obtained by those who did not reach the leveling-off criteria during the treadmill test (0.681 males; 0.628 females). They also found that the average velocity during the 1600 meter run was a better predictor of $\dot{V}O_2max$ ($ml.kg.min^{-1}$) than the recorded time of the run (0.645 males; 0.762 females).

In 1977, Krahenbuhl and his associates investigated the predictive value of the mile run to actual $\dot{V}O_2max$ values in 8 year olds. The males' performances were significant ($r = 0.71$) at the 0.01 level when correlated with their treadmill $\dot{V}O_2max$ expressed in $ml.kg.min^{-1}$. The girls' values were not significant (-0.26) at the same level but the mile run was more closely related to the $\dot{V}O_2max$ than any of the other distance runs (549 meters, 1207 meters).

Six Hundred Yard Run

For a number of years the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) has used the 600 yd run as a predictor of cardiorespiratory fitness in youth. Numerous studies

(Doolittle & Bigbee, 1968; Metz & Alexander, 1971) have shown a run over this distance to be both a valid and reliable predictor of cardiorespiratory fitness.

The reliability of AAHPERD 600 yd run-walk test was studied by Willcoom, Askew, and Askew (1966). Seventy-six girls and seventy boys were administered the test twice with a one week interval separating the two tests. The authors found a reliability coefficient of 0.92 for both the boys and girls. Willcoom and his associates pointed out, however, that proper administration of the test is imperative for accurate results. The AAHPERD testing manual (1981) allows for the variety of results found in the literature. The instructor has the option of administering any of the previously noted distance runs because the distance runs supply the same essential information. The Alliance also noted, as have others (Krahenbuhl et al., 1975; Willcoom et al., 1966), that motivation, proper instruction and practice of pace, body fatness and mechanical efficiency would all certainly affect the outcome of the test.

Doolittle and Bigbee (1968) investigated the relationship of $\dot{V}O_2max$ on the bicycle ergometer and the 600 yd run-walk test in 153 ninth grade boys. A correlation of 0.62 resulted, whereas the 12 minute run-walk correlation of 0.94 was found to be higher by these investigators. Doolittle and Bigbee (1968) concluded that the 12 minute run-walk was a better predictor of $\dot{V}O_2max$ than the 600 yd run-walk.

For 12 and 13 year old boys, the 600 yd run-walk test was significantly related ($r = -0.66$) to the treadmill $\dot{V}O_2max$. However, Metz and Alexander (1971) discovered that the 14 and 15 year old boys' ($r = -0.27$) results were not significant. The authors felt that the onset of physical maturity and motivation may have influenced their results.

In summary, authors have agreed (Burke, 1976; Jackson & Coleman, 1976; Krahenbuhl et al., 1977; Krahenbuhl et al., 1978) that the greater the length of the test, the higher the correlation to $\dot{V}O_2max$.

Specifically, results of research that have related to children (Doolittle & Bigbee, 1968; Jackson & Coleman, 1976; Krahenbuhl et al., 1977; Krahenbuhl et al., 1978) lean toward the use of the longer runs (9 min and 12 min) to predict $\dot{V}O_2max$ in children. Metz and Alexander (1971) favored the 600 yd run-walk for 12 and 13 year old boys. A test of longer duration would certainly be more accurate in determining maximum aerobic power than a test of shorter duration where more of an anaerobic capacity would be called upon.

Validity and Reliability of Field Tests

As previously shown, numerous prediction equations for $\dot{V}O_2max$ have been formulated (Bell & Hinson, 1974; Metz & Alexander, 1971; Ribisl & Kachadorian, 1969) from indirect methods. Only a few of these researchers have attempted to validate or show reliability for their equations. These studies where such an attempt was made are discussed below.

Reliability

It was shown earlier in this discussion that Willcoom and his associates (1966) demonstrated the reliability of AAHPERD 600 yd run-walk test through the use of two testing sessions administered to 76 girls and 70 boys. Reliability coefficients of 0.92 for both sexes resulted when an interval of one week separated the tests. Falls, Ismail, and Macloed (1966) also found the 600 yd run-walk to be a reliable test in males 23 - 58 years of age.

Krahenbuhl et al. (1978) utilized the test-retest method of establishing reliability. Krahenbuhl and his co-workers randomly selected 120 children from the original sample of 151 to repeat the 1600 meter run test. The first grade females recorded the lowest reliability coefficients of 0.824 while the third grade males recorded the highest, 0.918.

Validity

Bonen et al. (1979) utilized a slightly different method to validate the results of their multiple regression equations. Of the 139 subjects, Bonen and his associates set aside 39 subjects for the purpose of cross validation. The subjects were randomly selected from the 139 original subjects. These 39 boys, ages 7 - 15, validated the authors' results of the prediction equation utilizing the treadmill $\dot{V}O_2max$ ($L.min^{-1}$), heart rate, and height. A significant correlation of 0.95 resulted from their cross validation attempt. Similar results were obtained for their other prediction equations.

Summary

Variables of age, height, weight, heart rate, fat free weight an a variety of running distances have been manipulated in the literature to obtain an accurate prediction equation that can be easily administered to large groups of children and adults with reasonable ease. There exists a general consensus that the longer distance runs elicit the higher correlations to the actual $\dot{V}O_2max$ value obtained from either the bicycle ergometer or treadmill. However, only a few researchers (Bonen et al., 1979; Krahenbuhl et al., 1978) have attempted to show the validity and/or reliability of their results. It is this area that demands more investigation in the future.

CHAPTER III

METHODS

Introduction

This study was an attempt to validate the prediction equations for peak $\dot{V}O_2$ formulated from a 9 minute run-walk by Baldwin (1983) and Kreun (1984). It is necessary, therefore, to repeat their methods precisely. Following is a description of the methods utilized.

Selection of Subjects

A non-random sample of boys and girls between the ages of 9 and 14 was solicited by word of mouth with the persuasive help of subjects already taking part in a longitudinal study that was concurrently being conducted at the University of Wisconsin - LaCrosse, LaCrosse, Wisconsin. Some of the subjects were also obtained from a fitness program at State Road Elementary School, LaCrosse, Wisconsin, with which this researcher was associated. This fitness program, however, was not school sponsored. Others were obtained from a junior high school track and field team, a private gymnastics club and through outside acquaintances of this author.

Generally, the subjects were active in a variety of activities. In addition to the three times per week fitness program attended by some subjects, others participated in swimming, gymnastics, cross-country running and downhill skiing.

Before any data was collected, informed consents were mailed out to the parents of each subject explaining the testing procedures and possible hazards involved (see Appendix A). Parents signed the consent forms and sent them to the laboratory prior to the day of their first practice session.

At the conclusion of the collection data, the LaCrosse Computers in Education System (LACE) and a random table of numbers were utilized to obtain a random sample of subjects from the pooled sample of 78 subjects (43 boys, 35 girls) which also included those subjects from Baldwin's (1983) and Kreun's (1984) studies. A sample of 13 boys and 12 girls were used in validating the prediction equation derived from the 30 boys and 22 girls.

Maximum Oxygen Uptake Determination

All testing was conducted in the Human Performance Laboratory located in Mitchell Hall on the campus of the University of Wisconsin - LaCrosse, LaCrosse, Wisconsin. Due to some of the subjects' unfamiliarity of the testing setting, practice sessions were conducted on the treadmill prior to data collection to acquaint them with the apparatus such as the mouthpiece, headgear, nose clip and incline of the treadmill itself. At least one practice session was conducted for each subject.

On the day of testing, the subjects were asked to abstain from eating for at least two hours preceding the treadmill or 9 minute run. Height and weight were recorded with the subject fully clothed except for footwear. The subject was then prepared for electrode placement in the CM-5 position with the positive electrode in the standard V_5 position, the ground electrode positioned on the lower right-hand side of the rib cage, and the negative electrode was placed on the manubrium.

The treadmill protocols utilized were the same as those used by Baldwin (1983) and Kreun (1984) in their testing of boys and girls, respectively. Baldwin utilized the protocol developed by Skinner et al., (1971) presented in Table 1 while Kreun chose to use the Bruce (1973) protocol presented in Table 2.

Table 1. Skinner Treadmill Test Protocol

Stage	Speed (mph)	Grade (%)
I	3.5	10.0
II	3.5	12.5
III	3.5	15.0
IV	3.5	17.5
V	3.5	20.0

Skinner et al., 1971, p. 25

The Skinner et al. (1971) protocol was preceded by a three minute warm-up at Stage I followed by a seated rest period of two minutes. There was no warm-up period preceding the Bruce (1973) protocol.

Table 2. Bruce Treadmill Test Protocol

Stage	Speed (mph)	Grade (%)
I	1.7	10
II	2.5	12
III	3.4	14
IV	4.2	16
V	5.0	18

Bruce et al., 1973, p. 547

As an added incentive, T-shirts were awarded to the male and female that could stay on the treadmill for the longest period of time.

Instrumentation

Expired gases were analyzed through the use of the Beckman Metabolic

Measurement Cart (MMC) to determine the respiratory exchange ratio (RER) and other gas fractions. The MMC was calibrated prior to and immediately following each test with gas previously determined by the Scholander techniques. Heart rates were determined on a Quinton electrocardiograph monitor via a single bi-polar lead (CM-5). Electrodes were placed on the chest prior to the beginning of the treadmill test as previously described.

The temperature, humidity and barometric pressure were recorded each day prior to testing. Height and weight were also recorded before testing through the use of a calibrated scale located in the Human Performance Laboratory.

Treadmill Procedures

With the nose clip, headgear and mouthpiece adjusted to the comfort of the subject, the treadmill was turned on as the subject straddled it. The MMC and air hoses were positioned so as not to interfere with the running movements of the subjects as they breathed through the mouthpiece. The subject began to walk as the speed and grade were adjusted for the first stage of the Bruce (see Table 2) or Skinner (see Table 1) protocol at which time the clock was started.

Gas samples were analyzed each minute with a readout following. The highest values collected during exercise were used in the determination of peak $\dot{V}O_2$. Verbal encouragement was given to each subject to keep running as long as possible until the subject lost control of the mouthpiece, voluntarily ceased running or signaled that he/she could no longer continue. Heart rate was recorded during the last 15 seconds of each minute to give an indication of the approaching exhaustion of the subject and as an indicator of true maximal exertion. After the subject reached exhaustion, the speed and grade of the treadmill were immediately lowered and the subject walked for approximately three minutes or until the subject indicated that he/she had recovered.

Nine Minute Run-Walk Procedures

On the same day that the subject practiced the treadmill running, a practice session of approximately five minutes of running was conducted on the 200 yd indoor running track located in the fieldhouse of Mitchell Hall on the campus of the University of Wisconsin - LaCrosse, LaCrosse, Wisconsin. However, due to the difficulties encountered in scheduling the use of the fieldhouse, not all participants were able to practice prior to testing. Those subjects were taken to the fieldhouse and were given instructions identical to the others that practiced. All subjects were informed to run as far and as fast as possible to nine minutes as well as the proper pacing and passing techniques. Participants were told that the time would be called out at 4.5, 7, 8, and 8.5 minutes into the run and that T-shirts would be awarded to the top male and female in each age group.

The purpose of the practice run was to familiarize the subjects to indoor track running in the fieldhouse and to allow the subjects an opportunity to become comfortable with a suitable pace.

Subjects were scheduled at their convenience as well as within the time limits for the researcher's use of the fieldhouse. All age groups and sexes ran at the same time with no more than 10 running at any one time. As the cut-off date for testing neared, it was necessary to allow subjects to run alone due to the difficulty in scheduling.

Prior to testing, volunteers were recruited to aid in the scoring of laps and portions of laps completed by each subject. Each volunteer received a 5" x 7" card with the subject's race number and name recorded (see Appendix B). As each subject completed a full lap, the recorder marked it on the card. Cones (4) were placed 55 yds apart to separate the track into four equal parts. It was necessary for the subject to pass a cone in the last seconds of the test in order for that portion to be recorded. Full laps equaled 220 yds while portions of a lap equaled 55 yds. Total yardage was recorded on the card.

On test day the subjects were given repeat instructions as to pacing and the maximal effort that was required from them to go as far as they possibly could in 9 minutes. Again subjects were told that they would be notified when 4.5, 7, 8, and 8.5 minutes had elapsed in the test to give them an indication of the time remaining in the test. Each subject was given a race number that was worn in the front to aid the recorders in counting the laps run. After receiving instruction, participants were led in a warm-up by the researcher consisting of stretches involving the major muscle groups and a slow one lap jog (220 yds) around the track.

A whistle was blown to signal when the 9 minutes had elapsed. When the subjects heard the whistle for stopping, they were told to walk back and forth across the track until the recorders had noted the finishing point of their subject. Participants were then informed to walk as a cool down to facilitate recovery.

Statistical Treatment of Data

The purpose of this study was to validate the stepwise multiple regression equations developed by Baldwin (1983) and Kreun (1984) to predict $\dot{V}O_2max$ from a 9 minute run. With the assistance of the University of Wisconsin - LaCrosse Computers in Education (LACE) system, 13 boys and 12 girls were randomly selected from the total number of boys (n = 43) and girls (n = 35) tested. These randomly selected groups were not used to extrapolate the stepwise multiple regression equations. These subjects were used for validating the equation developed from the remaining 30 boys and 23 girls.

The data for the girls were entered into Kreun's equation (1984) presented in Tables 5 and 6 and data for the boys were programmed into Baldwin's equation (1983) presented in Tables 1 and 2. A correlation coefficient was then determined from the predicted $\dot{V}O_2max$ values of the 9 minute run-walk and the actual $\dot{V}O_2max$ values obtained from the treadmill test through the Interactive Data Analysis (IDA) program. A paired t-test was also calculated between the actual and predicted $\dot{V}O_2max$ values.

Table 3

Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($ml.kg.min^{-1}$)

Boys

Equation Number	Equation	R	SEE
1	Peak $\dot{V}O_2 = 17.661 + 0.016115\ (X_1)$	0.6930	3.8988
2	Peak $\dot{V}O_2 = 18.604 - 0.1069\ (X_2) + 0.17896\ (X_1)$	0.7217	3.8118
3	Peak $\dot{V}O_2 = -12.12 + 0.29609\ (X_3) - 0.3521\ (X_2) + 0.016055\ (X_1)$	0.7894	3.4451
4	Peak $\dot{V}O_2 = -11.12 + 0.34276\ (X_4) + 0.26371\ (X_3) - 0.3509\ (X_2) + 0.015992\ (X_1)$	0.7916	3.4973

Key: X_1 = 9 minute run distance (yds)

X_2 = Weight (kg)

X_3 = Height (cm)

X_4 = Age (years)

Baldwin (1983), p.37

Table 4

Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($L.min^{-1}$)

Boys

Equation Number	Equation	R	SEE
5	Peak $\dot{V}O_2$ = −1.163 + .0016135 (X_1)	0.5829	0.5289
6	Peak $\dot{V}O_2$ = −0.1041 + 0.054382 (X_2)	0.9121	0.2668
7	Peak $\dot{V}O_2$ = −1.587 + 0.00082973 (X_1) + 0.048108 (X_2)	0.9533	0.2002
8	Peak $\dot{V}O_2$ = −3.391 + 0.017377 (X_3) + 0.00072169 (X_1) + 0.033714 (X_2)	0.9659	0.1748
9	Peak $\dot{V}O_2$ = −3.351 + 0.013687 (X_4) + 0.016085 (X_3) + 0.00071915 (X_1) + 0.033764 (X_2)	0.9661	0.1777

Key: X_1 = 9 minute run distance (yds)
X_2 = Weight (kg)
X_3 = Height (cm)
X_4 = Age (years)

Baldwin (1983), p.38

Table 5

Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($ml.kg.min^{-1}$)

Girls

Equation Number	Equation	R	SEE
1	Peak $\dot{V}O_2 = 18.869 + 0.015408\ (X_1)$	0.5939	5.20598
2	Peak $\dot{V}O_2 = 18.278 - 0.2622\ (X_2) + 0.021577\ (X_1)$	0.6573	4.99703
3	Peak $\dot{V}O_2 = 17.229 + 5.1026\ (X_4) - 0.3277\ (X_2) + 0.020446\ (X_1)$	0.6616	5.10104
4	Peak $\dot{V}O_2 = 22.721 - 0.06326\ (X_3) + 0.5373\ (X_4) - 0.2645\ (X_2) + 0.020958\ (X_1)$	0.6632	5.23085

Key: X_1 = 9 minute run distance (yds)

X_2 = Weight (kg)

X_3 = Height (cm)

X_4 = Age (years)

Kreun (1984)

Table 6

Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($L.min^{-1}$)

Girls

Equation Number	Equation	R	SEE
5	Peak $\dot{V}O_2 = -1.220 + 0.0017400\ (X_1)$	0.7950	0.3311
6	Peak $\dot{V}O_2 = -0.2067 + 0.054395\ (X_2)$	0.9064	0.2306
7	Peak $\dot{V}O_2 = -1.1290 + 0.00078805\ (X_1) + 0.040451\ (X_2)$	0.9472	0.1794
8	Peak $\dot{V}O_2 = -1.050 - 0.03835\ (X_4) + 0.00087306\ (X_1) + 0.045374\ (X_2)$	0.9496	0.1799
9	Peak $\dot{V}O_2 = -1.349 + 0.0034476\ (X_3) - 0.03982\ (X_4) + 0.00084512\ (X_1) + 0.041929\ (X_2)$	0.9500	0.1840

Key: X_1 = 9 minute run distance (yds)

X_2 = Weight (kg)

X_3 = Height (cm)

X_4 = Age (years)

Kreun (1984)

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

A sample of 13 boys and 12 girls, 9 - 14 years of age, completed both phases of testing which included the treadmill $\dot{V}O_2max$ and the 9 minute run. The children were studied to determine the validity of Baldwin's (1983) and Kreun's (1984) multiple regression equations.

Subjects

The physical characteristics of the 13 boys and 12 girls are presented in Table 7. Due to the random sampling from the testing groups of 43 boys and 37 girls, the 13 boys of this study were slightly younger than the mean age reported by Baldwin (1983) with the 12 girls being similar to the mean age of Kreun's (1984) subjects.

The average height and weight of the subjects was compared to the normal height and weight values for boys and girls ages 2 - 20 which were developed by Hamill, Drizid, Johnson, Reed, and Roche (1977). The normal values reported for boys 9 - 14 for stature in centimeters were 134.3 - 168.6. The range of the boys participating in this investigation was much wider, 128.3 - 184.2 centimeters, than the norm reported. A mean height of 153.6 centimeters was given by Baldwin (1983), compared to the mean height of 147.2 centimeters in the present study. In comparison to the sample of boys (7 - 15 years of age) studied by

Table 7

Means, Ranges, and Standard Deviations for Physical Characteristics

of All 13 Boys and 12 Girls

Variable	Boys (n = 13)			Girls (n=12)		
	Mean	SD	Range	Mean	SD	Range
Age	10.8	1.6	9-14	11.0	1.4	9-14
Height (cm)	147.2	16.3	128.3-184.2	147.2	10.2	130.2-165.1
Weight (kg)	37.3	12.2	22.9-66.4	38.1	9.1	26.0-52.6
$\dot{V}E$ (L.min^{-1})*	72.8	26.6	42.1-143.5	75.8	12.1	61.8-99.6
$\dot{V}O_2max$ (L.min^{-1})*	2.08	7.7	1.33-4.01	1.95	.4477	1.41-3.14
$\dot{V}O_2max$ (ml.kg.min^{-1})*	54.7	4.8	48.9-60.9	52.0	6.2	36.5-59.8
RER*	1.01	.0031	.95-1.07	1.16	.0053	1.04-1.22
Heart Rate*	202	6.8	190-216	202	6.3	192-212
9 Minute Run Distance	2195	254	1870-2695	1824	342.9	1155-2420

*denotes peak exercise values

Bonen et al. (1979) and Baldwin (1983, the boys in the present study were taller and lighter.

Smaller differences in stature were found when the girls were examined. Normative height values of 132.6 - 162.1 centimeters were reported by Hamill et al. (1977) for girls 9 - 14 years. Similar to the boys, the range of 130.2 - 165.1 centimeters for the girls in this study was wider. Kreun (1984) reported a mean height of 150.9 centimeters which was taller than the mean height of 147.2 centimeters found in this study.

Similar results were found for both boys and girls when weight in kilograms was examined. The normative values given by Hamill et al. (1977) for boys 9 - 14 years were 29.3 - 56.3 kg. Again, the range of weight for the boys of this study (22.9 - 66.4 kg) was much wider. The mean weight in kilograms reported by Baldwin was 44.2 with the subjects of this study recording a lower value, 37.3 kgs.

The reported normative values for girls 9 - 14 years ranged from 27.95 to 50.74 kg as reported by Hamill and his associates (1977). The mean weight of the girls in the present study was much lower (38.1 kg) than the 43.3 kg reported by Kreun (1984). As with height, the range for the girls studies was 26.0 - 52.6 kg, which was wider than the range reported by Kreun (1984).

In summary, the boys and girls participating in this study were taller, with the exception of the girls, and lighter than the norms presented. The girls, however, exhibited a narrower range of difference in regards to height and weight than did the boys.

Treadmill Responses

The boys performed a walking protocol that has previously been described by Skinner et al. (1971) while the girls utilized the Bruce (1973) protocol. In both instances the test was terminated at volitional exhaustion of the individual.

The boys elicited a mean peak $\dot{V}O_2max$ of 54.7 $ml.kg.min^{-1}$ which was slightly higher than those found by other investigators. Baldwin (1983) reported a mean peak $\dot{V}O_2$ of 51.8 $ml.kg.min^{-1}$ in her study of 30 boys ages 9 - 14 years. Boileau et al. (1977) observed a mean $\dot{V}O_2max$ of 49.7 $ml.kg.min^{-1}$ in their study of boys 11 - 14 years. Bonen et al. (1978) reported results of treadmill $\dot{V}O_2max$ ($ml.kg.min^{-1}$) mean values of 48.3 in their study of boys 7 - 15 years.

A different result was found when peak $\dot{V}O_2$ was measured in $L.min^{-1}$. In the present study, the peak $\dot{V}O_2$ of 2.08 $L.min^{-1}$ was lower than others found in the literature. Woynarowska (1980) investigated 80 boys 11 and 12 years of age. Her result of 2.34 $L.min^{-1}$ is in agreement with the peak $\dot{V}O_2$ of 2.30 $L.min^{-1}$ reported by Woynarowska (1980) when $\dot{V}O_2$ of 1.95 $L.min^{-1}$ was similar to the 2.12 $L.min^{-1}$ found by Woynarowska (1980). However, Woynarowska utilized the bicycle ergometer to obtain the $\dot{V}O_2max$ value. The differences found in the present study may be due to the small sample studied and the use of different methods to obtain the peak $\dot{V}O_2$ value.

Nine Minute Run Performance

Recently, the 9 minute run has been accepted as a valid predictor of cardiorespiratory endurance. The American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) has included the 9 minute run in their Health Related Physical Fitness Test Manual (1981). Normative values were developed by AAHPERD with data collected on more than 12,000 students. The boys and girls in the present study covered a mean distance of 2195 yds and 1824 yds, respectively, in 9 minutes. The AAHPERD percentile scale indicates that these subjects fell about the 90 percentile when the mean age for boys was used. When the mean age for girls was examined, the result was found to be slightly lower than the 85 percentile.

Jackson and Coleman (1976) also established norms for 557 boys and 662 girls ages 10 - 12. Utilizing the mean age for both the boys and girls, it was found that both sexes' 9 minute run performances fell at the 85 percentile. These performances are better than those reported by Baldwin (1983) whose boys were ranked above the 70 percentile for the AAHPERD (1981) norms and those established by Jackson and Coleman (1976). These differences may be due to the small sample size of the present study.

In comparison to Kreun's (1984) results, the girls in the present study were ranked lower than Kreun's (1984) subjects on both the AAHPERD scale and the ranking scale developed by Jackson and Coleman (1976). Kreun's (1984) subjects were ranked in the 90 percentile on the AAHPERD scale while those girls in the present study were ranked in the 85 percentile. According to the scale developed by Jackson and Coleman (1976), the subjects of the present study were ranked in the 85 percentile while Kreun (1984) reported a ranking above the 90 percentile.

Validation of Boys' Regression Equations

Baldwin (1983) developed stepwise multiple regression equations to predict peak $\dot{V}O_2$ in $ml.kg.min^{-1}$ and $L.min^{-1}$ utilizing the 9 minute run and other independent variables. The equations, correlation coefficients and standard error of the estimate may be found in Tables 3 and 4, Chapter III. Predicted peak $\dot{V}O_2$ values were calculated by substituting each of the 13 boy's values into each of the equations.

<u>$ml.kg.min^{-1}$</u>

Equation 1 involved the use of the 9 minute run to predict peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$. Baldwin's (1983) correlation of 0.69 was lower than the correlation of 0.80 obtained from the present study. This may have been due to the greater distance covered by the subjects of this study in the 9 minute run (2195 yds). When the 9 minute run distance was substituted into Baldwin's (1983) equation, a correlation of 0.80 resulted between the measured and predicted peak $\dot{V}O_2$. A correlation of 0.72 resulted when Baldwin included weight in kilograms and the 9 minute run (Equation 2). When individual values were substituted into Baldwin's (1983) Equation 2, a correlation of 0.86 was discovered between the measured and predicted peak $\dot{V}O_2$. Height in centimeters, weight in kilograms and the 9 minute run distance were included in Equation 3. Baldwin (1983) reported a correlation of 0.79. In the present study a correlation of 0.73 resulted when the relationship between the measured and predicted peak $\dot{V}O_2$ was examined. In Equation 4, peak $\dot{V}O_2$ was predicted by Baldwin (1983) utilizing height in centimeters, weight in kilograms, age and the distance (yds) covered in the 9 minute run. Baldwin (1983) obtained a correlation of 0.79 which was the highest correlation produced from the equations using peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$. When the relationship between the measured and predicted peak $\dot{V}O_2$ was compared, the resulting correlation was $r = 0.73$.

Correlations for validating Baldwin's (1983) regression equations for peak $\dot{V}O_2max$ expressed in $ml.kg.min^{-1}$ were in closer agreement than those found in the literature. Bonen et al. (1979) utilized a sample of 39 boys ages 6 - 15 to cross-validate their regression equations developed from the same sex and age group to predict $\dot{V}O_2max$. When $\dot{V}O_2max$ was expressed in $ml.kg.min^{-1}$, a cross-validation coefficient of 0.57 resulted when the variables of age, height in centimeters and weight in kilograms were used.

$\underline{L.min^{-1}}$

Baldwin (1983) also used the peak $\dot{V}O_2$ expressed in $L.min^{-1}$ and the 9 minute run distance to develop her predictive regression equations for boys 9 - 14 years of age. The regression equations may be found in Table 4, Chapter III. Equation 5 examined the relationship between peak $\dot{V}O_2$ ($L.min^{-1}$) and the 9 minute run. A correlation coefficient of 0.58 resulted from Baldwin's (1983) work. The correlation obtained from this study, however, was much higher, r = 0.84. This was identical to the correlation obtained when the measured and predicted peak $\dot{V}O_2$ were compared. Weight in kilograms was included in Equation 6, and Baldwin (1983) reported a correlation of 0.91, while this investigation showed similar results (r = 0.95). However, the comparison between the measured and predicted peak $\dot{V}O_2$ resulted in a correlation of 0.89. When the 9 minute distance and weight in kilograms were combined (Equation 7) by Baldwin (1983), the correlation coefficient was 0.95. When the individual values were substituted into Baldwin's (1983) equations, a correlation of 0.98 between the measured and predicted peak $\dot{V}O_2$ was obtained.

In Equation 8, Baldwin (1983) utilized height in centimeters, the distance covered in the 9 minute run and weight in kilograms which resulted in a correlation of 0.97 with peak $\dot{V}O_2$. In the present study, these variables resulted in a strong relationship between the measured and predicted peak $\dot{V}O_2$ as evidenced by the correlation of r = 0.98. This was the strongest correlation obtained from this study.

Lastly, age was the final variable to be added to the others previously mentioned which resulted in the highest correlation (r = 0.97) from Baldwin's (1983) work. Again when the relationship between the measured and predicted peak $\dot{V}O_2$ was examined, a correlation of 0.98 was discovered from this investigation.

Summary of Boys' Regression Equations

In all instances in which singular variables were included in the equations formulated by Baldwin (1983) (Equation 1, Table 3; Equation 1, Table 4; Equation 2, Table 4), the correlations obtained in this study were generally higher than those reported by Baldwin. When the relationship between the measured and predicted peak $\dot{V}O_2$ was examined, height in centimeters, the distance covered in the 9 minute run and weight in kilograms (Equation 8, Table 4) provided the highest correlation in the present study (r = 0.98).

Comparison of Predicted Peak $\dot{V}O_2$ to Measured Peak $\dot{V}O_2$

A dependent t-test was performed to examine the difference between the measured and predicted peak $\dot{V}O_2$. These results may be found in Table 8. When peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$ was examined, it was found that there was significant ($P < 0.05$) difference between the predicted (53.0 $ml.kg.min^{-1}$) and measured (54.7 $ml.kg.min^{-1}$) peak $\dot{V}O_2$

when the 9 minute run distance was used alone in Equation 1, Table 3. The percent error of 3.1 was the highest for all the equations using the criterion measure of $ml.kg.min^{-1}$. The underestimation is probably due to the greater mean distance covered in the 9 minute run and the higher peak $\dot{V}O_2$ (54.7 $ml.kg.min^{-1}$) when compared to Baldwin's (1983) subjects of 2121 yds and 51.8 $ml.kg.min^{-1}$. Equations 2, 3, and 4 all resulted in no significant ($P > 0.05$) difference between the predicted and measured peak $\dot{V}O_2$. Equation 2, Table 3, which included weight in kilograms and the distance covered in the 9 minute run, resulted in the highest correlation of 0.86. The difference between the predicted (53.9 $ml.kg.min^{-1}$) and measured (54.7 $ml.kg.min^{-1}$) values was 0.6 $ml.kg.min^{-1}$ with the lowest percent error of 1.46. As height in centimeters was added, the percent error increased to 2.01 (Equation 3, Table 3) and lowered the correlation to 0.73. This lessened the predictive qualities of Baldwin's (1983) equation. Finally, when age was the last variable to be included, the percent error increased to 2.37 and once again decreased the accuracy of a predicted peak $\dot{V}O_2$ (53.4 $ml.kg.min^{-1}$) as compared to the measured peak $\dot{V}O_2$ (54.7 $ml.kg.min^{-1}$). This may be due to the greater mean age of Baldwin's (1983) subjects (11.8) as compared to those in the present study (10.8). Based upon these results, it appears that when the 9 minute run distance and weight in kilograms were used to predict peak $\dot{V}O_2$ in $ml.kg.min^{-1}$ (Equation 2, Table 3) the strongest relationship to the measured peak $\dot{V}O_2$ obtained in the laboratory resulted.

$L.min^{-1}$

Similar results were discovered when the relationship between

Table 8

Comparison of Measured and Predicted Peak $\dot{V}O_2$ Values in $ml.kg.min^{-1}$ and $L.min^{-1}$ for Boys

Equation Validated	Predicted Peak VO_2 ($ml.kg.min^{-1}$)	Predicted Peak VO_2 ($L.min^{-1}$)	Measured Peak VO_2 ($ml.kg.min^{-1}$)	Measured Peak VO_2 ($L.min^{-1}$)	Summary Statistics t	r	% error[a]
1	53.0 ±4.10	--	54.7 ±4.84	--	2.06	0.795	3.10
2	53.9 ±3.76	--	54.7 ±4.84	--	1.20	0.864	1.46
3	53.6 ±4.59	--	54.7 ±4.84	--	1.14	0.731	2.01
4	53.4 ±4.73	--	54.7 ±4.84	--	1.32	0.728	2.37
5	--	2.42 ±0.41	--	2.08 ±0.77	-2.49*	0.837	-16.34
6	--	1.94 ±0.69	--	2.08 ±0.77	1.52	0.887	6.73
7	--	2.03 ±0.75	--	2.08 ±0.77	1.37	0.982	2.40
8	--	2.03 ±0.83	--	2.08 ±0.77	1.71	0.983	2.40
9	--	2.01 ±0.83	--	2.08 ±0.77	1.78*	0.982	3.36

% error[a] = 100 (measured - predicted/measured)

* = $P < 0.05$

predicted peak $\dot{V}O_2$ and measured peak $\dot{V}O_2$ expressed in $L.min^{-1}$ was examined. Again, when the 9 minute run was used to predict peak $\dot{V}O_2$ (Equation 5, Table 4), a significant ($P < 0.05$) difference was observed between the predicted (2.42 $L.min^{-1}$) and measured (2.08 $L.min^{-1}$) values. This resulted in a percent error of 16.3 and lowest correlation coefficient of 0.84. It is understandable that Baldwin's (1983) equation overestimated the 9 minute run performance of the present study's sample since the mean distance in yards covered by Baldwin's (1983) subjects (2121) was less than that covered by the subjects participating in this study (2195).

Equations 6, 7, and 8 all resulted in no significant ($P > 0.05$) difference between the predicted and measured peak $\dot{V}O_2$. Weight in kilograms was used to predict peak $\dot{V}O_2$ (1.94 $L.min^{-1}$) (Equation 6, Table 4) which resulted in a percent error of 6.73 and a correlation of 0.89. This was in comparison to the measured value of 2.08 $L.min^{-1}$. Equations 7 and 8 were almost identical in their ability to predict peak $\dot{V}O_2$ in the sample of 13 boys used in this study. Equation 7 utilized both the distance covered in the 9 minute run and weight in kilograms. Equation 8 added height in centimeters to the variables found in Equation 7. Both predictive equations resulted in high correlation coefficients of 0.98 and 0.98 for Equations 7 and 8, respectively. Each also resulted in a predicted peak $\dot{V}O_2$ of 2.03 $L.min^{-1}$ as compared to the measured value of 2.08 $L.min^{-1}$. Identical percent errors of 2.40 also resulted from each equation which was the smallest percent error for any equation using peak $\dot{V}O_2$ expressed in $L.min^{-1}$. This slight underestimation of peak $\dot{V}O_2$ is possibly due to the fact that Baldwin's (1983) subjects were, on the average, taller and heavier than those participating in this study. Lastly, age was added to the stepwise regression equation. Age lowered the predictive value (2.08 $L.min^{-1}$) of Equation 9, Table 4, as indicated by the increase in the percent error to 3.6.

Based upon these results, it appears that Equations 7 and 8, Table 4, are the most valid equations for predicting peak $\dot{V}O_2$ in the participants examined in this study.

Summary of the Comparison of Predicted Peak $\dot{V}O_2$ to Measured Peak $\dot{V}O_2$

Stepwise regression euqations were developed by Baldwin (1983) to predict peak $\dot{V}O_2$ based upon the 9 minute run distance and other variables measured. These equations were examined for their predictive validity utilizing a sample of 13 boys, ages 9 - 14. A comparison of Baldwin's (1983) correlations and those developed from the present study may be found in Table 9.

Upon examination of the data developed from this study, three of Baldwin's (1983) prediction equations are deemed valid. When peak $\dot{V}O_2$ was expressed in $ml.kg.min^{-1}$, and the 9 minute run distance (yds) and weight in kilograms were used in Equation 2, Table 3, the smallest percent error (1.46) resulted between the predicted (53.0 $ml.kg.min^{-1}$) and measured (54.7 $ml.kg.min^{-1}$) peak $\dot{V}O_2$.

If peak $\dot{V}O_2$ is expressed in $L.min^{-1}$, then both Equations 7 and 8, Table 4, may be used to predict peak $\dot{V}O_2$. Both equations utilized the easily measured variables of the 9 minute run distance and weight in kilograms. The addition of height in centimeters weakened Equation

Table 9

Comparison of Correlations Between Baldwin's (1983) and Present Study

Equation Number	Baldwin's (1983) R	Present Study R
ml.kg.min^{-1}		
1[a]	0.69	0.80
2[ab]	0.72	0.86
3[abc]	0.79	0.73
4[abcd]	0.79	0.73
L.min^{-1}		
5[a]	0.58	0.84
6[b]	0.91	0.89
7[ab]	0.95	0.98
8[acb]	0.97	0.98
9[acbd]	0.97	0.98

a - 9 minute run
b - weight in kg
c - height in cm
d - age

8, Table 4, nominally, as evidenced by the standard deviation of the peak $\dot{V}O_2$ ($L.min^{-1}$). Both equations elicited identical percent errors of 2.40. However, the standard deviation of peak $\dot{V}O_2$ ($L.min^{-1}$) for Equation 7, $\pm$ 0.75, was slightly lower than that found for Equation 8, $\pm$ 0.83.

Validation of Girls' Regression Equations

Kreun (1984) developed stepwise multiple regression equations to predict peak $\dot{V}O_2$ in $ml.kg.min^{-1}$ and $L.min^{-1}$ utilizing the 9 minute run and other measured variables. The equations, correlation coefficients and standard error of the estimate may be found in Tables 5 and 6. Predicted peak $\dot{V}O_2$ values were calculated by substituting each of the 12 girl's values into each of the equations.

$ml.kg.min^{-1}$

Equation 1, Table 5, involved the use of the 9 minute run distance to predict peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$. The correlation resulting from Kreun's (1984) work was 0.59 which was much lower than the correlation of 0.74 discovered by the present investigator. When Kreun (1984) included weight in kilograms in Equation 2 along with the 9 minute run distance, a correlation coefficient of 0.66 resulted. In the present study, the individual values of each girl were substituted into Kreun's (1984) equation. A correlation of 0.85 resulted from the comparison of the measured and predicted peak $\dot{V}O_2$. As age and weight in kilograms were added to the 9 minute run distance, Kreun's (1984) correlation coefficient of 0.66 was slightly higher than the previous equation. The comparison of the measured and predicted $\dot{V}O_2$ in the present study elicited a much higher correlation of 0.86. Lastly, 4 employed the use of height in centimeters, age, weight in kilograms and the distance covered in the 9 minute run to predict peak $\dot{V}O_2$ in girls 9 - 14 years of age. A correlation coefficient of 0.66 resulted which was the highest correlation obtained from Kreun's (1984) work with peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$. Again, the results of this study show a strong relationship (r = 0.85) between the measured and predicted peak $\dot{V}O_2$.

The results of the present study show higher relationships than those obtained from other investigators involving females. Bell and Hinson (1974) investigated the prediction of peak $\dot{V}O_2$ in a much older group of women, 20 -40 years of age, utilizing the bicycle ergometer to obtain the measured peak $\dot{V}O_2$. The authors examined the distance covered in the 880 yd run, age, weight in pounds, and resting heart rate to predict peak $\dot{V}O_2$. A correlation of 0.73 was the result, which was higher than the correlation of 0.66 obtained when age, height in centimeters, and the 9 minute run distance was used by Kreun (1984) but lower than the correlation of 0.86 obtained from the present study. When Bell and Hinson (1974) examined the relationship of the peak $\dot{V}O_2$ to the performance time of the 880 yd run, the result was a correlation of -0.69 as compared to Kreun's (1984) correlation of 0.59 and the correlation of 0.74 obtained from the present study.

Jackson and Coleman (1976) investigated the relationship between the treadmill peak $\dot{V}O_2$ and the distance covered in the 9 minute run tests in elementary school children. These authors reported a correlation of 0.71 which was similar to the correlation of 0.74 obtained from the present study.

$L.min^{-1}$

Kreun (1984) also utilized the peak $\dot{V}O_2$ expressed in $L.min^{-1}$ and the 9 minute run distance to develop predictive regression equations for girls 9 - 14 years of age. These regression equations may be found in Table. 6. Equation 5 examined the relationship between peak $\dot{V}O_2$ ($L.min^{-1}$) and the 9 minute run distance. This author obtained a correlation of 0.53 which was considerably lower than the correlation of 0.80 reported by Kreun (1984). This may be due to the fact that Kreun's (1984) subjects elicited higher mean values for both the 9 minute run (1936 yds) and $L.min^{-1}$ (2.15 $L.min^{-1}$) as compared to the subjects in this study as shown in Table 7. Weight in kilograms was used in Equation 6. A correlation of 0.79 resulted from the present study which was much lower than Kreun's (1984) correlation of 0.91. This may be due to the difference in weight between Kreun's (1984) subjects (43.3 kg) and those subjects examined in this study (38.1 kg). Wells et al. (1973) also used weight in kilograms to predict peak $\dot{V}O_2$ in a sample of subjects (n = 12) ranging in age from 12 - 18 years. Their subjects were active in organized sports and possessed a mean treadmill $\dot{V}O_2max$ in 2.47 $L.min^{-1}$. These authors reported a correlation of 0.86, which was higher than that obtained from this study but lower than the correlation reported by Kreun (1984).

The results obtained from Equation 7 are in agreement with those reported by Kreun (1984). This equation used weight in kilograms and the distance covered in the 9 minute run to predict peak $\dot{V}O_2$. Kreun (1984) reported a correlation of 0.95. When the individual values were substituted into Kreun's (1984) equation, a correlation of 0.95 resulted from the comparison of the measured and predicted peak $\dot{V}O_2$. Equation 8 utilized age in addition to the variables used in Equation 7. The correlation resulting from Kreun's (1984) work was 0.95 and was the highest reported in her study. When the relationship between the measured and predicted peak $\dot{V}O_2$ was examined, a similar correlation of 0.94 was found in the present study.

The final equation (Equation 9) added height in centimeters to the previous variables. The correlation coefficient of 0.94 was reported by Kreun (1984). Again, the relationship between the measured peak $\dot{V}O_2$ and predicted peak $\dot{V}O_2$ was examined, and the resulting correlation was the highest (r = 0.95) in the present investigation.

Comparison of Predicted Peak VO_2 to the Measured Peak VO_2

Kreun's (1984) regression equations were used to predict peak $\dot{V}O_2$ ($ml.kg.min^{-1}$ and $L.min^{-1}$) for the 12 girls examined in this study. The predictive values obtained from the regression equations utilizing $ml.kg.min^{-1}$ and $L.min^{-1}$ were compared to the actual measured values obtained in the laboratory. This was accomplished through the use of a paired t-test. The results of this statistical treatment may be found in Table 10. As with the boys, percent error, as described by Bonen et al. (1979) has been included in the discussion to allow for a more accurate interpretation of the predictive validity of each equation.

$ml.kg.min^{-1}$

There was a significant difference ($P < 0.05$) between the predicted and measured peak $\dot{V}O_2$ expressed in $ml.kg.min^{-1}$. This may be due to the difference in the measured peak $\dot{V}O_2$ ($ml.kg.min^{-1}$). Kreun (1984) reported a mean peak $\dot{V}O_2$ of 48.7 $ml.kg.min^{-1}$ which was lower than the

Table 10

Comparison of Measured and Predicted Peak $\dot{V}O_2$ Values

in $ml.kg.min^{-1}$ and $L.min^{-1}$ for Girls

Equation Validated	Predicted Peak VO_2 ($ml.kg.min^{-1}$)	Predicted Peak VO_2 ($L.min^{-1}$)	Measured Peak VO_2 ($ml.kg.min^{-1}$)	Measured Peak VO_2 ($L.min^{-1}$)	Summary Statistics t	r	% error[a]
1	46.9 ±5.28	--	52.0 ±6.25	--	28.80*	0.736	9.80
2	47.6 ±7.77	--	52.0 ±6.25	--	28.81*	0.854	8.46
3	47.7 ±7.69	--	52.0 ±6.25	--	28.81*	0.864	8.26
4	47.5 ±7.62	--	52.0 ±6.25	--	28.81*	0.854	8.65
5	--	1.95 ±0.59	--	1.96 ±0.45	2.09	0.525	.16
6	--	1.86 ±0.50	--	1.96 ±0.45	1.00	0.794	5.10
7	--	1.85 ±0.46	--	1.96 ±0.45	2.56*	0.951	5.61
8	--	1.84 ±0.47	--	1.96 ±0.45	2.36*	0.940	6.12
9	--	1.86 ±0.46	--	1.96 ±0.45	2.20*	0.942	5.10

% error[a] = 100 (measured - predicted/measured)

* = $P < 0.05$

52.0 ml.kg.min^{-1} found in the present study.

Equation 1, Table 5, used the 9 minute run distance to predict peak $\dot{V}O_2$. The percent error of 9.80 was the highest among the equations based upon ml.kg.min^{-1} and the predicted peak $\dot{V}O_2$ of 46.9 ml.kg.min^{-1} was significantly ($P < 0.05$) lower than the actual peak $\dot{V}O_2$ of 52.0 ml.kg.min^{-1}. As weight was added in Equation 2, the percent error decreased to 8.46 but the difference between the predicted and peak $\dot{V}O_2$ values was still a significant ($P < 0.05$) 4.4 ml.kg.min^{-1}. Age was the next variable that Kreun (1984) included in Equation 3. The percent error of 8.26 was the lowest for the equations expressed in ml.kg.min^{-1} but still resulted in a significant ($P < 0.05$) difference between the predicted (47.7 ml.kg.min^{-1}) and the measured (52.0 ml.kg.min^{-1}) peak $\dot{V}O_2$ values. When the final variable, height in centimeters, was included in Equation 4, the percent error increased from that found for Equation 3. A significant ($P < 0.05$) difference of 4.5 ml.kg.min^{-1} between the predicted and measured peak $\dot{V}O_2$ resulted with a percent error of 8.65.

Based upon these results, none of the equations expressed in ml.kg.min^{-1} may be used to accurately predict peak $\dot{V}O_2$ in the sample studied by this investigator.

<u>L.min^{-1}</u>

Similar results were discovered when the relationship between predicted mean peak $\dot{V}O_2$ and mean measured peak $\dot{V}O_2$ expressed in L.min^{-1} was examined. Equation 5, Table 6, utilized the 9 minute run distance to predict peak $\dot{V}O_2$. It was found that there was no significant ($P > 0.05$) difference between the mean measured (1.957 L.min^{-1}) and the mean predicted (1.953 L.min^{-1}) peak $\dot{V}O_2$. This was due to the nominal difference (0.2 $L.min^{-1}$) between the mean measured peak $\dot{V}O_2$ of Kreun's (1984) subjects (2.15 $L.min^{-1}$) and those investigated in the present study (1.96 $L.min^{-1}$). Weight in kilograms was examined in Equation 6, and there was no significant ($P > 0.05$) difference between the mean measured (1.96 $L.min^{-1}$) and mean predicted (1.86 $L.min^{-1}$) peak $\dot{V}O_2$. Kreun's (1984) equation resulted in a predictive percent error of 4.60. Equation 7, Table 6, utilized both weight in kilograms and the 9 minute run distance to predict peak $\dot{V}O_2$. There was a significant ($P < 0.05$) difference between the mean measured (1.96 $L.min^{-1}$) and the mean predicted (1.85 $L.min^{-1}$) peak $\dot{V}O_2$ with a percent error of 5.12 resulting. This underestimation of peak $\dot{V}O_2$ may be due to the fact that Kreun's (1984) subjects were heavier (43.3 kg) than those in the present investigation (38.1 kg). Age was added in Equation 8 with a resulting decrease in the predictive validity of that equation. Again there was a significant (P 0.05) difference between the mean measured (1.96 $L.min^{-1}$) and mean predicted (1.84 $L.min^{-1}$) peak $\dot{V}O_2$. The resulting percent error was 5.64. Kreun's (1984) subjects were slightly older (11.9 years) than those in the present study (11.0 years), which may account for the difference in results.

Lastly, height in centimeters was included in Equation 9. Again, there was a significant ($P < 0.05$) difference between the mean measured (1.96 $L.min^{-1}$) and the mean predicted (1.86 $L.min^{-1}$) peak $\dot{V}O_2$. However, height in centimeters increased the predictive validity slightly from Equation 8 by decreasing the percent error to 4.6.

Based upon these results, it appears that Kreun's (1984) equation using the 9 minute run distance (Equation 5, Table 6) is best when predicting peak $\dot{V}O_2$ for the sample studied in the present investigation. Although the correlation coefficient of 0.525 is low, Bonen et. a., (1979) believed that the percent error of .16 is more indicative of an equation's ability to predict $\dot{V}O_2$ than the correlation coefficient itself. The difference between the mean measured and mean predicted peak $\dot{V}O_2$ was .004 $L.min^{-1}$ for the respective equation.

Summary of the Comparison of Predicted Peak $\dot{V}O_2$ to Measured Peak $\dot{V}O_2$

Kreun (1984) developed regression equations to predict peak $\dot{V}O_2$. A comparison of correlations developed by Kreun (1984) and those developed from the present study may be found in Table 11. Kreun's (1984) equations were expressed in $ml.kg.min^{-1}$ and $L.min^{-1}$. Those expressed in $ml.kg.min^{-1}$ do not appear to be valid for use with the sample studied in this investigation. Of those using $L.min^{-1}$ as the criterion measure, only Equation 5, Table 6, appears valid for use with the sample studied based upon the correlation coefficient and percentage error. Although this relationship is weak in regards to the correlation coefficient, it is the strongest relationship elicited from the present study to validate Kreun's (1984) equations.

Table 11

Comparison of Correlations Between Kreun's (1984) and Present Study

Equation Number	Kreun's (1984) R	Present Study R
ml.kg.min^{-1}		
1[a]	0.594	0.736
2[ab]	0.657	0.854
3[abc]	0.662	0.864
4[abca]	0.663	0.854
L.min^{-1}		
5[a]	0.795	0.525
6[b]	0.906	0.794
7[ab]	0.947	0.951
8[abd]	0.950	0.940
9[abdc]	0.942	0.942

a - 9 minute run
b - weight in kg
c - height in cm
d - age

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Thirteen boys and 12 girls between the ages of 9 and 14 participated in this investigation to determine the predictive validity of multiple regression equations developed by Baldwin (1983) and Kreun (1984). For purposes of cross-validation, a random sample of 13 boys and 12 girls were removed from Baldwin's (1983) and Kreun's (1984) original samples. Physical characteristics of height and weight were measured for each subject. Each boy performed the volitional treadmill $\dot{V}O_2$ test utilizing the protocol as described by Skinner (1971) while the girls performed the volitional treadmill peak $\dot{V}O_2$ test utilizing the Bruce protocol (Bruce et al., 1973). The boys and girls also performed a 9 minute run for distance. Each of the boy's and girl's values for age (yrs), height (cm), weight (kg), and the distance covered (yds) in the 9 minute run were inserted into each multiple regression equation developed by Baldwin (1983) and Kreun (1984), respectively. A simple correlation was then performed to determine the relationship between each equation's predicted peak $\dot{V}O_2$ and the measured peak $\dot{V}O_2$ obtained in the laboratory. A paired t-test determined whether or not a significant difference existed between the mean predicted and mean measured peak $\dot{V}O_2$. Based upon those results it was determined that three of Baldwin's (1983) equations were valid in predicting peak $\dot{V}O_2$ in the 13 boys participating in the present study. The best predictive equation expressed in $ml.kg.min^{-1}$ included weight in kilograms and the 9 minute run distance (yds).

Equation 2, Table 3

$$\text{Peak } \dot{V}O_2 \ (ml.kg.min^{-1}) = 18.604 - 0.1069 \ (\text{weight in kg}) + 0.017896 \ (\text{9 minute run yds})$$

This resulted in a correlation of 0.86 and a percent error of 1.46.

When peak $\dot{V}O_2$ was expressed in $L.min^{-1}$, two equations (Equations 7 and 8, Table 4), developed by Baldwin (1983) appeared valid in predicting peak $\dot{V}O_2$ in the sample studied.

Equation 7, Table 4

$$\text{Peak } \dot{V}O_2 \ (L.min^{-1}) = -1.587 + 0.00082973 \ (\text{9 minute run yds}) + 0.048108 \ (\text{weight in kg})$$

Equation 8, Table 4

$$\text{Peak } \dot{V}O_2 \ (L.min^{-1}) = -3.391 + 0.017377 \ (\text{height in cm}) + 0.00072169 \ (\text{9 minute run yds}) + 0.033714 \ (\text{weight in kg})$$

Equation 7 utilized the 9 minute run distance (yds) and weight (kg) while Equation 8 added height (cm). Identical correlations of 0.98 and 0.98 resulted in Equations 7 and 8, respectively, with identical percent errors of 2.40. This is in agreement with Baldwin (1983) who found that Equation 8, Table 4, was best for predicting peak $\dot{V}O_2$ in her sample of boys.

The results obtained for the girls were not as valid as those obtained from the boys. From the results of this study, one equation (Equation 5, Table 6) was found to be valid.

Equation 5, Table 6

$$\text{Peak } \dot{V}O_2 \ (L.min^{-1}) = -1.220 + 0.0017400 \ (9 \text{ minute run yds})$$

Equation 5 utilized the 9 minute run distance only, resulting in a correlation of 0.53 and a small percent error of .16. Based upon the results of this investigation, it is recommended that the above equations are valid for predicting peak $\dot{V}O_2$ for the sample of boys or girls 9 - 14 years of age studied.

Recommendations for Future Study

Upon the conclusion of this investigation it became apparent that the following recommendations need to be considered by those wishing to undertake future research in this area.

Future samples used for purposes of cross-validation should be larger so that accuracy is not endangered. A larger sample may elicit different correlations and percent errors.

Subjects from which the equations are developed need to be randomly selected to insure a heterogenous sample. This would help to eliminate any sampling error that may possibly occur when a random sample is pulled out for the purpose of cross-validation.

A running protocol to elicit peak $\dot{V}O_2$ in children may lead to higher peak $\dot{V}O_2$ than obtained from a walking protocol or a protocol using a combination of walking and running. This may possibly strengthen the predictive validity of future equations developed from running protocols.

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APPENDIX A

PARENTAL INFORMED CONSENT
FOR 9 MINUTE RUN

I, the parent/guardian of _________________________________, give permission for my son/daughter to participate in the 9 minute run for distance being conducted at the University of Wisconsin-LaCrosse fieldhouse. I understand that participation in this study will involve running/walking on the track for 9 minutes. The objective of this test is to determine how far he/she can go in the 9 minute time limit. He/she will run with other children his/her age. Pacing is important in this test so he/she will have an opportunity to practice running with one of our college student helpers. Although the greatest distance will be completed by running the entire 9 minutes he/she may walk at any time. I understand my son/daughter can stop the test anytime he/she wishes. Both the girl and boy in each age group who covers the greatest distance in the 9 minutes will be awarded a "Tee-shirt" if they also complete the treadmill test (see yellow sheet).

As with any vigorous exercise there exists the possibility of adverse changes occurring (i.e., dizziness, staggering, difficulty in breathing, etc.) during the test. In addition he/she will feel tired at the end of the run. If any abnormal observations are noted the test will be immediately terminated.

The actual testing will be conducted by Tami Kreun, Debbie Baldwin and Peg Morsch, graduate students at the University of Wisconsin-LaCrosse. They will be under the supervsion of Nancy Kay Butts, Ph.D.

To my knowledge my son/daughter is no infected with any disease or has any limiting physical conditions or diabilities, especially with respect to his/her heart, that would preclude such a strenuous exercise.

I, ____ parent/guardian of

____, approve the participation of my son/daughter in the 9 minute run at the University of Wisconsin-LaCrosse fieldhouse. I have read the foregoing and I understand it, and any questions which may have occurred to me have been answered to my satisfaction. The potential risks have been explained to me and I fully understand their implications. I hereby acknowledge that no representations, warranties, guarantees, or assurances of any kind pertaining to the procedures have been made to me by the University of Wiscosin-LaCrosse, the officers, administrators, employees, or by anyone acting on behalf of any of them.

Signed: ___________________________________ Date: ______________________
(parent/guardian)

APPENDIX A

PARENTAL INFORMED CONSENT
FOR MAXIMAL TREADMILL TEST

I, the parent/guardian of ______________________________, give permission for my daughter to participate in the maximal treadmill test at the Human Performance Laboratory at the University of Wisconsin-LaCrosse. I understand that this test consists of walking/running to voluntary exhaustion on a motor-driven treadmill. The speed of the treadmill will be gradually increased from 1.7 mph to approximately 5 mph. The treadmill will also be inclined gradually throughout the test. During this test heart rates will be monitored continuously on an electrocardiograph (ECG). She will breathe room air through a mouthpiece so that her exhaled air can be collected. This test requires a maximal effort, however, I understand my daughter can stop the test anytime she wishes.

As with any exercise, there exists the possibility of adverse changes occurring (i.e., dizziness, staggering, difficulty in breathing etc.) during the test. In addition she will feel tired at the end of the exercise. If any abnormal observations are noted the test will be immediately terminated.

The actual testing will be conducted by Tami Kreun, Debbie Baldwin and Peg Morsch, graduate students at the University of Wisconsin-La Crosse. They will be under the supervision of Nancy Kay Butts, Ph.D.

To my knowledge my daughter is not infected with any disease or has any limiting physical conditions or disabilities, especially with respect to her heart, that would preclude such a strenuous exercise.

I, ____ parent/guardian of

____, approve the participation of my daughter in the maximal treadmill test at the Human Performance Laboratory at the University of Wisconsin-LaCrosse. I have read the foregoing and I understand it, and any questions which may have occurred to me have been answered to my satisfaction. The potential risks have been explained to me and I fully understand their implications. I hereby acknowledge that no representations, warranties, guarantees, or assurances of any kind pertaining to the procedures have been made to me by the University of Wisconsin-LaCrosse, the officers, administrators, employees, or by anyone acting on behalf of any of them.

Signed ______________________________ Date: __________________
(parent/guardian)

APPENDIX B

Complete Laps Run

1 2 3 4 5 6 7 8 9 10

Total Yards Run (laps x 220) =

Portions of Laps Run

1 2 3

Portions Completed (portions x 55) =

TOTAL YARDS RUN =