

ABSTRACT

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Thirty young male volunteers, 9-14 yrs, were studied to determine if a relationship existed between peak $\dot{V}O_2$ and the 9-min run distance. Physical characteristics for all Ss included ht, wt, and % fat. Ss were tested for volitional peak $\dot{V}O_2$ on the treadmill using the Skinner et al. (1971) protocol. Variables measured were VE max, RER, HR max, and peak $\dot{V}O_2$ ($l \cdot min^{-1}$ & $ml \cdot kg^{-1} \cdot min^{-1}$). A 9-min run for distance was also performed by the Ss. A multiple regression technique was used to predict peak $\dot{V}O_2$ from the 9-min run distance. The resulting r value when predicting peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ from the 9-min run distance was 0.693. The r value for prediction of peak $\dot{V}O_2$ in $l \cdot min^{-1}$ from the 9-min run distance was 0.583. Other variables measured were entered into the regression technique to improve the R such as age, ht, wt, HR, RER, % fat, and body density. It was concluded that 2 equations which utilized wt (kg) and ht (cm) with the 9-min run distance (yds) predicted peak $\dot{V}O_2$ values with the most accuracy and practicality in $ml \cdot kg^{-1} \cdot min^{-1}$ ($R=0.789$) and $l \cdot min^{-1}$ ($R=0.966$):

$$\text{Peak } \dot{V}O_2 \text{ (ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}\text{)} = -12.13 + 0.29608 (X_3) - \\
 .3521 (X_2) + 0.016055 (X_1)$$

$$\text{Peak } \dot{V}O_2 \text{ (l} \cdot \text{min}^{-1}\text{)} = -3.391 + 0.017377 (X_3) + \\
 0.00072169 (X_1) + 0.033712 (X_2)$$

Key: X_1 = 9-min run distance (yds)
 X_2 = Wt (kg)
 X_3 = Ht (cm)

The multiple R value (0.812) which combined % fat with the 9-min run was also concluded to be a good predictor of peak $\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$).

Prediction of Peak $\dot{V}O_2$ Values from 9-Minute
Run Distances in Young Males, 9-14 Years

A Thesis Presented
to
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In Partial Fulfillment
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by

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There are people in this world that constantly are giving of their talents to others without hesitation.

There are people who always exhibit an unending patience no matter how frustrating situations become.

There are people who lovingly support others in a manner much stronger than any concrete pillar supporting the tallest building.

There are people that willingly give up much of their lives so that others grow and develop.

And lastly, there are people who, believe it or not, keep honour alive in investigators everywhere.

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TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Background	1
Purpose of the Study	2
Null Hypothesis	2
Assumptions	2
Delimitations.	3
Limitations	3
Definition of Terms	3
II. REVIEW OF RELATED LITERATURE	5
Introduction	5
Body Composition	5
Performance Values of Children	7
Protocol Selection	9
Prediction of Max $\dot{V}O_2$	11
Physical Characteristics	13
Heart Rate	15
Field Tests	16
Fitness Tests	16
Running Performance Time	17
Specific Time Runs	19
Summary	19

III. METHODS	21
Introduction	21
Subject Selection	21
Hydrostatic Weighing	22
Peak Oxygen Uptake Determination	23
Practice Session	23
Testing Procedure	24
Instrumentation	25
9-Minute Run	26
Preliminary Procedures	27
Run Procedures	28
Statistical Methods	28
IV. RESULTS AND DISCUSSION	29
Introduction	29
Subjects	29
Treadmill Responses	33
9-Minute Run Performance	35
Prediction of Peak $\dot{V}O_2$	36
$\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$	36
9-Minute Run	39
Weight	41
Height	41
Age	42
Percent Fat	43

1'min ⁻¹	44
9-Minute Run	45
Weight	46
Height	47
Age	47
Summary	48
V. SUMMARY AND RECOMMENDATIONS	50
Summary	48
Recommendation for Future Study	52
REFERENCES CITED	53
APPENDICES	
A - Letter of Invitation	59
B - Informed Consents	60

LIST OF TABLES

TABLE	Page
1. Means and Standard Deviations for Physical Characteristics of All 43 Subjects According to Age	30
2. Means and Standard Deviations for Physical Charac- teristics of Remaining 30 Subjects According to Age	31
3. Means and Standard Deviations of Physiological Responses to Peak Treadmill Tests and Distances Covered in the 9-Minute Run (n=30)	34
4. Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$)	37
5. Multiple Regression Equations for Prediction of Peak $\dot{V}O_2$ ($\text{l}\cdot\text{min}^{-1}$)	38

CHAPTER I
INTRODUCTION
Background

In the past several years an enormous trend toward physical fitness has evolved in the United States. Physical educators have turned the "back-to-basics" educational movement into a "back-to-fitness" movement. This has made necessary a constant search for a practical, as well as a valid method of measuring the cardiovascular fitness of school-age children. Although the maximal oxygen uptake ($\dot{V}O_2$) is considered to be one of the best measurements of cardiovascular fitness, it is impractical due to the expensive equipment, trained personnel, and excessive time necessary to perform this test (Astrand & Rodahl, 1977; McArdle, Katch, & Katch, 1981; Pollock, Wilmore, & Fox, 1978). Therefore, a more realistic approach would be to determine a method of predicting $\dot{V}O_2$ which would be a more practical tool for the physical educator.

Many attempts have been made to develop prediction equations for $\dot{V}O_2$ that would eliminate the necessity of the actual maximal exercise test thus eliminating expensive equipment (Binyildiz, 1980; Bonen, Hayward, Cureton, Boileau, & Massey, 1979; Hermansen & Oseid, 1971; Krahenbuhl, Pangrazi, Petersen, Burkett, Schneider, 1975). These researchers have used a number of different variables ranging from submaximal heartrates to field tests in their attempts to predict $\dot{V}O_2$. The field test

stands out as the most practical of the prediction methods due to the ease at which it can be administered. A practical field test that is already used by many physical educators to assess cardiovascular fitness is the 9-minute run. This test would be a logical choice for the prediction of $\dot{V}O_2$ in school-age children, and it has been sanctioned by the American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD, 1961). Although normative values have been developed for the 9-minute run, very little research has been conducted dealing with prediction of $\dot{V}O_2$ from this field test. The practical benefits of this type of research, especially with school-age subjects, consequently becomes apparent.

Purpose of the Study

The purpose of this study was to determine if a significant relationship existed between distance covered in a 9-minute run and peak oxygen uptake (peak $\dot{V}O_2$) values in boys 9 to 14 years of age. If such a relationship does exist, then a secondary purpose would be the development of useful regression equations for the prediction of peak $\dot{V}O_2$ values from the 9-minute run.

Null Hypothesis

There will be no relationship between peak $\dot{V}O_2$ and distance covered in the 9-minute run.

Assumptions

The results of this study were based on the following assumptions. All subjects were in good health throughout the study.

Familiarity with the testing procedures and equipment was sufficient enough to allow subjects to perform to the best of their ability.

Internal and external motivation was the same for all subjects and all subjects performed maximally on both the 9-minute run and the peak $\dot{V}O_2$ determination.

Delimitations

The study was delimited to boys between the ages of 9 and 14 years who were volunteer participants.

Limitations

Due to the nature of the study, volunteers were used rather than randomly selected subjects.

The motivational level of each subject could not be controlled.

Due to scheduling problems, the time order of the 9-minute run and the peak $\dot{V}O_2$ measurement was not randomized.

Definitions of Terms

9-Minute Run - A distance run recommended by the AHPERD as a measure of cardiovascular function. It is performed by attempting to run/walk the greatest distance possible within a 9-minute period.

Peak Oxygen Uptake (peak $\dot{V}O_2$) - the highest amount of oxygen which can be taken in, transported, and utilized during an exhaustive bout of exercise on a treadmill as described by Skinner, Bar-Or, Bergsteinova, Bell, Royer and Buskirk (1971), with the endpoint being at the subject's

volition. The value was expressed in liters per minute ($l \cdot \text{min}^{-1}$) and milliliters per kilogram of body weight per minute ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$).

Percent Fat - the percentage of the total body mass that is fat as determined by the formula derived by Brozek, Grande, Anderson, and Keys (1963).

Respiratory Exchange Ratio (RER) - the ratio of expired carbon dioxide (CO_2) over the oxygen (O_2) consumed.

CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The measurement of maximal oxygen consumption ($\dot{V}O_2$) has become widely accepted as a cardiovascular fitness evaluation method. Physical educators, however, frequently do not have access to the equipment or the trained personnel necessary to perform oxygen consumption measurements. A number of attempts have been made to predict $\dot{V}O_2$ using various parameters including field tests. The extent of those attempts have been examined in the following chapter. Summarization of materials relating to the performance values of children, the unique consideration in protocol selection, and an overview of body composition characteristics have also been included.

Body Composition

The measurement of body composition in adults has become a relatively accepted practice. Hydrostatic weighing has emerged as the most valid method and has become the "gold standard" in body composition determination. The same circumstances do not exist, however, for the determination of body composition in children. Accepted methods of indirectly determining body composition are simply not available (Caretton, Boileau, & Lohman, 1975; Heald & Hunt, 1963; Parizkova, 1961; Slaughter & Lohman, 1977). The validity of using methods of estimating percent fat from

body density using equations derived from research performed from body density using equations derived from research performed with adult male cadavers by Brozek et al. (1963) has yet to be determined.

Cureton et al. (1975) questioned the application of the Brozek et al. (1963) formula to children due to the changes that occur during growth. They questioned whether the basic assumption of the formula that the fat-free body density is constant can be assumed with children. Lohman (1981) stated that, "body densities of the fat-free body and lean body mass are known to change from population to population depending on age, racial background, sex and degree of physical activity" (p.200). Cureton et al. (1975), however, found that there was no significant difference when the percent fat was determined by densitometrics, potassium-40 or skinfold estimates. Due to this consistency, they concluded that the Brozek et al. (1963) formula was indeed valid for children. Additional research confirming or questioning these conclusions has not been published.

A number of studies have assumed the body composition methods to be valid for children and have gained information regarding the changes in body composition of children during growth. Parizkova (1961) established nomograms for predicting body density and subsequently percent fat from skinfold measurements using 241 children aged 9 to 16. She stated that:

...in boys there is a temporary decline of body density at the age of 10 to 12 years (average 1.048 SE = 0.005), and with the onset of clinical puberty the body density increases considerably (1.063 SE = 0.004) at the expense of body fat. (p.796)

She also found that the greatest proportion of body fat is subcutaneous in children and that the ratio approaches that of adulthood during growth. Forbes and Amirhakani (1970) measured 293 boys and 179 girls between the ages of 8 and 18 using the potassium-40 assay method. They concluded that girls progressively increase in percent fat through growth while boys, in contrast, have a short-lived "fat spurt" and eventually a reduction in percent fat. Boys between the ages of 9 and 14 declined in percent fat from approximately 19% to 10%. Heald and Hunt (1963) concluded a similar decline in the percent fat of boys during the ages of 12 and 18. They illustrated a 50% loss of body fat and a definite increase in lean body weight. That is, body fat percent dropped from 24% at age 12 to 10.9% at age 18. Careton et al. (1975), in their study involving a younger age category of boys (8-11 years), estimated the mean percent fat using the body density method to be approximately 20%. This was greater than most adult values.

In conclusion, although the validity of the application of adult body composition methods in children has not yet been determined or alternative methods established, these methods have been used with success by researchers. Percent fat has been illustrated to decline in male children through the growth spurt, especially as adolescence arrives. Younger aged males have exhibited a higher percent fat than their adult counterparts.

Performance Values of Children

A number of researchers have investigated children's physiological responses to various types of exercise. (Boileau, Bonen, Hayward, & Massoy,

1977; Krahenbuhl et al., 1975; Mocellin, Lindeman, Rutenfranz, & Stroseny, 1971; Paterson, Cunningham, & Donner, 1981). Since $\dot{V}O_2$ has been accepted as a method of evaluating cardiovascular fitness, it has also become the target of many of the investigations dealing with children. Some unique characteristics have been cited, however, that must be considered when testing children. For example, Cunningham, MacFarlane van Waterschoot, Paterson, Lefcoe, & Sangal (1977), when testing 66 ten-year-old ice hockey players, found difficulty in meeting the standard criteria for $\dot{V}O_2$ determination of a plateau in oxygen consumption and a respiratory equivalent ratio (RER) of 1.0 or greater. They stated that this could be due to incomplete development of the anaerobic capacity of the boys. The mean data were equally reproducible without the plateau. Paterson et al. (1981) confirmed these results.

A number of other factors have been cited by researchers as topics of special consideration when determining $\dot{V}O_2$ in children. Krahenbuhl et al. (1975) stated that motivation and the short attention span of children must be considered. Astrand (1971) stated that through the growth period "we can expect improved physical performance just because there is an increase in body size" (p.12). He also stated that "the maturity of the neuromuscular function, improving coordination, and the sexual maturity must be considered" (p.12).

Research has provided data concerning $\dot{V}O_2$ testing involving children on both the bicycle and treadmill testing modes. Cunningham et al. (1977) reported $\dot{V}O_2$ mean values of $56.0 \text{ ml.kg.min}^{-1}$ when testing 10 year old boys on the treadmill. A slightly lower value of

55.5 ml.kg.min⁻¹ on a walking treadmill protocol was obtained by Paterson et al. (1981) in 10 to 12 year old boys. Boileau et al. (1977) measured the maximal aerobic capacity of 21 boys age 11 to 14 years and found an average max $\dot{V}O_2$ of 49.7 ml.kg.min⁻¹ using a constant speed and an increasing grade protocol. Woynarowska (1980) elicited a max value of 2.34 l.min⁻¹ in 80 boys age 11 to 12 on the bicycle. Mocellin et al. (1971) found a slightly higher value in 13 to 14 year old males of 3.82 l.min⁻¹ on the bicycle. These data represent a sampling of the studies performed examining the max $\dot{V}O_2$ values of children.

Protocol Selection

A valid measurement of maximal oxygen consumption has been found to be very dependent upon the mode and procedure utilized when placing the stress on the subject. Astrand (1971) stated that any test of the oxygen transport system must at least meet the following requirements:

1. The work in question must involve large muscle groups.
2. The work load must be measurable and reproducible.
3. The test conditions must be such that the results are comparable and repeatable.
4. The test must be tolerated by all healthy individuals.
5. The mechanical efficiency (skill) required to perform the task must be as uniform as possible in the population to be tested. (p.10)

A number of different types of tests meet Astrand's recommendations, but a controversy still exists as to which of the methods or protocols best evaluates aerobic capacity.

Studies which have compared the modes of treadmill and bicycle ergometry have consistently reported a lower max $\dot{V}O_2$ value during bicycle exercise. McArdle, Katch, and Pechar (1973) compared six different types of testing protocols and found that all of the bicycle

maximal values were significantly lower than the treadmill values in college-aged males. The total deficit was approximately 6.4%. McArdle and Magel (1970) found an even greater reduction of 9.3% when comparing bicycle to treadmill. These results were confirmed by Boileau et al. (1977) when comparing the two modes in boys 11 to 14 years old. They observed a 7.9% lower mean $\dot{V}O_2$ value on the bicycle. "Leg strength and subsequent local muscular fatigue may be limiting factors with the bicycle ergometer in children" (Boileau et al., 1977), p.159). These investigators concluded that the treadmill was the superior mode to utilize when assessing the $\dot{V}O_2$ of children due to the ease at which a constant rate of work could be maintained, the less chance of local muscle fatigue, and lastly the eliciting of higher maximal values. The treadmill has also been recommended by Astrand (1971) as the preferable modality for young children for similar reasons.

The treadmill testing mode has been investigated in reference to the appropriate speed and grade necessary to elicit a maximal oxygen consumption value. A number of studies have compared various protocols. Maksud and Coutts (1971) compared a continuous-graded protocol to a multi-session discontinuous-graded treadmill protocol in 21 young healthy males. They found no significant difference in the mean $\dot{V}O_2$. Froehlicher, Brammel, Davis, Noguera, Stewart, and Lancaster (1974) compared three treadmill protocols in 15 male volunteers between the ages of 21 and 52. The protocols were the Bruce, Balke and modified Taylor. The investigators reported that the Taylor protocol elicited the highest

max $\dot{V}O_2$ value with the Bruce and the Balke protocols 6.5% and 9.7% less, respectively.

An investigation which compared three treadmill speeds of walking, moderate and supramaximal illustrated that the moderate rate elicited the highest max $\dot{V}O_2$ value. This study used a rate of 7 miles per hour for 3 minute intervals as a moderate speed for 24 college age males (Knowlton, Sawka, & Deutsch, 1977). Other researchers also have compared treadmill speeds by comparing walking to running. Walking protocols have elicited decreased max $\dot{V}O_2$ values in comparison to running (Paterson et al., 1981; Stanford, 1975).

Skinner et al. (1971) compared three different walking protocols. They found no significant difference between the mean max $\dot{V}O_2$ values. The investigators also commented on the practicality of using a walking test when testing children in that the method was familiar and required little mental involvement. One of the protocols derived by Skinner et al. (1971) was chosen, for these practical reasons and reasons relating to the on-going longitudinal study in which the subjects were participating, for use in this study.

Prediction of Max $\dot{V}O_2$

Max $\dot{V}O_2$ has become the best measure of cardiovascular fitness. The measurement of max $\dot{V}O_2$, however, is often impractical and difficult to perform in a school setting. Many efforts have, therefore, been made to predict max $\dot{V}O_2$ values from more practical parameters.

Astrand and Ryhming (1954) pioneered the prediction of $\dot{V}O_2$ when they established a nomogram for the prediction of $\dot{V}O_2$ using 16 females and 17 males between the ages of 20 and 30 years of age. They assumed a linear relationship between the percent of $\dot{V}O_2$ and heart rate. Nomograms were established for submaximal work on the bicycle, treadmill, and step test. Subsequent to the establishment of these nomograms a number of researchers have investigated the accuracy of the Astrand-Ryhming prediction methods with varying results.

Rowell, Taylor, and Wang (1964) found a low correlation between predicted and actual $\dot{V}O_2$ in males ages 18 to 24. They stated that the $\dot{V}O_2$ values were underestimated by as much as 27.7% in trained subjects. The researchers felt that heart rate variations that were independent of oxygen uptake were evident.

Hermansen and Oseid (1971) found a 10-20% deficit in prediction when using the Astrand-Ryhming nomogram to predict maximal oxygen consumption in pre-pubertal boys. Numerous other researchers found significant differences between $\dot{V}O_2$ predicted by the nomogram and actual $\dot{V}O_2$ values in various groups such as children, (Binyildiz, 1980; Woyarcowska, 1980), adult males, (VonDobeln, Astrand, & Bergstrom, 1967; Wiley & Shaver, 1972) and trained males (Wright, Sidney & Shepard, 1980).

Several investigators have, however, found the Astrand-Ryhming nomogram to be an accurate predictor. DeVries and Klafa (1965) tested 16 men and compared six fitness tests to $\dot{V}O_2$. They found that in active college men the $\dot{V}O_2$ value can be predicted with reasonable error using the Astrand-Ryhming nomogram. Other researchers confirmed these results (Glassford, Baycroft, Sedgwick, & Macnab, 1965; Mocellin et al., 1971).

Due to inconclusive nature of the prediction method devised by Astrand and Ryhming there exists some question as to whether this method should be applied when accurate individual values are required (Hermansen & Oseid, 1971). Caution must be taken to assure the prediction method is indeed valid for the intended population.

Since the establishment of the Astrand-Ryhming nomogram, a mass of prediction methods have flooded the literature. A number of parameters have been investigated as to their feasible use as an accurate predictor of $\dot{V}O_2$. These methods range in nature from submaximal heart rates combined with age and weight to distance covered in a specific time run. Each prediction method has a corresponding correlation value and a subsequent regression equation devised to predict the $\dot{V}O_2$ value from the chosen parameters(s).

Physical Characteristics

Physical characteristics have been used by researchers, alone and in combination with other parameters, to predict $\dot{V}O_2$. Characteristics such as age, height, weight, and lean body weight have been used.

Hermiston and Faulkner (1971) measured a variety of parameters while testing 60 male subjects on a treadmill. They found that age, lean body weight, physical activity level, cardiovascular strain, and pulmonary function were the five parameters that best predicted $\dot{V}O_2$ max ($R=0.90$).

Bonen et al. (1979) used a multiple regression on 100 boys between the ages of 7 and 15 years. They utilized the parameters of age, height, and weight, along with performance values of $\dot{V}O_2$, heart rate, and $\dot{V}CO_2$ during the third minute of treadmill exercise. Two equations were

developed for predicting $\max \dot{V}O_2$ in $l \cdot \min^{-1}$. The first equation combined heart rate during the third minute of a treadmill walk with height ($R=0.95$). The second equation simply relied on age, height, and weight ($R=0.94$). Two equations were also developed to predict $\max \dot{V}O_2$ in $ml \cdot kg^{-1} \cdot \min^{-1}$. The first equation combined age with heart rate, $\dot{V}CO_2$, and $\dot{V}O_2$ during the third minute of a treadmill walk ($R=0.62$). The second utilized age, height, and weight only ($R=0.52$).

The correlation found between $\max \dot{V}O_2$ and steady state heart rate was increased from $r=0.70$ to $R=0.80$ when age and height were added. This occurred in boys age 11 to 13 who were tested on the bicycle by Binyildiz (1980).

Age has become a factor often incorporated to improve prediction accuracy. VonDobeln et al. (1967) improved their prediction of $\max \dot{V}O_2$ considerably by adding age. They stated that the difference between predicted and actual $\max \dot{V}O_2$ "disappeared when the age correction factor . . . was used" (p.938).

Thirty women between the ages of 20 and 40 were tested by Bell and Hinson (1974). They correlated the 880 yard run with $\max \dot{V}O_2$ ($r=0.689$). The investigators stated that when age, weight, and resting heart rate were added the predictive value improved ($R= -0.728$).

Bruce, Kusumi, and Hosmer (1973) found a functional prediction measure for healthy people. They included sex, activity level and age. This study was based on a subgroup of 151 men and 144 women 29 to 73 years of age. They stated that equations could not be used universally, but were specific to age groups and activity levels.

Heart Rate

Heart rate has been one of the parameters most frequently used to predict $\dot{V}O_2$. Astrand and Ryhming (1954) were the first to utilize this parameter. They assumed a direct relationship between oxygen uptake and heart rate. This, however, has been questioned by researchers. Mocellin et al. (1971) predicted values of $\dot{V}O_2$ using equations extrapolated to maximal levels based on a direct linear relationship between heart rate and oxygen consumption. They found oxygen consumption to be underestimated by $0.41 \text{ l}\cdot\text{min}^{-1}$ by this method which indicated a non-linear relationship existed. Rowell et al. (1964) suggested that factors independent of oxygen consumption may alter heart rate responses and thus the linear relationship. They cited emotions and temperature as possible interfering factors. Therefore, the heart rate in reality may not be in direct relation to the oxygen consumption.

A bench stepping nomogram was developed by Margaria, Aghemo, and Rovelli (1965) that utilized heart rate values at two submaximal workloads. This study again assumed a linear relationship between heart rate and oxygen consumption in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$. They found a variability of only $\pm 7\%$ between directly determined $\dot{V}O_2$ and predicted values. The investigation had, however, a limited subject number of only 47 considering the age span of 9 to 80.

Fox (1973) also developed a regression equation derived from a submaximal heart rate during the fifth minute of a bicycle test. He found that this method was an accurate predictor for untrained college males ($r=0.76$).

Other previously mentioned studies have utilized heart rate as a prediction method (Biriyildiz, 1980; Von Döbeln et al., 1967; Woynarowska, 1980). All of these investigators found that the use of heart rate alone as a prediction method was improved with the addition of other parameters.

Field Tests

Although it is often difficult for physical educators to have access to the equipment necessary to perform a maximal oxygen uptake measurement directly, a track or space to run is often very available. These circumstances have led many investigators to examine the possibilities of utilizing field testing to predict $\dot{V}O_2$.

Fitness Tests. Varied fitness measurements have been incorporated to estimate $\dot{V}O_2$. Falls, Ismail, and MacLeod (1966) tested 87 male Purdue University staff and faculty ages 23 to 58 years of age using a variety of fitness parameters. Measures used were pull-ups, standing broad jump, sit-ups, 50-yard dash, 600 yard-run-walk, shuttle run and medicine ball put. Subjects also performed a bicycle $\dot{V}O_2$ determination. They found that when all of the parameters were included, the multiple correlation value for predicting $\dot{V}O_2$ measured in $ml \cdot kg^{-1} \cdot min^{-1}$ was $R=0.760$.

Metz and Alexander (1970) tested 12 to 15 year old boys using the AMPER Motor Fitness Test, the Harvard Step Test, the McCloy Strength Test and the Taylor Treadmill Test. The boys were subdivided into two groups consisting of 12 to 13 year olds and 14 to 15 year olds, respectively. All boys were given all three fitness tests plus a series of treadmill tests using the Taylor protocol. Correlation coefficients and

linear and stepwise multiple regression analyses were then performed utilizing all physical fitness items. The results indicated that:

For boys 12 to 13 years of age, all items of the AAHPER Youth Fitness Test, except sit-ups, were significantly related to maximal oxygen intake. For 14 to 15 year old boys all items but sit-ups, softball throw, and 600-yard run-walk were significantly related to maximal oxygen uptake, as were pull-ups, dips and right grip strength from the McCloy Strength Test and the Harvard Step Test Score. p.75

Utilizing all items of the AAHPER test to form regression equations resulted in an R value of 0.777 in 12 to 13 year old boys. Cross validation to older boys was unsuccessful.

Running Performance Time. Oxygen uptake has been compared to the performance time of subjects during various running events. Fall et al. (1966) reported the relationship between the 600 yard run-walk and $\dot{V}O_2$ in adults to be -0.64. A similar correlation of -0.62 was obtained by Doolittle and Bigbee (1968) using the same run-walk distance. Their subjects were 153 ninth-grade males. Metz and Alexander (1970) and Krahenbuhl et al. (1977) also investigated the relationship of the 600 yard-run-walk to $\dot{V}O_2$ and found correlations of -0.66 and -0.843, respectively. Metz and Alexander (1970) focused on 12 and 13 year old boys while Krahenbuhl et al.'s data were for 8 year old males.

Other timed runs for distance have been utilized by investigators. Most investigators have agreed that the prediction value of the run increases with the distance of the run provided motivational levels are not exceeded (Kearney & Byrnes, 1975; Krahenbuhl et al., 1975; Krahenbuhl et al., 1977; Ribisl & Kachadorian, 1969; Wiley and Shaver, 1972). Krahenbuhl et al. (1977) found the highest correlation to be found

with the 1-mile run when they compared the correlations of the following runs to $\dot{V}O_2$: 600-yard-run-walk, 0.75 mile run, and the 1-mile run. Kearney and Byrnes (1974) found that "the magnitude of the relationship increased sequentially" (p.14) with the distance of the run. Wiley and Shaver (1972) agreed with these results.

Ribisl and Kachadorian (1969) derived correlations of 0.85 and 0.86 between $\dot{V}O_2$ from 2 mile run times on trained young and middle-aged males, respectively.

Bell and Hinson (1974) arrived at a -0.702 correlation when relating the 880-yard-run to $\dot{V}O_2$ in twenty, 40 year-old women. They suggested that perhaps a longer run would have exhibited a still higher correlation.

An extremely high correlation was elicited by Getchell, Kirkendall, and Robbins (1977) when 21 females performed at 1.5-mile-run ($r=0.915$). This was relating $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ to run time. They surmised that the run must last at least 10 minutes to provide a good correlation. Motivational limits were also cited as a consideration.

Motivation is indeed a factor to consider when choosing an appropriate distance run according to the AAHPERD (1981). They have sanctioned both the one-mile run and the 9-minute run as valid measures of cardio-respiratory function, stating that the choice of which run is appropriate for their group of students is left to the discretion of the physical educator. The AAHPERD has claimed that these "distances give essentially the same information as longer distance runs" (p.11). The choice of distances also accommodates various motivational levels.

Specific Time Runs. In contrast to field tests that have utilized performance times to predict, distances covered in a specific amount of time have also been correlated to $\dot{V}O_2$ values.

Doolittle and Bigbee (1968) stated that "the distance an individual can cover, by running and/or walking, in 12-minutes is a highly reliable and valid indicator of cardiorespiratory fitness" (p.494). They compared 12-minute run distances and $\dot{V}O_2$ in adolescent boys ($r=0.90$) when measuring in $ml \cdot kg^{-1} \cdot min^{-1}$.

Burke (1976) studied college males between the ages of 17 and 30 and correlated 12-minute run distances to $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$. The same correlation was found ($r=0.90$) as found in the Doolittle & Bigbee (1968) study. They found this run to be much superior to the shorter 1-mile-run.

Jackson and Coleman (1976) tested 9 to 12 year old boys and girls. They measured distances covered on both the 9 and 12 minute runs and compared them to $\dot{V}O_2$ values in $ml \cdot kg^{-1} \cdot min^{-1}$. Correlational values were the same for girls on both runs ($r=0.71$) and for boys on both runs ($r=0.82$).

Custer and Chaloupka (1977) correlated predicted $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ on the bicycle to the 6-, 9-, and 12-minute runs. They found correlational values of $r=0.45$, $r=0.37$, and $r=0.49$, respectively. These tests were performed on college age females. Kearney and Byrnes (1974) utilized college age males in a similar study and found the 12-minute run correlated at slightly higher levels ($r=0.63$) when measuring in $ml \cdot kg^{-1} \cdot min^{-1}$.

Summary

In conclusion, a large amount of research has been performed to attempt to provide physical educators with an accurate method of predicting $\dot{V}O_2$. Various parameters such as heart rate, physical

characteristics, performance times, and field tests have been targeted as possible prediction methods with various results. Research indicates that, in general, distance runs of longer duration and prediction methods incorporating several parameters serve as the best predictors.

Investigators also have examined the characteristics of and the performance capabilities of children during the developmental period. Growth alone can improve physical performance according to Astrand (1971). Also the standard criteria of a plateau in oxygen consumption and an RER of 1.0 or greater used as a criteria for reaching max $\dot{V}O_2$ may be difficult to obtain in younger children due to incomplete development of the anaerobic capacity. These factors must be considered when evaluating research relating to children. All of the research, however, ultimately relates to the practical application of providing physical educators with a sound base of knowledge which will allow a better understanding of the capabilities of the children they teach.

CHAPTER III

METHODS

Introduction

The purpose of this study was to determine if a relationship existed between distance covered in a 9-minute run and peak $\dot{V}O_2$ in young boys. Subsequently prediction equations were developed based on this relationship. All peak $\dot{V}O_2$ and hydrostatic weighing procedures took place in the Human Performance Laboratory in Mitchell Hall on the University of Wisconsin-La Crosse campus. The 9-minute runs took place in the field house of the same building. The procedures and instrumentation used to obtain all necessary data are described within this chapter.

Subject Selection

Subjects were 43 male volunteers between the ages of 9 and 14 years. Twenty of the boys were participants in on-going longitudinal study at the University of Wisconsin-La Crosse. These boys had previously participated in laboratory testing which included a peak $\dot{V}O_2$ test on a treadmill. They were, therefore, familiar with the laboratory setting. Other boys were volunteers obtained from the La Crosse, Wisconsin area and were unfamiliar with the laboratory setting.

In general the subjects were an active group. They reported participating in various youth sport activities such as basketball, swimming,

gymnastics, wrestling, and dance. As expected, very few subjects exhibited a dislike for the rigorous activities required for participation in this study.

Letters of invitation (see Appendix A) and informed consent forms (see Appendix B) were mailed to each subject's parents prior to testing along with a return stamped envelope. These forms explained all procedures and any potential dangers involved. They were then signed by the parents and returned to the investigator prior to testing. The subjects were then contacted by phone and scheduled for an appropriate testing time.

Hydrostatic Weighing

Subjects reported to the laboratory at their first scheduled testing time. Height and weight measurements were then taken without shoes to the nearest 0.25 inch and 0.25 pound, respectively. The measurements were then converted to centimeters (cm) and kilograms (kg). Hydrostatic weighing procedures then took place. Residual lung volumes were measured on dry land outside of the weighing tank using the process described by Wilmore (1969) involving a closed-circuit oxygen dilution technique. The procedure was repeated until the investigator subjectively judged that the subject had completed all steps correctly. The criteria used for this decision was that the subject must have completed a maximal expiration and must have remained in contact with the mouthpiece until an equilibrium was reached.

After successful completion of the residual volume technique, subjects showered until completely wet and then entered the weighing tank. They sat in the weighing chair and removed as many air bubbles from their skin and swimming suit as possible with their hands. Procedures for weighing were described to the subject at this time. Subjects expired as much air as possible from their lungs above the water and then submerged completely. At this time additional air was exhaled. Subjects were asked to remain as still as possible to provide ease in reading the scale. Measurements were made on a Chiltillon scale attached to the weighing apparatus. The measurements were made to the nearest 0.10 kg. Repeated trials were made until the subject appeared to be exhaling maximally and three consistent readings within 0.10 kg were obtained. The subject was encouraged to improve on the former trial by exhaling an additional amount. The highest reading was used. Body density was determined and entered into the formula developed by Brozek et al. (1963) to determine percent fat.

Each subject participated in a practice session for both the peak $\dot{V}O_2$ determination and the 9-minute run on the same day they were hydrostatically weighed.

Peak Oxygen Uptake Determination

Practice Session

Several practice runs on the treadmill were given on the day the subjects were hydrostatically weighed. Each practice included being

fitted with all equipment necessary to perform the test including mouthpiece, noseclip, and headgear. Some subjects were too small for the headgear and an alternate method which suspended the mouthpiece with hoses was used. Practice continued until the investigator subjectively determined the subject was competent in treadmill procedures and comfortable with all equipment. At this time the boys were informed that an award would be given to the boy who achieved the longest time on the treadmill during the actual testing procedure.

Testing Procedures

On the day of the test subjects were asked to refrain from eating for at least three hours prior to their scheduled testing time. Subjects were prepared for testing by fitting all equipment in place. Electrodes were placed on the chest in the standard CM-5 position. This included rubbing the skin until slightly pink with cotton and alcohol. The positive electrode was placed in the V-5 position, the negative electrode was placed on the scapularium, and the ground was placed on the lower right side of the rib cage. Subjects were again reminded of the award for the longest time on the treadmill and encouraged to continue for as long as possible.

After all preliminary procedures were completed, the subject was asked to straddle the treadmill. At this time the treadmill was started. The subject then began to walk and the speed and grade were adjusted to the warm-up level of 3.5 miles per hour (mph) at a 7.5% grade. They then walked for three minutes and rested for two minutes. The subject was again asked to straddle the treadmill to begin the procedure. The treadmill was started and the subject began walking. The treadmill was then

adjusted to the first stage of the protocol described by Skinner et al. (1971). The protocol, in which speed remains at a constant 3.5 mph and the grade begins at 7.5% and increases 2.5% at three minute intervals, was then completed by the subject. Subjects were verbally encouraged by the investigator during the test to continue for as long as possible. Upon completion of the test the subjects remained walking on the treadmill at a reduced speed and grade to cool down.

The test was terminated when the subject reached volitional exhaustion. A RER of greater than one was strived for but not considered necessary for successful completion of the test because of reasons stated by Cunningham et al. (1977). A complete minute was defined as successfully finishing the entire minute. No fractional minute values were accepted.

Instrumentation

All measurements of oxygen uptake were taken with the Beckman Metabolic Measuring Cart (BMC) at 60 second intervals throughout the test. The BMC contains a carbon dioxide analyzer (LB-2) and an oxygen analyzer (OM-11). The BMC was calibrated prior to and after each subject was tested with a known gas sample which had been previously determined by the Scholander technique. Variables measured were oxygen consumption in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and $\text{l}\cdot\text{min}^{-1}$, RER, and volume of expired air.

The heart rate was monitored with a Viagraph electrocardiographic machine. Heart rates were taken the last 15 seconds of every minute during the test. The heart rate was then determined by counting the number of R waves within the 15 seconds and multiplying by four.

The entire test was performed on a Quinton treadmill.

9-Minute Run

Subjects were familiarized with the testing site on the same day they were hydrostatically weighed. This included an explanation of the 9-minute run procedure coupled with helpful hints to improve performance. Subjects were allowed to practice different running paces on the field house track. They were reminded to run near the inside at a constant pace. They were also told to speed up near the end of the run if possible. Subjects were informed that awards would be given to the runner within each age group that covered the greatest distance.

Preliminary Procedures

Seven 1/2 run sessions were arranged by the investigator as to the date and time of the 9-minute run. Subjects were allowed to choose a convenient testing time. A maximum limit of 10 subjects were placed in each running group.

The run took place at the Mitchell Hall Field House. The facility houses a 220 yard indoor track which was the site of the testing. Four parking cones were placed at 55 yard intervals around the track. They were then numbered 0, 1, 2, and 3. The cone numbered 0 was designated as the starting position.

Previous to the arrival of the subjects, each runner was assigned an identification number for recording purposes. This number was then placed on a 5" by 8" recording card next to the subject's name. Corresponding numbers were pinned to the subject's clothing upon arrival. The recording cards included numbers corresponding to the track laps

completed and portions of laps completed. Recorders were given instructions to place one slash through each lap number upon completion by the subject.

Recorders were volunteer students from the University of Wisconsin-La Crosse. All were previously informed of the recording methods and procedures involved in 9-minute run administration. Each reporter was responsible for no more than two subjects.

Run Procedures

Upon arrival, all participating subjects lined up at the starting point. Instructions were given as to the procedure the subjects would follow. Subjects were reminded of all points emphasized in the practice session. This included pacing, staying to the inside except to pass, walking as little as possible, and the award for the greatest distance covered in each age group. Subjects were also told that times would be given at two minutes, one minute, and 30 seconds remaining. Time was kept on a Casio wristwatch by the investigator. At the conclusion of the 9 minutes a whistle was blown and the command, "Stop! Walk in place!" was shouted.

Recording took place during the race for each completed lap and at the conclusion for the fraction of the track completed. Subjects were required to be completely past the parking cone to be credited with that portion of the lap. The distance covered was then recorded to the nearest 55 yard mark.

Statistical Methods

A total of 43 boys successfully completed all tests. The means and standard deviations were calculated for all physical characteristics and all other parameters measured. Subsequently a random sample of 13 boys was withdrawn from the total sample to be placed in study which would cross-validate the prediction equations. Thirty total subjects remained active. All other statistical methods were performed with these subjects only. Means and standard deviations were then calculated for the physical characteristics and all other parameters measured. A stepwise multiple regression technique was used to predict peak $\dot{V}O_2$ (dependent variable) from the 9-minute run results (independent variable). In addition, the stepwise multiple regression technique was used to predict peak $\dot{V}O_2$ from the 9-minute run with the addition of other parameters. Peak $\dot{V}O_2$ was predicted in both $ml \cdot kg^{-1} \cdot min^{-1}$ and $ml \cdot min^{-1}$. Emphasis was placed on the utilization of parameters with practical application for the physical educator.

CHAPTER IV
RESULTS AND DISCUSSION

Introduction

Forty-three male subjects between the ages of 9 and 14 completed all phases of testing. This included participation in a peak $\dot{V}O_2$ determination on a treadmill, a 9-minute run, and hydrostatic weighing. After completion of all testing, a stepwise multiple regression technique was used to predict peak $\dot{V}O_2$ (dependent variable) from the 9-minute run results (independent variable). Physical characteristics of the subjects were utilized to improve upon the predictive value of the 9-minute run. The results of all procedures have been discussed within this chapter.

Subjects

A group of 43 boys ranging in age from 9 to 14 participated in the investigation. The physical characteristics of all 43 subjects have been presented according to age in Table 1. A random sample of 13 boys was removed from the total sample for validation purposes in another study. The remainder of the data analysis deals with the remaining 30 subjects. The means and standard deviations of the physical characteristics of this group (n=30) have been presented in Table 2. Due to the random selection, some age groups were limited in number.

Table 1

Means and Standard Deviations for Physical Characteristics
of All 43 Subjects According to Age

Age	n	Height		Weight		Density		Fat		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
9	5	135.4	5.93	29.8	4.50	1.0720	.0071	11.9	2.76	
10	8	142.8	6.02	33.9	6.92	1.0615	.0017	16.4	4.11	
11	7	145.8	5.12	39.0	7.60	1.0497	.0028	17.8	8.40	
12	9	152.7	10.90	42.3	10.80	1.0663	.0015	14.5	3.95	
13	11	163.1	8.49	51.4	8.97	1.0671	.0013	14.0	4.24	
14	3	171.5	6.64	57.1	6.98	1.0750	.0050	11.0	1.98	
AVE	11.8	43	151.7	13.00	42.1	11.50	1.0642	.0160	14.7	5.38

Table 2
Means and Standard Deviations for Physical Characteristics
of 30 Remaining Subjects According to Age

Age	N	Height		Weight		Density		StPat	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
9	2	139.7	7.21	32.1	6.22	1.0665	.0035	14.3	1.48
10	4	145.6	2.80	36.5	5.17	1.0653	.0014	15.0	5.44
11	5	146.0	5.25	40.4	8.75	1.0544	.0023	19.4	9.69
12	8	153.0	11.60	43.0	11.33	1.0664	.0016	14.4	6.36
13	9	160.2	4.64	49.9	8.34	1.0668	.0011	14.1	4.59
14	2	175.3	0.00	60.3	6.15	1.0722	.0011	12.1	0.42
AVE	11.8	153.6	11.10	44.2	10.70	1.0648	.0147	15.1	6.00

Hamill, Drizd, Johnson, Reed, and Roche (1977) developed normal height and weight values for boys aged 2 to 18 years. The values they arrived at for stature in centimeters (cm) for 9 and 14 year old boys were 132.5 cm and 163.5 cm, respectively. The 30 boys participating in this investigation were slightly taller than the norm ranging from 139.7 to 175.3 cm.

When the weight of the subjects was compared to the average values derived by Hamill et al. (1977) they again appeared to be slightly above these values. Normal values ranged from 28.9 kilograms (kg) to 53.6 kg for 9 and 14 year olds, respectively. The subjects in the present study ranged from 32.1 kg to 60.25 kg.

The mean percent fat in the present study ranged from 14.3% for the 9 year olds to 12.17 for the 14 year olds. This conforms with the data presented by Heald and Hunt (1963) in that it illustrates a decline in percent fat with age. The decline observed in the present study is small, however. Heald and Hunt (1963) suggested that a much greater percent loss occurs with age, but the difference could be due to the age of the subjects tested. Their investigation involved 12 to 18 year old boys. Forbes and Amirhakimi (1970) found a much higher percent (19%) in boys aged 9 than the 14.3% observed in the present study. Therefore the decline in percent fat across the age span was much less apparent in the present study than in the Forbes and Amirhakimi (1970) study which reported an almost 50% decline. Body density values corresponded with the statement by Parizkova (1961) regarding body density decline between the ages of 10 and 12 years and a subsequent at the onset of puberty. The

body density values of the boys in this investigation declined slightly at age 11 (1.0544 and then increased in the 14 year old boys (1.0722). These values agree with Parizkova's (1961) results.

The boys participating in the present study were generally taller, heavier, and less fat than the norm. They were still, however, within the normal limits as set by Hamill et al. (1977). This slight deviation could be attributed to the active life-style exhibited by the majority of subjects participating in the study.

Treadmill Responses

The subjects performed a walking protocol as described by Skinner et al. (1971) to volitional exhaustion. Mean maximal values and standard deviations for all parameters measured are presented in Table 3.

The peak $\dot{V}O_2$ values elicited within this study compared favorably with those of other similar studies. Boileau et al. (1977) found an average max $\dot{V}O_2$ of $49.7 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ in boys 11 to 14 years of age which was similar to the $51.8 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ found in the present study. Paterson et al. (1981) elicited a slightly higher value of $55.5 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ on a walking treadmill protocol in boys ages 10 to 12. When max $\dot{V}O_2$ was measured in $\text{l}\cdot\text{min}^{-1}$ in the present study, the values obtained were also comparable to the results obtained by Woynarowski (1980). The investigator tested boys 11 to 12 years of age and found the value of max $\dot{V}O_2$ to be $2.34 \text{ l}\cdot\text{min}^{-1}$ while the present study value was $2.30 \text{ l}\cdot\text{min}^{-1}$.

Table 3
 Means and Standard Deviations of Physiological Responses
 to Peak Treadmill Test and Distance Covered in
 the 9-Minute Run (n=30)

Parameter	Mean	SD	Range
Expiratory Volume ($l \cdot \text{min}^{-1}$)	76.3	21.41	46.8-140.3
Peak $\dot{V}O_2$ ($l \cdot \text{min}^{-1}$)	2.3	0.64	1.48-3.98
Peak $\dot{V}O_2$ ($ml \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	51.8	5.30	41.5-63.2
RER	1.0	0.04	0.91-1.11
Heart Rate (bpm)	198.6	7.03	188-219
9-Minute Run Distance (yds)	2121.8	228.5	1760-2695

Other parameters measured were also consistent with the literature involving children. Boileau et al. (1977) found heart rates of 191 bpm in boys age 11 to 14 which is similar to the 198.6 bpm value exhibited in the present study. In Krahenbuhl et al.'s (1975) study of primary school children, mean maximal heart rates of 199.7 bpm were obtained which is also consistent with the present study. The average RER value of 1.0 is slightly lower but consistent with the 1.06 found by Krahenbuhl et al. (1975) and the 1.04 elicited by Boileau et al. (1977). Lastly the peak expired ventilation volume expressed in $l \cdot \text{min}^{-1}$ (76.3) was similar to Boileau et al.'s (1977) results of $67.1 l \cdot \text{min}^{-1}$ but higher than Krahenbuhl et al.'s data of $42.9 l \cdot \text{min}^{-1}$ which dealt with a younger age category.

9-Minute Run Performance

The 9-minute run has been sanctioned by the AAHPERD as an accurate measure of the endurance of the cardiorespiratory system. Norms have been developed on over 12,000 students in 13 states for use by physical educators (AAHPERD, 1981). The average distance in each age group covered during the 9-minute run by the subjects involved in the present study indicates that all subjects fell above the 70 percentile category according to the AAHPERD norms. Several age category means were above the 90 percentile range. Jackson and Coleran (1976) also developed norm values using 557 boys ages 10 to 12. Again, with respect to age, all of the subjects in the present study were above the percentile value of 70. The fact that the boys were a very homogeneous group in this

respect could influence the correlation between peak $\dot{V}O_2$ values and the 9-minute run distances. The peak $\dot{V}O_2$ values (see Table 3) were not as homogeneous as the 9-minute run values and thus the relationship between the two would be lowered.

Prediction of Peak $\dot{V}O_2$

A stepwise multiple regression technique was used to develop equations for the prediction of peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ and $l \cdot min^{-1}$ utilizing the 9-minute run and other parameters measured. The resulting equations, correlation coefficients and standard error of the estimate are listed in Tables 4 and 5. Although all parameters measured were examined as to their predictive value, these equations exhibited the highest correlations and were the most practical. Consequently they were chosen for examination as possible prediction methods in this study.

$ml \cdot kg^{-1} \cdot min^{-1}$

A series of regression equations were generated to predict peak $\dot{V}O_2$ expressed in $ml \cdot kg^{-1} \cdot min^{-1}$ from the 9-minute run (see Table 4). The correlation between the 9-minute run distance and peak $\dot{V}O_2$ expressed in $ml \cdot kg^{-1} \cdot min^{-1}$ was found to be 0.693 resulting in equation 1, Table 4. The second variable to enter in the prediction of peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ was weight in kilograms. Adding weight to the equation slightly increased the multiple correlation to 0.721 which resulted in a minimal reduction in the standard error to 0.087 (Table 4, Equation 2). The third variable to enter into the equation was height in centimeters. Adding this variable

Table 4

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

Equation Number	Equation	R	SEE
1	Peak $\dot{V}O_2 = 17.661 + 0.016115 (X_1)$	0.6930	3.6988
2	Peak $\dot{V}O_2 = 18.604 - 0.1069 (X_2) + 0.017896 (X_1)$	0.7217	3.8118
3	Peak $\dot{V}O_2 = -12.13 + 0.29609 (X_2) - 0.3521 (X_2) + 0.016055 (X_1)$	0.7894	3.4451
4	Peak $\dot{V}O_2 = -11.12 + 0.34276 (X_2) + 0.26371 (X_3) - 0.3509 (X_2) + 0.015992 (X_1)$	0.7916	3.4973

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

Table 5

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

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)

increased the correlation to 0.789 and reduced the standard error of the estimate by $0.4 \text{ ml} \cdot \text{kg} \cdot \text{min}^{-1}$ (see Table 4, Equation 3). The final variable was age in years which increased the correlation to 0.791, but also increased the standard error slightly (0.0522) (see Table 4, Equation 4).

9-Minute Run. The correlation values between the 9-minute run and peak $\dot{\text{V}}\text{O}_2$ expressed in $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$ was 0.693 with a standard error of 3.8988. The subsequent regression equation is found in Table 4, Equation 1. This value, although not extremely high, compared with the literature favorably. Again, the homogeneous nature of the performance values on the 9-minute run may be a possible reason as to the lack of an extremely high correlation between the 9-minute and the peak $\dot{\text{V}}\text{O}_2$ values.

Investigators have found correlations ranging as low as $r=0.37$ in college age female (Custer & Chaloupka, 1977) to $r=0.90$ in college males (Burke, 1976) for distance runs and max $\dot{\text{V}}\text{O}_2$. Varied correlational values have been elicited within this range. For example, the value for the prediction of peak $\dot{\text{V}}\text{O}_2$ in $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$ from the 9-minute run in the present study correlated at a lower rate ($r=0.693$) than that found by Jackson and Coleman (1976) in 9 to 12 year old boys ($r=0.82$). Custer and Chaloupka (1977), however as stated previously, found a much lower correlational value between the two variables ($r=0.37$) in college aged females.

Other distance and specific time runs have also elicited comparable results to the literature when predicting max $\dot{\text{V}}\text{O}_2$ in $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$.

An investigation performed by Burke (1976) utilized the 12-minute run, the 600-yard run, and the one-mile run as predictors in college males. Correlations of 0.90, -0.78, and -0.74, were found, respectively. These values were all higher than that found in the present study. Doolittle and Bigbee (1968) performed a similar study in which they found correlational values of $r=0.90$ and $r=0.62$ for the 12-minute run and the 600-yard run, respectively. Krahenbuhl et al. (1975) found a slightly lower correlation than the present study (-0.603) in boys, when correlating the 1600 meter run to $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. Ribisl and Kachadorian (1969) found correlations that increased from -0.14 for a 60-yard dash to -0.85 for the 2-mile run when examining runs of increasing duration in young men. In general, when considering various investigations dealing with field testing, runs of a longer duration than the 9-minute run have a higher correlation than the present value of 0.693 (Burke, 1976; Doolittle & Bigbee, 1968; Ribisl & Kachadorian, 1969). This logically corresponded with the statements by several investigators that longer runs have increased predictive value (Kearney & Byrnes, 1975; Krahenbuhl et al., 1975; Krahenbuhl et al., 1977; Ribisl & Kachadorian, 1969; Wiley & Shaver, 1972).

When comparing the developed equation for the prediction of peak $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ to the literature, the standard error of the estimate was also considered important. The standard error was not, however, reported by many of the investigators. Ribisl and Kachadorian (1969) found a much smaller standard error in young men of $1.55 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and a correlation of 0.94, but this dealt with a multiple regression equation

incorporating a 2-mile run time with age and body weight. Bell and Hinson (1974) found a correlation of -0.689 between $\dot{V}O_2$ and an 880 run time with a standard error of $4.47 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$. This correlation is less than the present study and the standard error is higher (see Table 4, Equation 1). The literature provided no comparative information concerning the standard error of the estimate when the 9-minute run was specifically used as a predictor. Therefore, the comparison value was limited.

Weight. The second variable to enter into the regression equation when measuring peak $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ was weight in kilograms. This factor, combined with the 9-minute run, only slightly increased the correlation value and did not reduce the standard error substantially (see Table 4, Equation 2). A number of researchers have incorporated body weight into equations predicting $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$. Bonen et al. (1979) for example, derived a prediction equation which utilized weight, age, and height to predict $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and found a multiple correlation of 0.52 which was considerably less than the 0.722 found in this study. Another prediction equation ($R=0.95$) for $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ was developed by Ribisl and Kachadorian (1969) combined body weight with age and a 2-mile run time. Bell and Hinson (1974) also utilized body weight when they developed their prediction equations for $\dot{V}O_2$ ($R= -0.689$). Lastly, Wilmore and Sigerseth (1967) correlated body weight and $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ at a relatively high level also ($r=0.79$).

Height. The third variable which entered into the prediction equation when predicting peak $\dot{V}O_2$ in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ was height. The correlation improved to $R= -.789$ and the standard error was also reduced (see Table 4, Equation 3). Height has been incorporated into prediction formulas by

various investigators. Height has been correlated to $\max \dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ by a number of investigators and has also been utilized to improve prediction equations. Wilmore and Sigerseeth (1967) correlated height to $\max \dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and found a relationship of $r=0.81$ in their bicycle study of girls 7 to 13 years of age. A very low correlation ($r=0.032$) between height in inches and $\max \dot{V}O_2$ ($\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) was found by Gatchell et al. (1977). Bonen et al. (1979) used a multiple regression incorporating height, age and weight ($R=0.52$) to predict $\max \dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ in boys 7 to 15 years of age.

Age. The last factor that entered into the multiple regression technique was age. The age factor was expected to improve predictability considerably due to the report by Astrand and Rodahl (1977) that $\dot{V}O_2$ max increased throughout the growth period and, therefore, increased with age. The addition of age, however, did not substantially alter the correlation (see Table 4, Equation 4). Also, the standard error of the estimate was increased. Therefore, the practicality of adding age as an additional parameter is questionable. Since height and weight were already contributing factors to the prediction equations, this could have minimized the effect of age. Age, in effect, was represented by height and weight in the equation because all three increase through the growth period.

Despite the results of the present study, age has often been incorporated into prediction equations. A prediction equation utilizing age as a predictor of $\max \dot{V}O_2$ in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ was developed for active men ($r = -0.704$) by Bruce et al. (1973). The correlation of the 880 yard run

to $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ was slightly increased to $R=0.728$ from $r=0.689$ by Bell and Hinson (1974) by adding age, weight, and resting heart rate. Bonen et al. (1979) found a correlation of 0.62 for predicting $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ when age was combined with heart rate, $\dot{V}CO_2$, and $\dot{V}O_2$. In 1967, Wilsore and Sigerseth (1967) found a high correlation between $\dot{V}O_2$ and age in young females (0.74). Getchell et al. (1977) contrarily found an extremely low correlation of age to $\dot{V}O_2$ ($r=0.121$).

Percent Fat. When all parameters measured were examined as to their contribution to the prediction of peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ the equations previously cited were chosen due to their correlation and practical value. Other parameters such as heart rate, expiratory volume, body density, and RER did not significantly improve upon the predictive values, with the exception of percent fat. Percent fat, although slightly less practical, deserves consideration. When the 9-minute run was combined with percent fat to predict peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ a higher correlation ($R=0.81$) was obtained. The equation generated was as follows:

$$\text{Peak } \dot{V}O_2 \text{ (ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}\text{)} = 30.416 - 0.3950 X_1 + 0.012906 (X_2) \quad (10)$$

Key: X_1 = Percent Fat

X_2 = 9-Minute Run Distance

The standard error in this case was also lower than other equations ($SEE=3.212$). The use of this equation would unfortunately require that each child be hydrostatically weighed.

Percent fat has not been used frequently to predict $\dot{V}O_2$, but has been considered important by many investigators. Horniston and

Faulkner (1971) included the percentage of fat when they incorporated the lean body weight into their prediction equations for male subjects. Astrand and Rodahl (1977) also stated that fatty tissue is relatively inactive and that consideration must be given to this fact when evaluating the oxygen transport system. The relationship of peak $\dot{V}O_2$ to percent fat in the present study is consistent with the Astrand and Rodahl's (1977) statement that the direct relationship is a negative correlation ($r = -0.618$). That is as percent fat increases, peak $\dot{V}O_2$ levels in $ml \cdot kg^{-1} \cdot min^{-1}$ tend to decrease.

Although the percent fat measure does improve the correlation value the practical value of utilizing this parameter is questionable. Hydrostatic weighing techniques involve excess time, extensive equipment, and trained personnel which are not readily available in the physical education setting.

$l \cdot min^{-1}$

Regression equations were developed to predict peak $\dot{V}O_2$ values in $l \cdot min^{-1}$. When the 9-minute run distance by itself was utilized, the subsequent correlational value was 0.583 with a standard error of 0.529 (see Table 5, Equation 5). This value was substantially lower than those values obtained when a multiple regression technique was employed and also had a greater standard error. In fact, weight alone correlated at a higher level than the 9-minute run ($r=0.912$) (see Table 5, Equation 6). The multiple regression which combined weight with the 9-minute run distance improved the correlation by 0.041 and decreased the standard error considerably (see Table 5, Equation 7). The next variable to enter the multiple regression was height in centimeters. Adding height only slightly

increased the correlation ($R=0.966$) but the standard error was again decreased ($SEB=0.1748$) (see Table 5, Equation 8). The final factor to be added to the regression was age in years. This factor was not beneficial since it did not increase the correlation ($R=0.9611$) substantially and also increased the standard error.

9-minute run. The 9-minute run correlated with peak $\dot{V}O_2$ expressed in $l \cdot \text{min}^{-1}$ at a slightly lower level ($r=0.583$) than when expressed in $ml \cdot \text{kg} \cdot \text{min}^{-1}$ ($r=0.693$). Investigations which have predicted max $\dot{V}O_2$ in the absolute form ($l \cdot \text{min}^{-1}$) from distance runs have not been as prevalent as those predicting max $\dot{V}O_2$ relative to body weight. This is due to the variance in $l \cdot \text{min}^{-1}$ due to weight alone rather than improved cardiovascular function (Burke, 1976). Falls et al. (1966) stated that very little use has been made of the gross max $\dot{V}O_2$ ($l \cdot \text{min}^{-1}$) measurement without considering body weight. However, there have been several studies which have utilized distance runs to predict max $\dot{V}O_2$ in $l \cdot \text{min}^{-1}$ with varied results. For example, Getchell et al. (1977) found a correlation value of $r=0.466$ in adult females when comparing the 1.5 mile run to max $\dot{V}O_2$ expressed in $l \cdot \text{min}^{-1}$. Wiley and Shaver (1972) found an extremely low correlation between max $\dot{V}O_2$ in $l \cdot \text{min}^{-1}$ and the 440 yard run ($r=0.05$), 1- ($r=-0.32$), 2- ($r=0.08$) and 3 mile run ($r=-0.07$) times expressed in seconds in males, 18 to 21 years. Once again the standard error of 0.5289 which existed for the prediction equation derived in the present study involving the 9-minute run could not be compared to the literature due to limited reporting of this factor by investigators.

Weight. When a forward multiple regression technique was utilized with the parameters of age, height, weight and the 9-minute run distance, the variable which had the highest correlation with $\dot{V}O_2$ expressed in $l \cdot \text{min}^{-1}$ was weight in kilograms ($R=0.912$) (see Table 5, Equation 6). Weight as a single prediction factor correlated at a substantially higher level ($r=0.912$) than the 9-minute run by itself ($r=0.583$) (see Table 5, Equation 5). This occurrence was similar to the relatively high correlation found by Wiley and Shaver (1972) between $\dot{V}O_2$ in $l \cdot \text{min}^{-1}$ and weight ($r=0.71$) in college age men. Bonen et al. (1979) developed a prediction equation which utilized weight, age and height to predict $\dot{V}O_2$ expressed in $l \cdot \text{min}^{-1}$ and found an extremely high correlation ($R=0.94$) in boys aged 7-15. These researchers felt confident enough in this relationship to state that these three parameters predicted $\dot{V}O_2$ with accuracy similar to various running performance tests. The high correlation between weight and peak $\dot{V}O_2$ may be more significant in children due to the increase in weight with age.

The practical use of an equation which utilizes only weight and/or physical characteristics as the predictor, such as the equation derived by Bonen et al. (1979) and equation 6 in the present study (see Table 5) is questionable from a physiological standpoint. The percentage of fatty tissue as part of the total weight would have to be considered. Astrand and Rodahl (1977) stated that "since fatty tissue is metabolically fairly inert, but can constitute a large proportion of the body weight, it may be important to exclude it when evaluating the oxygen transport capacity" (p.32). A second factor which limits the use of weight alone is the idea

that generally increased with age, and subsequently size. A result of this increase in weight would be an increase in the absolute $\max \dot{V}O_2$ due to the size increase alone, but not necessarily due to increased cardiorespiratory fitness. For these reasons, weight alone as a predictor of $\max \dot{V}O_2$ could be misleading.

Height. The third variable to combine with weight and the 9-minute run to predict $\max \dot{V}O_2$ in $l \cdot \min^{-1}$ was height in centimeters. The resulting equation, correlation, and standard error are found in Table 5, Equation 8. The logic behind the use of height has been based on height indicating size and thus size resulting in increased $\max \dot{V}O_2$. This was confirmed by Astrand (1971). Therefore, if indeed a high correlation does exist between height and $\max \dot{V}O_2$, then prediction methods should be improved if height has been incorporated. This may be misleading as far as cardiorespiratory function is concerned in that the absolute increase in $\max \dot{V}O_2$ may be strictly due to increased size and not improved cardiorespiratory performance.

Nevertheless, height has been used to improve prediction equations for $\max \dot{V}O_2$ in $l \cdot \min^{-1}$. Binyildiz (1980) increased the prediction correlation of the steady state heart rate ($r=0.70$) by adding height and age ($R=0.80$). Submaximal heart rate and height were also incorporated into a prediction equation by Bonen et al. (1979) which increased their correlation to $R=0.95$. Gatchell et al. (1977) found a 0.545 correlation between height in inches and $\max \dot{V}O_2$ expressed in $l \cdot \min^{-1}$.

Age. The last factor to enter the regression equation for the prediction of peak $\dot{V}O_2$ in $l \cdot \min^{-1}$ was age. This factor, however, did not

substantially improve upon the correlation and increased the standard error (see Table 5, Equation 9). The possible reasoning for the minimal contribution of age to the prediction of $\max \dot{V}O_2$ has been discussed in the previous section.

Although age did not contribute significantly to the prediction of $\max \dot{V}O_2$ in the present study, Von Döbeln et al. (1967) stated that the age factor is extremely important in increasing precision of prediction in adult males. This was confirmed by Bonen et al. (1979) who found an extremely high correlation of $\max \dot{V}O_2$ to $l \cdot \text{min}^{-1}$ ($r=0.94$) when they utilized only age, height, and weight as predictors. Lastly, Binyildiz (1980) improved upon a correlation of 0.70 between steady state heart rate and $\max \dot{V}O_2$ by adding age and height ($r=0.80$).

Summary

Based on the data obtained in this study, a number of prediction equations were developed. The equations were practical in nature in that they involved only one testing parameter, which was the 9-minute run. The other parameters were easily measured physical characteristics which improved the predictive value of the equations.

After examining all of the equations and considering the feasibility of their use, the following equations emerged as the best possible prediction methods:

$$\text{Peak } \dot{V}O_2 \text{ (ml} \cdot \text{kg} \cdot \text{min}^{-1}\text{)} = -12.13 + 0.29608 (X_3) - \quad (3)$$

$$.3521 (X_2) + 0.016055 (X_1)$$

$$\text{Peak } \dot{V}O_2 \text{ (l} \cdot \text{min}^{-1}\text{)} = -3.391 + 0.017377 (X_3) + \quad (8)$$

$$0.00072169 (X_1) + 0.033714 (X_2)$$

Key: X_1 = 9-minute run distance (yds)

X_2 = Weight (kg)

X_3 = Height (cm)

The equation which utilized weight alone as a predictor would have been a very simple prediction method, but as stated previously weight alone can be misleading. Adding age to the prediction methods does not improve the correlation significantly and the standard error is increased. Therefore, the use of age is not beneficial. Considering all of these factors, the equations that incorporate the 9-minute run, weight, and height emerge as the best predictors of peak $\dot{V}O_2$ in the units of $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$ and $\text{l} \cdot \text{min}^{-1}$.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Forty-three boys between the ages of 9 and 14 were involved in the investigation. A random sample was removed prior to the data analysis for cross validation purposes in another study. The physical characteristics of each subject (height, weight, and percent fat) were measured. Each subject was hydrostatically weighed to determine percent fat. Measurement of volitional peak $\dot{V}O_2$ was performed with each participant utilizing the treadmill protocol described by Skinner et al. (1971). Subjects were also required to perform a 9-minute run for distance. Multiple regression techniques were used to predict peak $\dot{V}O_2$ from the results of the 9-minute run. Other parameters such as age, height, weight, and percent fat were utilized to improve the prediction methods.

The prediction equations developed were very practical in nature in that they required only one testing parameter which was the 9-minute run. The correlation values between the 9-minute run and peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ (0.6930) and $l \cdot min^{-1}$ (0.5829) were not as high as other similar correlations in the literature. Multiple correlations incorporating other variables such as age, height, weight and percent fat improved upon the predictive value of the equations. The best multiple correlation incorporated the 9-minute run distance with age, height, and weight to predict peak $\dot{V}O_2$ in $ml \cdot kg^{-1} \cdot min^{-1}$ ($R=0.7916$, $SEB=3.497$) and also in $l \cdot min^{-1}$ ($R=0.9661$, $SEB=0.178$):

$$\text{Peak } \dot{V}O_2 \text{ (ml} \cdot \text{kg} \cdot \text{min}^{-1}\text{)} = -11.12 + 0.34276 (X_4) + \quad (4)$$

$$0.26371 (X_3) - 0.3509 (X_2) + 0.015992 (X_1)$$

$$\text{Peak } \dot{V}O_2 \text{ (l} \cdot \text{min}^{-1}\text{)} = -3.351 + 0.013687 (X_4) + \quad (9)$$

$$0.016085 (X_3) + 0.00071915 (X_1) + 0.033764 (X_2)$$

Key: X_1 = 9-minute run distance

X_2 = Weight (kg)

X_3 = Height (cm)

X_4 = Age (years)

Without the addition of age, however, the standard error of the estimate was decreased and the correlation was not substantially lower for the prediction of peak $\dot{V}O_2$ in $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$ ($R=0.7894$ SEE = 3.445) and $\text{l} \cdot \text{min}^{-1}$ ($R=0.9659$ SEE = 0.1748):

$$\text{Peak } \dot{V}O_2 \text{ (ml} \cdot \text{kg} \cdot \text{min}^{-1}\text{)} = -12.13 + 0.29608 (X_3) -$$

$$.3521 (X_2) + 0.016055 (X_1)$$

$$\text{Peak } \dot{V}O_2 \text{ (l} \cdot \text{min}^{-1}\text{)} = -3.391 + 0.017337 (X_3) +$$

$$0.00072169 (X_1) + 0.033714 (X_2)$$

Key: X_1 = 9-minute run distance (yds)

X_2 = Weight (kg)

X_3 = Height (cm)

Therefore, the equations incorporating the 9-minute run distance with weight and height were considered the best predictors and also the most practical.

Recommendations for Future Study

The following recommendations have become evident upon conclusion of this study as future considerations for research in this area:

Subjects should be randomized to insure a more heterogeneous group. This would eliminate the possibility of a sampling error occurring which could affect the equations developed and their correlations.

The difference between $\max \dot{V}O_2$ values elicited using a running protocol versus a walking protocol should be investigated in children. The running protocol may elicit a higher $\max \dot{V}O_2$ value. Leg fatigue associated with the walking protocol may also be eliminated with running. Subsequently, if a significant difference does exist between the walking and running protocol, the present study should be repeated using the running protocol to determine if prediction accuracy is altered.

All portions of the AAMPERD Health Related Fitness Test should be investigated to determine their value as predictors of $\max \dot{V}O_2$. A combination of fitness parameters may improve the predictive value of the 9-minute run distance. These factors would be practical and could possibly improve upon the correlation values found in the present study.

The prediction equations should be cross validated with a similar group of boys. This would determine if the equations could be practically utilized with accuracy in other boys of the same age.

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APPENDIX A

January 5, 1983

59

Dear

Approximately a year has elapsed since your son participated in our body composition and fitness study. Since that time you should have received his test results. At present we have data on more than 40 boys including your son.

We would like to extend an invitation to you and your son to participate in this project again this year. Only with your cooperation can we successfully complete the data collection for a second consecutive year. In addition to helping us, you would also have your son's results to compare with the previous years. If you are willing to continue participating in this study we plan on doing the testing in January, February and March at your convenience.

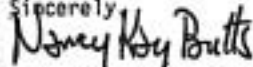
In addition to the body composition, treadmill and bicycle tests we would like to include a 9 minute run on the UWL fieldhouse track. This run is to determine how far your son can run in 9 minutes and compare this distance with his treadmill run. We plan on having 5 or 6 different times (after school/Saturdays) available for this run and your son can select any time that fits his schedule. Although we ask that he participate in at least one of these 9 minute runs, he may participate in all of them if he wishes. The boy in each age group who covers the greatest distance in the 9 minute run will receive a "Tee-shirt."

The body composition test should take only one visit and on that day your son will have an opportunity to practice on the treadmill, bicycle and learn how to pace himself for the 9 minute run. He will then return on separate days for the actual exercise tests. The specific information regarding these tests are provided on the enclosed sheets.

If, after discussing this with your son, you are willing to participate in any or all phases of this study please indicate this on the enclosed sheet(s). Although I would encourage your son to participate in all tests, he can do any combination. Regardless of your decision, would you please return the enclosed green sheet in the self-addressed, stamped envelope. If you have any questions pertaining to any part of this study, please do not hesitate contacting me at 785-8177 or leave a message for me to return your call at 785-8586.

I hope that you will again take this opportunity to assist us in this valuable research effort. I would like to thank you in advance for your cooperation and I am looking forward to hearing from you.

Sincerely,



Nancy Kay Butts, Ph.D.
Professor

APPENDIX B

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-La Crosse 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-La Crosse. They will be under the supervision of Nancy Kay Butts, Ph.D.

To my knowledge my son/daughter is not infected with any disease or has any limiting physical conditions or disabilities, 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-La Crosse 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 Wisconsin-La Crosse, the officers, administrators, employees, or by anyone acting on behalf of any of them.

Signed: _____ Date: _____
(parent/guardian)

PARENTAL INFORMED CONSENT
FOR MAXIMAL TREADMILL TEST

I, the parent/guardian of _____, give permission for my son to participate in the maximal treadmill test at the Human Performance Laboratory at the University of Wisconsin - La Crosse. 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 and be inclined gradually throughout the test. During this test heart rates will be monitored continuously on an electrocardiograph (ECG). He will breathe room air through a mouthpiece so that his exhaled air can be collected. This test requires a maximal effort, however, I understand my son can stop the test anytime he 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 he will feel tired at the end of the exercise. If any abnormal observations are noted the test will be immediately terminated.

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

I, _____ parent/guardian of _____,

approve the participation of my son in the maximal treadmill test at the Human Performance Laboratory at the University of Wisconsin-La Crosse. 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-La Crosse, the officers, administrators, employees, or by anyone acting on behalf of any of them.

Signed: _____ Date: _____
(parent/guardian)

PARENTAL INFORMED CONSENT
FOR BODY COMPOSITION TEST

63

I, the parent/guardian of _____, give permission for my son to participate in the body composition study being conducted in the Human Performance Laboratory at the University of Wisconsin-La Crosse. I understand that participation in this study will involve one or two visits to the Human Performance Laboratory and that at each visit my son will have anthropometric measurements taken, residual lung volume determined and be underwater weighed. I also understand that I may withdraw my son from the study at any time.

In any type of testing situation some potential risk is involved. In working in a water environment these risks include infection, accident and possible drowning. However, there has never been an accident or report of infection as a result of the hydrostatic weighing procedure at the Human Performance Laboratory.

The actual testing will be conducted by Debbie Baldwin, a graduate student in the Adult Fitness/Cardiac Rehabilitation program at the University of Wisconsin-La Crosse. She will be under the supervision of Nancy Kay Butts, Ph.D.

I, _____, parent/guardian of _____,

approve the participation of my son in the body composition test at the Human Performance Laboratory at the University of Wisconsin-La Crosse. I have read the foregoing and I understand it, and any questions which may have occurred to me have been fully 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-La Crosse, the officers, administrators, employees, or by anyone acting on behalf of any of them.

Signed: _____
(parent/guardian)

Date: _____