FIELD ESTIMATION OF CARDIORESPIRATORY

FITNESS IN YOUNG FEMALES, EIGHT TO ELEVEN YEARS OF AGE

by

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B.P.E., The University of British Columbia, 1977

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF PHYSICAL EDUCATION

in

THE SCHOOL OF PHYSICAL EDUCATION AND RECREATION

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April 1982

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ABSTRACT

The purpose of this study was twofold:

1. To determine the validity of the 9 minute and 12 minute timed runs and the 1600 metre distance run as predictors of peak oxygen uptake and therefore as measures of cardio-respiratory fitness in girls 8 to 11 years of age.

2. To determine the reliability of the 9 minute and 12 minute timed runs and the 1600 metre distance run as measures of cardiorespiratory endurance.

Hypotheses were formulated from these two major purposes as well as from additonal problems which included: (i) studying the relationship between the timed/distance runs and peak oxygen uptake as the distance and time components of the runs increased, (ii) determining the intercorrelatons between two different timed or distance runs with respect to the distance and the length of time spent running.

Sixty female subjects from Crofton House School and St. Patrick's Elementary School, Vancouver, B.C., were tested on the three timed/distance runs, the 9 minute, 12 minute and 1600 metre runs and a peak oxygen uptake treadmill test. Anthropometric measures (height, weight and percent body fat) were also taken. Prior to the timed/distance run testing all of the subjects were taught the concept of paced running and had four practise runs to practise this concept. Twenty of the subjects completed all the testing.

The validities of the 9 minute, the 12 minute and the 1600 metre runs as predictors of peak oxygen uptake and the interrelationships between all the variables were determined by developing a correlation matrix. Stepwise multiple regression analyses were conducted to select the independent

variables (age, height, weight, percent body fat, 9 minute timed run, 12 minute timed run and the 1600 metre distance run) that best predicted the dependent variable, peak oxygen uptake.

The reliabilities of the 9 minute, the 12 minute and the 1600 metre runs were determined by developing test-retest reliability correlation coefficients.

The results indicated that all three timed/distance runs were significantly correlated with peak oxygen uptake. The 9 minute timed run exhibited the highest correlation with peak oxygen uptake followed by the 1600 metre distance run and the 12 minute timed run. Both the 1600 metre distance run and the 12 minute timed run showed significant test-retest reliability correlations, therefore were reliable predictors of peak oxygen uptake in girls 8 to 11 years of age. The intercorrelations between the timed and distance runs showed the 9 minute timed run and the 1600 metre distance run having the highest degree of relationship followed by the 1600 metre distance run and the 12 minute timed run and finally the 9 minute and 12 minute timed runs.

In conclusion both the 1600 metre distance run and the 12 minute timed run were considered to be reliable field tests and predicted peak oxygen uptake in girls 8 to 11 years of age. The 1600 metre distance run exhibited higher validity and reliability correlations and therefore would be the preferred field test of cardiorespiratory fitness in girls 8 to 11 years of age.

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Chapter I

INTRODUCTION TO THE PROBLEM

A. Introduction

Cardiorespiratory fitness is "unquestionably one of the key components of physical fitness, and to some educators it is the single most indicative measure of a person's physical condition" (Johnson and Nelson, 1974). Cardiorespiratory fitness can be defined as the efficiency of the oxygen transport system (i.e., the heart, the lungs, and the blood vessels) in supplying oxygen and removing waste materials from the body's cells. It has generally been accepted that the most suitable measure of cardiorespiratory fitness is maximal oxygen uptake (mVO_2) which measures the amount of oxygen consumed per kilogram of body weight per minute of exercise (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978; Johnson and Nelson, 1974). Unfortunately this measurement is very time consuming and requires the use of special, expensive equipment in a laboratory setting. Consequently measurement of maximal oxygen uptake is not feasible for the general public.

A field test that could accurately predict maximal oxygen uptake would provide a valid measure of the efficiency of the oxygen transport system, i.e. cardiorespiratory fitness. Many field tests have been developed to measure cardiorespiratory fitness but unfortunately there is little information in this area relating to younger age groups and particularly for girls below the age of 18 years. Currently the American Alliance for Health, Physical Educa- tion and Recreation lists no test of cardiorespiratory fitness for children under 10 years of age (Krahenbuhl, Pangrazi, Burkett, Schneider and Petersen, 1977). Recently the British Columbia Physical Education Learning Assessment (1979) showed that valid and reliable tests to measure cardiorespiratory fitness were practically non-existent for young children, particularly young females. There are few studies in this area and the results are contradictory.

More information regarding this problem is necessary.

B. Statement of the Problem

The purpose of this study was to investigate:

1. The validity of the 9 minute and 12 minute timed runs and the 1600 metre distance run as predictors of peak oxygen uptake and therefore as measures of cardiorespiratory fitness in girls 8 to 11 years of age.

2. The reliability of the 9 minute and 12 minute timed runs and the 1600 metre distance run as measures of cardiorespiratory endurance.

C. Hypotheses

1. The 9 minute and 12 minute timed runs and the 1600 metre distance run will be valid field measures of cardiorespiratory fitness in girls 8 to 11 years of age.

   (a) the performance of girls 8 to 11 years of age on timed and distance runs is related to peak oxygen uptake and is therefore a predictor of peak oxygen uptake.

   (b) as the distance and time components of a run increase, the relationship to peak oxygen uptake also increses; therefore

   (i) the 12 minute timed run will have the highest correlation with peak oxygen uptake (ml/kg. min);

   (ii) the 1600 metre distance run will have the second highest correlation with peak oxygen uptake (ml/kg. min);

   (iii) the 9 minute timed run will have the lowest correlation with peak oxygen uptake (ml/kg. min).

2. Both timed and distance runs, specifically the 9 minute, the 12 minute and the 1600 metre run, are reliable field measures of cardiorespiratory fitness in girls 8 to 11 years of age.

D. Sub-Hypothesis

1. The correlation between two different timed or distance runs will

   increase as the runs become closer in the distance and the length

   of time spent running, therefore

   (a) the 12 minute timed run and the 1600 metre distance run will

   have the highest correlation;

   (b) the 1600 metre distance run and the 9 minute timed run will

   have the second highest correlation;

   (c) the 12 minute and the 9 minute timed runs will have the lowest

   correlation.

E. Limitations

1. The motivation of the subjects to perform in each of the tests may

   affect their scores;

2. Weather changes may affect the performances of the subjects on any

   one day;

3. The condition of the field where the run is to be conducted may

   affect the performance of the subjects; and

4. The ability of each subject to understand and practice the concept

   of pacing may affect the scores.

F. Delimitations

1. This study is delimited to 8 to 11 year old girls.

2. The subjects in this study are not representative of a random

   sample.

G. Definitions

1. Maximal Oxygen Uptake (max VO_2) ml/Kg.- min

   This measurement refers to the largest volume of oxygen uptake

   possible as determined by the efficiency and capacity of the heart,

lungs and the blood vessels (the cardiorespiratory system).

Maximal oxygen uptake is usually expressed in millilitres/

kilogram-minute (ml/kg-min).

2. Cardiorespiratory Fitness

This can be defined as the ability of the body to endure at a high

metabolic loading and is affected by the efficiency of the oxygen

transport system (the heart, the lungs, the blood vessels) in sup-

plying oxygen and removing matabolites from the body's cells. The

most suitable measure of this known to date is maximal oxygen uptake

(ml/kg-min).

3. Aerobic Working Capacity

The word "aerobic" means "with oxygen," therefore, aerobic working

capacity can be considered to reflect the cardiorespiratory condition.

4. Peak Oxygen Uptake

Due to the controversy in determining if a subject has actually ob-

tained his/her true maximal oxygen uptake the investigator in the

present study has chosen to use peak oxygen uptake as the criterion

measure.

Peak oxygen uptake will be defined as the highest oxygen uptake ob-

tained by the subject over the last two workloads of the treadmill

test.

5. Validity

The validity of a test may be defined as the accuracy with which the

test measures that which it is used to measure, or as the degree to

which it approaches infallibility in measuring that which it purports

to measure (Safrit, 1973).

A test is valid for a particular purpose or in a particular situation

- it is not generally valid.

There are different types of validity, however in this study the investigator was concerned with criterion-related validity.

There are two types of criterion-related validity:

(a) Predictive validity

Predictive validity is the degree to which a criterion beha-
viour is predicted from predictor scores. A person's expected
future performance is predicted from a test and the usefulness
of the test score is judged against the criterion. Predictors
are tests or variables that predict criterion behaviour
(Safrit, 1973).

(b) Concurrent Validity

Concurrent Validity involves the comparison of a given test
with another test that has an established validity but is
excessively time-consuming or costly to administer. The
proven test with an established validity could be the
criterion (Safrit, 1973).

6. Criterion

A criterion is a standard of judging that which is a known and
accepted measure of whatever the author wishes to test. The
criterion may be another test which has proven its worth or it
may be some score determined subjectively such as that provided
by a rating (Safrit, 1973).

The criterion is the yardstick against which the test in question
is to be measured. Therefore it is important that the criterion
is appropriate.

7. Reliability

Reliability refers to the precision and consistency of a measure.
The reliability of a test refers to the dependability of scores,
their relative freedom from errors. It is the tendency toward
consistency exhibited by a given individual's repeated performance
of one behaviour.

A test can be reliable without being valid, but a valid test

must also be reliable (Safrit, 1973).

In this study the investigator will be concerned specifically

with test-retest reliability.

H. Justification of the Study

Measurement is an important component in any school program.
Measurements allow a teacher to evaluate the strengths and weaknesses of
individuals and groups and to formulate goals and programs that will meet
the needs for each individual and for each group. Evaluation can help
inform teachers of beneficial changes that occur for each student and
ultimately for society (Johnson and Nelson, 1974). Specifically cardio-
respiratory tests are important for:

1. assessing the status and improvement of students as they progress

    through a physical education program;

2. screening students for possible cardiac and/or respiratory problems.

    It is important to note that this should not be considered as a

    substitute for a medical examination; and

3. use as an educational learning experience for the students involved

    in the testing. Cardiorespiratory tests can be very effective for

    their motivational properties and for the information that is

    derived from the body's reactons to exercise, specifically the

    circulatory, respiratory and thermoregulation systems.

If significant correlations are obtained between peak oxygen uptake
and the timed and distance runs the results of the present study will be a
positive step in the development of a valid field test to measure cardio-
respiratory fitness in young girls 8 to 11 years of age.

In addition, the information and data obtained from this thesis will

add to the scant body of knowledge presently existing regarding the

physiological capabilities of 8 to 11 year old girls.

Chapter II

REVIEW OF LITERATURE

A. Rationale for Field Tests That Measure Cardiorespiratory Capacity

Canadians are becoming aware of the importance of being in good physical

condition. This attitude is reflected in the increasing number of partici-

pants in Young Men Christian Association (YMCA) and Young Women Christian

(YWCA) programs, employee fitness, community centre and individual jogging

programs.

In recent years, physical education programs have also reflected a

renewed interest in the development of physical fitness (Jackson and Coleman,

1976). These concerns shown by the public are due to a variety of reasons

including the popularity of Cooper's Aerobic Program (1968) and the growing

body of scientific research linking endurance fitness to health and

physiological well-being (Fox and Skinner, 1964).

Health concerns such as coronary heart disease are major issues con-

fronting the medical profession and society as a whole. More Canadians die

from heart disease than all other causes combined (B.C. Heart Foundation,

excerpt from the Programme for Fitness in the 80's, 1980). It is now

recognized that coronary heart disease, which results in arterial damage

long before the first overt symptoms appear, is mainly of pediatric origin

(Wilmore and McNamara, 1977; Krahenbuhl, Pangrazi, Petersen, Burkett and

Schneider, 1978). Several of the risk factors for coronary heart disease

have been identified in adults and the incidence of these risk factors in

children has been studied (Drash, 1972; Friedman, 1972; Gilliam, Katch,

Thorland and Weltman, 1977; Kannel and Dawber, 1972; Lauer, Conner, Leaverton,

Reiter and Clark, 1975). In fact, the prevalence of coronary heart disease

risk factors in children, 7 to 12 years of age, seems to be quite high

(Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978). According to

Astrand and Rodahl (1970), the training and efficiency of the oxygen transport

system is particularly important as a risk reduction measure for coronary

heart disease (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978).

These renewed interests in health concerns have been instrumental in

the improvement of measurement procedures to evaluate physical fitness status.

Exercise physiologists agree that the best physiological measurement for

determining one's cardiorespiratory endurance or aerobic power is maximal

oxygen uptake, that is, the maximal capacity of the cardiorespiratory system

to take-up, transport and give off oxygen to the tissues (Astrand and Rodahl,

1970; Mitchell, Sproule and Chapman, 1958; Shephard, 1966; Taylor, Buskirk,

and Henschell, 1955). Some people still question the use of this

measurement as a suitable indication of one's cardiorespiratory fitness

status (Cureton, Boileau, Lohman and Misner, 1978). Nevertheless, cardio-

respiratory endurance is widely accepted as a component of fitness and for

many people it is considered the most important (Getchell, Kirkendall and

Robbins, 1978).

There have been several techniques developed for measuring maximal

oxygen uptake. Most of these require expensive and time consuming

laboratory procedures which are not feasible for mass testing in a public

situation. Consequently, researchers have attempted to develop valid field

tests that can predict laboratory determined maximal oxygen consumption.

B. Types of Field Tests

Generally field tests to measure aerobic endurance have been either

step tests, timed or distance runs.

During World War II, Brouha (1943) developed the Harvard Step Test as

a field measure to predict maximal oxygen uptake in college aged men. This

test required a subject to exercise on a 20-inch bench at a cadence of 30

steps per minute for as long as possible, up to a maximum of 5 minutes. The

post exercise pulse rate was recorded 3 times during recovery: from 1 to 1.5 minutes, from 2 to 2.5 minutes and from 3 to 3.5 minutes. The sum of the pulse counts in the three recovery periods and the time spent stepping measured in seconds were applied to a formula from which the index of physical efficiency was determined.

Meyers (1969) reported reliability coefficients of 0.77 for college aged males and 0.65 for grade 8 males using the Harvard Step Test. Metz and Alexander (1970) investigated the relationship between various physical fitness test items and maximal oxygen uptake in boys 12 to 15 years old. A correlation of 0.54 was obtained between the Harvard Step Test and maximal oxygen uptake in 30 of the boys, ages 12 to 13 years. This correlation decreased when the older boys, ages 14 to 15 years, were tested (r = 0.42). Both of these correlations were significant at the .05 level. However, a multiple correlation coefficient of 0.70 or larger (r^2 = .50 approximately) was accepted as the criterion for the estimation of maximal oxygen uptake. This criterion was decided upon by the investigators so that no more than approximately 50% of the variability would be unaccounted for. Consequently, since the regression equations for estimating maximal oxygen uptake from the Harvard Step Test score produced multiple correlation coefficients of 0.54 and 0.42, the Harvard Step Test was considered inadequate for estimating maximal oxygen uptake.

The Harvard Step Test was generally criticized for its strenuousness resulting in fatigue and cramps in the large leg muscles. As a result of this criticism, the Harvard Step Test was modified in 1969 (Kurucz, Fox and Matthews, 1969) and renamed the Ohio State University (OSU) Step Test. This test utilized a split level bench with step heights of 15 and 20 inches, along with a handbar. The test consisted of three phases with six innings in each. An inning consisted of 30 seconds of stepping and a 20 second rest

period during which a 10 second pulse count was taken between the 5 to 15th second. Each of the three phases had a different workload: phase one - 6 innings at 24 steps per minute on a 15 inch bench; phase two - 6 innings at 30 steps per minute on a 15 inch bench; phase three - 6 innings at 30 steps per minute on a 20 inch bench. The test terminated at the end of the 18th inning (phase three) or whenever the pulse rate reached 150 beats per minute. This test was developed for men between the ages of 18 and 60 years. A validity coefficient of 0.94 was obtained with the Balke Treadmill Test as the criterion measure. The test-retest reliability coefficient was 0.94.

Cotten (1971) modified the Ohio State University (OSU) Step Test further to make it applicable for high school physical education students. This test was designed to be given on bleacher steps which are usually 17 inches high. The test procedures are identical to the OSU Step Test except a 17 inch step was used, no handbar was required and the stepping cadence in Phase three was 36 steps per minute. Cotten (1971) reported a validity coefficient of 0.84 with the Balke Treadmill Test, using male students in grades 9 to 12. The test-retest relaibility coefficients were 0.95 for male physical education majors and 0.75 for male high school students, grades 9 to 12.

Witten (1973) developed a step test for college females between the ages of 18 to 22 years. The test consisted of stepping for 30 seconds followed by a 20 second rest at a cadence of 24 steps per minute on a 14 inch step and progressing to a cadence of 30 steps per minute on a 17 inch bench. The test was scored by counting the number of innings required to raise the heart rate to 168 beats per minute. A validity coefficient of 0.85 was obtained when the test was correlated to the Balke Treadmill Test.

Martens (1978) compared four different field tests to measure cardio-vascular fitness in children, grades 4 to 6. The four tests, the one mile run, the 9 minute run, Physical Work Capacity with the heart rate at 170

beats per minute and the Action B.C. Children's Aerobic Step Test, were inter-correlated for the total group of subjects and then intercorrelated separately for both the boys and the girls. The correlation between the 9 minute run and the 1 mile run was significant (r = -0.834) at the 0.001 level. The correlation between the step test and the mile run was significant (r = 0.377) at the .05 level. However, this correlation was not high enough for predictive purposes because it left approximately 80% of the variability unaccounted for. The other correlations between the four tests were not significant. Although the four field tests were not validated with maximal oxygen uptake, Martens (1978) concluded that since the 9 minute run had been shown in previous studies to be a valid cardiovascular test for this age group, both the 9 minute run and the 1 mile run (correlation with the 9 minute run, r = 0.834) were valid cardio-vascular tests for elementary school children. Martens (1978) stated further that both the Physical Work Capacity (PWC-170) and the Action B.C. Step Test were not valid or reliable cardiovascular tests for elementary school children when the 9 minute run was used as the criterion of cardiovascular fitness.

From the data presented it appears that results from the Harvard Step Test and modifications of it become less reliable and less consistent as the ages of the subjects decrease. The sources of error and inconsistency appear to exist mainly in the counting of pulses and the inability of the subjects to maintain the cadence and proper stepping action. Due to the limited number of subjects that can participate at one time (equipment) and the number of assistants needed to ensure proper technique and pulse counting, the step test does not appear to be the most efficient field test to measure cardio-respiratory endurance in a mass testing situation. Also the data available using this type of test on young children, especially young girls, is non-existent.

Since Balke's work in 1963, walk-run tests for distance have been the field tests most often recommended (Jackson and Coleman, 1976).

Balke (1963) reported the existence of a linear relationship between running velocities and oxygen requirements when expressed per unit of body weight. The oxygen cost of running speeds has compared well with maximal oxygen uptake values when the distance runs were 10 to 20 minutes in duration. This relationship was reinforced by findings in further studies which involved prolonged running (over 10 minutes) and resulted in high correlations with maximal oxygen uptake. Cooper (1968) reported a correlation of $r = 0.897$ between a 12 minute distance run and maximal oxygen uptake in males ages 17 to 52 years. Using a rank order correlation, Doolittle and Bigbee (1968) obtained a correlation of $r = 0.90$ for nine grade 9 boys using the 12 minute run. Burke (1976) reported a similar correlation of $r = 0.90$ between the 12 minute run and maximal oxygen uptake for males, ages 17 to 30 years. Gregory (1970) obtained a correlation of $r = 0.66$ for college age males when comparing the 12 minute run to maximal oxygen uptake.

Kearney and Byrnes (1974) investigated the relationship between running performance and predicted maximal oxygen uptake in male physical education majors. Correlation coefficients were obtained for three different distance runs including a correlation of $r = 0.30$ for a half mile run and a correlation of $r = -0.59$ for a 1 mile run and a correlation of $r = 0.64$ for a 12 minute run.

Katch (1970, 1972) conducted two different studies dealing with the relationship between running performance and maximal oxygen uptake. In the first study (1970), a comparison between the 12 minute run and maximal oxygen uptake was investigated in college age males, resulting in a correlation of $r = 0.54$. In the second study (1972), using the same age group, a comparison between a 2 mile run and maximal oxygen uptake revealed a correlation of $r = 0.55$. Wiley and Shaver (1972) conducted a similar study reporting correlations of $r = -0.43$ and $r = -0.47$ between maximal oxygen uptake and 2 and 3 mile runs, respectively, in college men.

Ribisl and Kachadorian (1969) obtained correlations fo r = -0.79 between maximal oxygen uptake and a 1 mile run and r = -0.85 between maximal oxygen uptake and a 2 mile run in college males. A correlation of r = -0.86 was reported between maximal oxygen uptake and a 2 mile run when using middle age men as subjects.

The correlations reported in the Ribisl and Kachadorian (1969) study were higher than the correlations obtained by Wiley and Shaver (1972). For a 2 mile run, Wiley and Shaver (1972) reported r = -0.43 compared to a correlation of r = -0.85 reported by Ribisl and Kachadorian (1969) for the same age group. The Wiley and Shaver (1972) study used untrained men as subjects whereas Ribisl and Kachadorian (1969) used trained, conditioned men who were experienced in long distance running. A close relationship has been shown between maximal oxygen uptake and performance in endurance running events for trained athletes (Costill, Thomason and Roberts, 1973). Daniels (1974) supported these findings for runners and Foster and Daniels (1975) noted similar relationships among trained cyclists.

C. The Validity of Short Distance versus Long Distance Running Tests

The shorter distance runs such as the 600 yard walk-run test used by the American Association of Health, Physical Educaton and Recreation (AAHPER), exhibit significant correlations with maximal oxygen uptake, but have a relatively low validity coefficient when compared to the longer running events. Falls, Ismail and MacLeod (1966) and Olree, Stevens, Nelson, Agnevik and Clark, (1965) have investigated the validity of estimating maximal oxygen uptake from the AAHPER Youth Fitness Test items. The correlation coefficients obtained for predicting maximal oxygen uptake from the 600 yard run times were r = 0.64 (Falls, Ismail and MacLeod, 1966) and r = 0.53 (Olree, Stevens, Nelson, Agnevik and Clark, 1965). Vodak and Wilmore (1974) studied the validity of a 6 minute jog-walk and the 600 yard run-walk in estimating

endurance capacity in boys 9 to 12 years of age. The correlation coefficient obtained for the 600 yard run time and maximal oxygen uptake was $r = 0.50$ while a correlation of $r = 0.49$ was reported for the 6 minute jog-walk. Doolittle and Bigbee (1968) reported a correlation of $r = 0.62$ between the 600 yard run and maximal oxygen uptake for adolescent boys. A correlation of $r = 0.66$ was obtained for 12 and 13 year old children while a correlation of $r = 0.27$ was obtained for the older 14 and 15 year old children.

The results from these studies suggest that test runs of a short duration (such as the 600 yard run) measure aerobic capacity to some extent, but other factors such as the running speed and general athletic skill are also measured in this type of test (Getchell, Kirkendall and Robbins, 1978). In addition, some factor analytic studies by Disch, Frankiewicz and Jackson (1975) and Jackson and Coleman (1976) have illustrated that runs of 800 metres or 6 minutes and less in duration cluster with tests of running speed and running endurance. Distance runs of at least one mile and runs lasting for more than 9 minutes were found to form a distance run factor (Morrow, Jackson and Bell, 1978). These results indicate that a common source of variation underlies measures of long distance running which is different from short distance runs.

Jackson and Coleman (1976) examined the construct validity, that is, the variance structure of various distance run tests (50 yard, 3 minute, 6 minute, 9 minute and 12 minute runs) using alpha factor analysis and canonical factor analysis followed by a varimax rotation to an orthogonal solution. Both the alpha and canonical factor analysis supported the use of 9 and 12 minute runs as field tests for elementary school boys and girls. One factor was recovered with the 50 yard run and the 3 minute run and a second factor was isolated with the 9 and 12 minute runs. The 6 minute run was complex and exhibited substantial loadings on both factors. Concurrent validity of the 9 and 12 minute runs was estimated using maximal oxygen

uptake as the criteria. The study concluded that both the 9 and 12 minute run tests were significantly correlated with maximal oxygen uptake. However, running the additional 3 minutes in the 12 minute run test did not significantly improve the concurrent validity. Consequently, the data supported the use of a 9 minute run test with elementary school boys and girls. This study also indicated that distance runs provided a reliable factor to measure distance running ability.

Martens (1978) study, as mentioned earlier, compared four different field tests to measure cardiovascular fitness in children, grades 4 to 6. The results of the study concluded that both the 9 minute run and the one mile run were valid cardiovascular tests for elementary school children.

Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider (1978) studied field testing of cardiorespiratory fitness in primary school children and concluded that the relationship of maximal oxygen uptake with performance on a timed run improved as the distance of the run increased for both males and females. The 1200 metre and the 1600 metre distance runs were found to be significantly related to maximal oxygen uptake.

D. Factors Affecting Running Performance

Aerobic working capacity has been shown to increase with age up to approximately 20 years (Astrand, 1970). Since distance running performance is known to be correlated with aerobic working capacity, one would expect to find improvements in running ability as a function of age. Gilliam, Sady, Thorland and Weltman (1978) found that as chronological age increases from 6 to 13 years, children have a greater ability to consume more oxygen. These differences among age groups do not exist when body weight is taken into consideration. Astrand (1976) reported a significant increase in peak oxygen consumption (ml/Kg B.W.) from ages 6 to 8 years for both sexes and a levelling off from ages 8 to 14 for boys and a decrease for girls.

During puberty, boys, due to an increase in the level of testosterone in the blood, tend to increase the proportion of muscle to fat, while girls, due to an increase in the levels of estrogen and progesterone in the blood, tend to increase the proportion of fat to muscle. Fat is metabolically inert and noncontributory during heavy work compared to muscle which is metabolically active and contributory during heavy work. Consequently, a higher proportion of muscle/fat would result in a higher metabolic rate and oxygen use. Peak oxygen consumption appears to develop proportionally to the development of body mass.

Cureton, Boileau, Lohman and Misner (1978) conclude that low maximal oxygen uptake (ml/Kg B.W.-min) and poor distance running performance due to excess body fat was not necessarily indicative of poor cardiovascular respiratory function due to inactivity or pathology. Cardiorespiratory capacity was only one important determinant of distance running performance and variations in the ability to run fast, body fatness and body size were other important determinants in distance running tests. Cureton, Boileau, Lohman and Misner (1978) suggested that it was important to distinguish between the metabolic influence of per cent fat on prolonged running performance (which influence is primarily to increase the energy cost of running at a given speed) and the cardiorespiratory capacity (as indicated by the aerobic capacity expressed relative to the appropriate reference standard of active muscle mass) because the two have different interpretations.

Morrow, Jackson and Bell (1978) reported that distance run performance did not improve consistently with age. The 12 minute run performance for girls showed that the decrease in performance as a function of age could be due to body composition. As the girls were getting older their body mass index (BMI) was increasing, which suggests that they were gaining higher

amounts of fat weight in proportion to total weight. (The BMI is a measure of relative weight and has been found to have a high correlation with weight and adiposity, but a low correlation with height.) This apparent change in body composition appeared to be responsible for the decreased running performance and suggests that the physical fitness level of the girls was decreasing.

E. Research Conducted On Young Female Children

Due to the sparsity of data on young children many public schools have generalized the findings obtained from research on adult populations to elementary school age populations. This practise of generalizing results violates the basic principles of reliability and validity. Tests that are valid and reliable for one populaton may or may not be valid and relaible for other populations (Jackson and Coleman, 1976).

The American Alliance for Health, Physical Education and Recreation (Hunsicker and Reiff, 1976) currently lists no test of cardiorespiratory fitness for children under 10 years of age. Since coronary heart disease risk factors commonly appear in childhood it would be desirable to develop a test of cardiorespiratory fitness for children.

Since children develop and mature at different rates during the growing years it is extremely important that studies are conducted with specific age and sex groups. As mentioned earlier, the physical work capacity of children has been reported to increase significantly (as much as eight times) from ages 6 through 13 (Gilliam, Sady, Thorland and Weltman, 1978; Adams, 1973). Consequently, data from a slightly older group may not adequately represent the younger groups of children.

The few studies that have been conducted on young children suggest that reliable measurements of both distance run performance (Jackson and Coleman, 1976; Krahenbuhl, Pangrazi, Burkett, Schneider and Petersen, 1977;

Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978) and maximal oxygen uptake (Cunningham, MacFarlane Van Waterschoot, Paterson, Lefcoe and Sangal, 1977; Wilmore and Sigerseth, 1967) are possible. Furthermore, previous studies have shown that the results of distance run tests provide a useful index of relative cardiorespiratory fitness if the subjects' experience and skill are similar (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978; Cumming, 1971; Gutin, Fogle and Steward, 1976; Metz and Alexander, 1970).

Chapter III

METHODS AND PROCEDURES

A. Introduction

The data for this study were collected at two different schools over a two year period. To clarify the descriptions of the subjects the section entitled 'Subjects' will be divided in two parts.

The methods and procedures for both groups of subjects were identical, therefore the description will be stated once.

B. Procedures

1. Subjects

(a) Group I

Forty subjects in grades 4 and 5 who were between the ages of 8 to 11 years at Crofton House School, Vancouver, British Columbia, were asked to participate in this study during May, 1979.

(b) Group II

Twenty subjects in grades 3,4 and 5 who were between the ages of 8 to 11 years at St. Patrick's Elementary School, Vancouver, British Columbia, were asked to participate in this study during April, 1980.

The initial contact for the study was done by personal appearance, followed by a letter and a consent form to the parents of the children who wished to participate in the study. Parental consent and medical clearance were obtained for all subjects. Each subject was informed verbally of the exact nature of the tasks she was expected to perform, i.e., a 9 minute, a 12 minute, and a 1600 metre run, a maximal oxygen uptake treadmill test along with measures of height, weight and body fat assessment.

2. Testing Procedures

The testing procedures will be divided into two stages.

(a) Stage 1

All of the testing in this stage was conducted at the two schools, Crofton House and St. Patrick's Elementary School.

During the two weeks prior to the actual testing, the subjects practised running for approximately 10 minutes at the beginning of four physical education classes. The concept of pacing was explained to the children before each practise run. A pacer ran with the children and emphasized the concept of paced running.

The field test runs were conducted in the two week period following the two weeks practise runs. The subjects were tested on three distance runs including 9 minutes, 12 minutes, and 1600 metre runs. All of the runs were conducted during school hours and, where possible, in physical education classes.

At the end of the two week testing period, one physical education class was devoted to retesting the students from Crofton House in the 9 minute, the 12 minute and the 1600 metre distance runs.

(b) Stage 2

All of the testing in this stage was conducted at the J.M. Buchanan Fitness and Research Centre, University of British Columbia. Each student attended one testing session lasting approximately one hour. Four measures were obtained at this time; peak oxygen uptake, height, weight and body fat assessment.

3. Testing Protocols

As stated in the review of literature, the use of step tests with children has not been very successful, therefore in this study timed and distance runs were chosen as field tests.

The 12 minute timed run was chosen because Balke (1963) originally reported that a run lasting 12 to 15 minutes was needed to tax the cardi-

respiratory system to indicate how these body systems reached and adjusted to being placed under a metabolic workload. Distance runs of a shorter length were thought to rely too heavily on running ability and skill rather than the ability of the oxygen transport system to do work.

Further research by Cooper (1968) in this area has shown the 12 minute run to be a suitable length as a field test for adults.

The 9 minute timed run and the 1600 metre distance run have been used recently in studies for elementary and high school age boys. Reasonably high correlations have been reported between these runs and maximal oxygen uptake (ml/kg-min).

In view of the above information, three runs were chosen as field tests: the 9 minute timed run, the 12 minute timed run and the 1600 metre distance run.

(a) Timed Distance Runs

Each student performed distance runs of 9 minutes, 12 minutes, and 1600 metres. The distance runs were performed on a two hundred metre grass track marked off in five metre gradations by orange parking cones. All of the runs were started and finished with the blow of a whistle.

The subjects were divided by grades initially and then each grade was divided into two groups, with 10 subjects in each. The order of administration of the running tests were randomly assigned to each of the groups. One group ran at a time while the other group acted as spectators. Each subject was identified by a coloured numbered bib. There was one lap counter/timer for every three subjects. Verbal encouragement was given to each subject by both the lap counters and the classmates who were in the spectator group. The distance covered in both the 9 minute and the 12 minute runs were recorded to the nearest metre. The time for the 1600 metre run was recorded to the nearest second.

(b) Retesting the Distance Runs

i) Group I: Crofton House School

Fifteen Grade 4 and fifteen Grade 5 girls were randomly selected to be retested on the three distance runs. The fifteen girls in each grade were divided into three groups of five girls each. Each group was retested on one of the distance runs. This gave a total of ten retest scores on each of the three distance runs.

ii) Group II: St. Patrick's Elementary School

It was deemed not necessary to retest the subjects due to the small number of subjects.

(c) Peak Oxygen Uptake

Prior to the actual treadmill test, the subjects practised getting on and off the treadmill, as well as walking and running at various speeds and grades on the treadmill. Each subject was given two practises of approximately five to ten minutes each.

The exercise test consisted of a three minute warm-up walking at zero per cent grade, followed by a two minute rest. The subject then ran at 4.5 m.p.h. at three per cent grade. Throughout the test the speed was held

constant with three per cent grade increments every three minutes until voluntary fatigue.

Prior to the warm-up, the subject was connected to a Cardioguard 4000 Electrocardiogram machine. Three electrodes were attached to the subjects' skin at three different locations:

   i) right midaxillary line at the level of the fith intercostal;

   ii) directly over the manubrium; and

   iii) left midaxillary line over a rib.

These electrodes were plugged into the Electrocardiogram (ECG) via a belt worn around the subject's waist. A resting ECG was obtained while the subject was verbally informed of the exact procedure of the test.

The warm-up for the exercise test consisted of walking at 3.5 m.p.h. on the treadmill at zero per cent grade for three minutes. During this time the heart rate was recorded and the ECG tracing monitored. Following the warm-up, the subject was given a two minute rest while the breathing apparatus was connected. The tubing that collected the exhaled air was fed into a Beckman Metabolic Measurement Cart which analyzed the per cent oxygen, per cent carbon dioxide, and oxygen uptake in millilitres. This information was simultaneously fed into a computer which tabulated the results every fifteen seconds throughout the exercise test, coordinating the time, the speed of the treadmill, the grade of the treadmill, the heart rate, the volume of oxygen, the volume of carbon dioxide, oxygen pulse, respiratory quotient, ventilation rate, per cent oxygen and per cent carbon dioxide.

After the rest period, the grade of the treadmill was increased to three per cent and the subject started walking on the treadmill. Gradually the speed was increased to four and one-half (4.5) m.p.h. at which point the time clock started. Throughout the rest of the test the speed was held constant with three per cent grade increments every three minutes until

voluntary fatigue. Since the subjects were exercising to exhaustion, the peak oxygen uptake was taken to be the maximal oxygen uptake. Other criteria such as the respiratory quotient approaching a value of 1.0, a plateau in both the oxygen uptake and the heart rate were also used to decide if the subject had in fact reached maximal oxygen uptake (Cunningham, MacFarlane Van Waterschoot, Paterson, Lefcoe and Sangal, 1977).

(d) Anthropometric Measures

The height measures were taken to the nearest centimetre and the weight measures were taken to the nearest 0.5 kilogram on a Detecto Weight Scale. The body fat measures were taken at four body sites, the biceps, the triceps, subscapular and suprailiac. These measures were then substituted into a formula derived by Durnin and Rahaman (1967). The skinfold calipers were manufactured by Harpenden.

C. Statistical Analysis and Research Design

1. Validity

The BMD P2R Computer Program was used to determine the degree of relationship between the seven independent variables and the criterion or dependent variable tested in this study. The seven independent variables included age, height, weight, percentage body fat, 9 minute run, the 12 minute run and the 1600 metre run. Peak oxygen uptake (ml/kg-min) was chosen as the dependent, criterion measure.

The means and standard deviations of the variables were calculated. A zero order correlation matrix was obtained to investigate the interrelationship between all the variables when no variables were held constant. The data was also entered into both forward and backward stepwise multiple linear regression analyses to select the variables and subsequent regression equations that provided the optimal prediction of peak oxygen uptake. Partial correlations of the variables were obtained through this process.

To determine the significance of the correlations the null hypothesis was applied. In applying the null hypothesis, the amount of correlation needed for rejection at a given level of significance was determined. In this case the null hypothesis stated that the population n is in fact zero, and any correlation obtained was due to sampling error. A table was used to obtain r values needed to reject the null hypothesis at the .05 and .01 levels of significance. The sample size was very important in the significance of correlation coefficients; the smaller the sample size (and therefore the degrees of freedom), the higher the correlation must be for it to be significant at the .05 and .01 levels. Consequently, any discussion of correlation coefficients as being high or low are meaningless without reference to the correlation needed for the number of subjects which the correlation was based on. (Clarke and Clarke, 1970, p. 230).

Table I shows the required r values when n = 20 and df = 18, to reach significance at the .05 level and the .01 level.

Table I

Required Correlation Coefficients

to Reach Significance at the .05 and .01 Levels

Degress of Freedom	Levels of Significance	
(n-2)	.05	.01
18	.444	.561

n = 20

Taken from: Clarke and Clarke, p. 231, Table 19.

2. Reliability

The SIMCORT Computer Program (U.B.C.) was used to determine the

test-retest reliability correlation coefficients (r) between Trial 1 and Trial 2 on each of the timed and distance runs; the 9 minute, the 12 minute and the 1600 metre run. In addition, the reproducibility of the mean scores of the 9 minute, 12 minute and 1600 metre runs achieved in Trial 1 and Trial 2 were determined by a two tailed t test for correlated means.

Table 2 shows the value r must be when n = 10 and degrees of freedom = 8 to reach significance at the .05 and .01 levels.

Table 3 shows the value t must be when n = 10 and degrees of freedom = 9 to reach significance at the .05 and .01 levels.

Table 2

Required Correlation Coefficients
at the .05 and .01 Levels of Significance

| Degrees of Freedom | Levels of Significance | |
(n-2)	.05	.01
8	.632	.765

n = 10

Table 3

Required t Values to Reach Significance
at the .05 and .01 Levels

| Degrees of Freedom | Levels of Significance | |
(n-1)	.05	.01
9	2.26	3.25

n = 10

Chapter IV

RESULTS AND DISCUSSION

The purpose of this study was twofold:

1. to determine the degree of validity of timed and distance runs, the
   9 minute, the 12 minute and the 1600 metre runs, as predictors of
   peak oxygen uptake as determined by a maximal treadmill test;

2. to determine the test-retest reliability of the three distance runs.

A. Descriptive Data

Sixty female subjects enrolled at Crofton House School and St. Patrick's
Elementary School in Vancouver, British Columbia, participated in the study.
All of the subjects were enrolled in grades four, five and six at the two
schools. The data was collected over a 1 year period from May 1979 to
June 1980.

Forty of the sixty subjects were from Crofton House School and fourteen
of these subjects (35%) completed all the tests. The remaining twenty
subjects were from St. Patrick's Elementary School and seven of these
subjects (35%) completed all the tests giving a total of twenty-one subjects
with complete data. Three-quarters of the subjects with incomplete data
(n = 29) did not receive parental consent for the maximal oxygen uptake
testing and one-quarter of the subjects (n = 10) were unable to attend some
of the field testing sessions due to various reasons.

The basic descriptive data for the subjects with complete data is
summarized in Table 4.

The age range of the subjects varied from eight to eleven years with
an average age of ten years. The mean weight of the subjects was 34.5
kilograms with an average of 24 per cent or 8.35 kilograms of body fat.
The subjects ranged from 18.3 to 33.4 percentage body fat and from 27.0 to
49.2 kilograms of body weight.

B. <u>Results</u>

1. Validity

As seen in the correlation matrix there was a significant correlation between age and weight ($r = .44$, $p < 0.05$), age and height ($r = .60$, $p < 0.01$), weight and height ($r = .69$, $p < 0.01$) and weight and percentage body fat ($r = .78$, $p < 0.01$).

The average value for peak oxygen uptake was 1.6499 1/min, with values ranging from 1.446 to 1.8195 1/min. The criteria used in determining peak oxygen uptake included heart rate, ventilation, respiratory quotient and the presence of a plateau in oxygen uptake values over the last two workloads of the treadmill test. It should be noted that peak oxygen uptake was chosen as the criterion variable rather than maximal oxygen uptake. Therefore the highest oxygen uptake value obtained by the subject in additon to the other criteria mentioned earlier, was chosen as the peak oxygen uptake. The mean heart rate, respiratory quotient and ventilation values attained at peak oxygen uptake were 203 beats per minute, 0.89 and 58.16 1/min (BTPS), respectively.

The average distance run in the 9 minute run was 1598 metres, with a range from 1290 to 1945 metres. In the 12 minute run the average distance covered was 2022.8 metres with a range from 1650 to 2566 metres. The amount of time taken to run the 1600 metres ranged from 424 seconds or 7 minutes and 6 seconds to 754 seconds or 12 minutes and 56 seconds with a mean time of 565.86 seconds or 9 minutes and 43 seconds.

The highest correlation was found between the 9 minute run and peak oxygen uptake (ml/kg-min), $r = .82$. This was followed by percentage body fat and peak oxygen uptake (ml/kg-min), $r = -.79$, the 1600 metre run and peak oxygen uptake (ml/kg-min), $r = -.75$ and finally the 12 minute run and peak oxygen uptake (ml/kg-min), $r = .73$.

Table 4

Descriptive Data of the Subjects (n = 21)

Variable	Mean	Standard Deviation
Age (months)	121.86	7.11
Age (years)	10.1	.60
Height (cm)	138.91	6.09
Weight (kg)	34.54	6.37
Percentage Body Fat	24.23	4.38
Peak $\dot{V}O_2$ (ml·kg^{-1}·min^{-1})	48.58	7.86
Peak $\dot{V}O_2$ (1·min^{-1})	1.6499	0.2505
Heart Rate (bpm at peak VO_2)	203	
RQ (at peak VO_2)	0.89	
R.E.R.	0.93	
V_E (BTPS)(1 min^{-1})	58.16	
9 minute run (metres)	1598.1	188.1
12 minute run (metres)	2022.8	264.8
1600 metre run (seconds)	565.86	85.7
1600 metre run (minutes)	9 min. 43 sec.	1.43

The intercorrelations between the three timed/distance runs were significantly high with the 9 minute run and the 1600 metre run exhibiting the highest relationship, $r = -.90$, accounting for 81% of the variance. The 1600 metre run and the 12 minute run ranked second with a correlation of $r = -.87$, accounting for 79% of the variance. The lowest intercorrelation was between the 9 minute run and the 12 minute run with $r = .79$, accounting for 69% of the variance.

Table 5

Correlation Matrix

Variables	Age	Weight	Height	%Body Fat	VO_2(ml)	9 min	12 min	1600	VO_2(liters)
Age	1.000								
Weight	0.4384	1.000							
Height	0.6016[b]	0.6935[b]	1.000						
% Body Fat	0.0665	-0.7765[b]	0.1819	1.000					
VO_2 (ml)	0.0850	-0.6116[b]	-0.1500	-0.7934[b]	1.000				
9 minute	0.0505	-0.5495[a]	-0.1164	-0.7702[b]	0.8179[b]	1.000			
12 minute	0.1891	-0.5079[a]	0.0734	-0.7540[b]	0.7307[b]	0.7877[b]	1.000		
1600 metre	-0.2239	+0.4670[a]	-0.0984	+0.7431[b]	-0.7465[b]	-0.8953[b]	-0.8696[b]	1.000	
VO_2(liters)	0.5347[a]	0.5347[a]	0.5988[b]	-0.0055	0.4264	0.2726	0.1877	-0.2513	;/000

a Significant at the .05 level

b Significant at the .01 level

The correlations between percentage body fat and the three timed/ distance runs were significant but not as high as the intercorrelations between the three timed/distance runs. The correlation between the 9 minute run and percentage body fat was $r = -.77$ followed by the 12 minute run with a correlation of $r = -.75$ and finally the 1600 metre run with a correlation of $r = .74$.

Body weight was also significantly intercorrelated with the three timed/distance runs. The intercorrelation between body weight and the 9 minute run was the highest with $r = -.55$, followed by body weight and the 12 minute run with a correlation of $r = -.51$ and body weight and the 1600 metre run with a correlation of $r = .47$.

Age and height were not significantly intercorrelated with any of the three timed/distance runs.

In addition to the descriptive data and the correlation matrix, the data was also entered into both forward and backward stepwise multiple linear regression analyses to select the independent variables that provided the best prediction of peak oxygen uptake.

In the stepwise regression analysis the independent variables were entered one at a time to formulate regression equations to predict peak oxygen uptake $(ml \cdot kg^{-1} \cdot min^{-1})$.

The 9 minute run was entered first and a regression equation was developed producing a standard error of estimate in predicting peak oxygen uptake equal to 4.648 ml/kg·min. The multiple correlation for this regression equation utilizing one variable was $R = 0.8179$ which accounts for 66.9% of the variance. Table 6 lists these values as well as an adjusted R^2 that considers the number of subjects and variables used in the derivation of the regression equation. The adjusted R^2 is slightly lower than the R^2 (Adjusted $R^2 = 0.6506$; $R^2 = 0.6690$).

Table 6

Regression Equation to Predict Peak Oxygen Uptake $(ml \cdot kg^{-1} \cdot min^{-1})$

Step	Variables	Multiple R	Multiple R^2	Adjusted R^2	Standard Error of Estimate
1	9 minute timed run	0.8179	0.6690	0.6506	4.6480
2	Percentage body fat	0.8571	0.7347	0.7035	4.2822
3	Age	0.8616	0.7423	0.6940	4.3500
4	Body weight	0.8683	0.7539	0.6882	4.3908
5	1600 metre distance run	0.8706	0.7580	0.6715	4.5071
6	Height	0.8730	0.7621	0.6522	4.6374
7	12 minute timed run	0.8738	0.7634	0.6255	4.8126

Peak Oxygen Uptake = 0.02287 (9 minute run) -0.71217 (Percent Body Fat)
+ 29.78812

Table 7

Partial Correlations of Independent Variables

With 9 Minute Run Removed		With 9 Minute Run and Per Cent Body Fat Removed	
Variable	Correlation	Variable	Correlation
Age	0.07614	Age	0.16966
Weight	-0.33732	Weight	-0.06275
Height	-0.09579	Height	-0.01160
Percent Body Fat	-0.44535	12 minute run	0.09265
12 minute run	0.24385	1600 metre run	0.03250
1600 metre run	-0.05538		

With the 9 minute run removed, or held constant, the partial correlations of the remaining variables changed. The 12 minute run and the 1600 metre run exhibited partial correlations of $r = 0.2438$ and $r = -0.0553$ respectively. (Table 7). These correlations were low and not significantly different from zero. These findings indicate that the variances of the 12 minute run and the 1600 metre run that were not in common with the 9 minute run, were not significantly related to peak oxygen uptake.

In step two of the stepwise regression analysis the variable percentage body fat was added. Percentage body fat as seen in Table 7 showed a partial correlation of $r = -0.44535$ accounting for 22% of the variance that was not in common with the 9 minute run but was significantly related to peak oxygen uptake. The addition of percentage body fat to the equation increases the multiple correlaton to $R = 0.8571$. Both the values for R^2 and the adjusted R^2 increase as seen in Table 6. The Standard Error of Estimate for predicting peak oxygen uptake is lower than the value reported when the single variable, the 9 minute run, was used for the regression equation. As noted in Table 7, with both the 9 minute run and percentage body fat partialled out or held constant, none of the remaining variables exhibited significant correlations.

In step three, the variable age was added to the regression equation. The multiple correlation R and R^2 increased slightly. However the adjusted R^2 decreased slightly and the Standard Error of Estimate increased (Table 6).

Based on these findings, the regression equation to predict peak oxygen uptake (ml/kg·min) would be:

Peak Oxygen Uptake = 0.02287 (9 minute run) - 0.71217 (Percentage Body Fat) + 29.78812

Standard Error of Estimate = ± 4.2822 ml/kg·min.

When peak oxygen uptake was considered in litres per minute (1/min.) without body weight accounted for, the correlations between the 7 independent variables and this variable differed substantially. The two variables age and height exhibited significant correlations with peak oxygen uptake (1/min.). However, peak oxygen uptake was not significantly related to the 9 minute and 12 minute timed runs or the 1600 metre distance run. Consequently when these variables were entered into the stepwise regression analysis the resultant regression equation was quite different.

In step one, body height was entered first giving a multiple correlation of $R = 0.5988$. The multiple R^2 and adjusted R^2 were reasonably close in value. The Standard Error of Estimate was 0.2061 1/minute.

In step two, the 9 minute run was entered into the regression equation resulting in a multiple correlation of $R = 0.6909$. The Standard Error of Estimate was 0.1915 1/min.

In step three, body weight was entered into the equation causing the multiple correlation (R) to increase even more, $R = 0.7741$. The Standard Error of Estimate was 0.1728 1/min. and the adjusted R^2 increased to 0.5241.

The subsequent addition of variables in steps 4 and 5 were only able to marginally increase the adjusted multiple R^2 and concurrently lower the Standard Error of Estimate as seen in Table 8. Therefore the investigator decided that the amount of effort required to collect the extra data needed for the 5 variables was not warranted. Consequently the first three variables were retained to formulate the regression equation.

The best equation to predict peak oxygen uptake (1/min.) was:

Peak Oxygen Uptake = 0.02458 (Body Weight) + 0.00932 (Height)
$$+ 0.00093368 \text{ (9 minute run)} - 1.96845$$

Standard Error of Estimate = $\pm$ 0.1728 ($1 \cdot min^{-1}$).

Table 8

Regression Equation to Predict Peak Oxygen Uptake ($1 \cdot min^{-1}$)

Step	Variable	Multiple R	Multiple R^2	Adjusted R^2	Standard Error of Estimate
1	Height	0.5988	0.3585	0.3229	0.2061
2	9 minute timed run	0.6909	0.4773	0.4158	0.1915
3	Body weight	0.7741	0.5992	0.5241	0.1728
4	1600 metre distance run	0.7904	0.6247	0.5246	0.1727
5	Age	0.8069	0.6510	0.5264	0.1724
6	Percent Body Fat	0.8111	0.6580	0.5001	0.1771
7	12 minute timed run	0.8112	0.6580	0.4585	0.1843

Best Equation to Predict Peak Oxygen Uptake (1/min) =

    0.02458 (Body weight) + 0.00932 (Height) + 0.00093368 (9 minute run)
      + 1.96845

B.   Test-Retest Reliability

    As demonstrated in Table 9, the 12 minute run and the 1600 metre run exhibited test-retest reliability correlation coefficients that were significant at the .01 level of significance. The 9 minute run test-retest reliability correlation coefficient was not significant.

    In addition to the reliability correlations, a t test for correlated means was performed to determine whether there was a difference between the mean scores of each timed/distance run at Trial 1 and Trial 2. The t ratios were not significant for Trials 1 and 2 of the 12 minute run, the 9 minute run and the 1600 metre run, therefore the null hypothesis was

accepted. The null hypothesis concluded that the given difference between the two means from Trial 1 and 2, may be due to sampling error and that no real or definite difference existed.

Table 9.

Test-Retest Reliability and Reproducibility

	Test	Means	Standard Deviation	Corre-lation	t ratio	Probability
Trial 1	9 minute run	1438.30	162.556	0.5507	0.005	0.9958
Trial 2		1438.70	173.246			
Trial 1	12 minute run	2158.00	207.976	0.8154[a]	0.215	0.8323
Trial 2		2177.00	187.071			
Trial 1	1600 metre run	586.799	91.4571	0.9772[a]	-0.467	0.6460
Trial 2		568.800	80.5258			

[a]Significant ($p \leq .01$)

C. Discussion

1. Validity.

The first objective of this study was to determine if timed and distance runs, specifically the 9 minute, the 12 minute and the 1600 metre runs, were adequate predictors of peak oxygen uptake and therefore valid tests to use in determining the cardiorespiratory fitness of girls ages 8 to 11 years.

The peak oxygen uptake values obtained by the subjects in this study were slightly higher than the peak oxygen uptake values reported in other

studies for females of this age (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978). Studies on children conducted before 1970 show maximal oxygen uptake values averaging 48 to 50 ml/kg-min for young males with female values being slightly lower (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978).

The literature has shown that it was difficult to obtain reliable maximal oxygen uptake values in young children. The protocol for the treadmill test that was used to elicit peak oxygen uptake in the present study differed from the protocols used in some of the other studies for children. In the present study the grade of the treadmill started at 3% and was raised 3% every three minutes until the subject was exhausted. In some other studies (Krahenbuh., Pangrazi, Petersen, Burkett and Schneider, 1978) the grade started at 0% and was raised 2 1/2 % every minute or two minutes until the subject was exhausted. For a ten minute test, both the protocol in this study using the 3% grade increments every three minutes and the protocol using 2 1/2% grade increments every two minutes would have reached similar grade increments at the conclusion of a ten minute test. The study using 2 1/2% grade increments every minute would have reached a similar grade increment at the end of five minutes. This was quite a notable difference for the total test time. The average time the subjects in the present study ran on the treadmill was 10.00 minutes with a range of 5.00 to 12.30 minutes.

One of the criteria that had been used in recent studies to determine if a true and reliable measure of maximal oxygen uptake was attained by the subjects was the presence of a plateau in the oxygen uptake values. This plateau should occur over the last two workloads of the treadmill test (which varied from two to four minutes) allowing for an increase of only 2.1 ml/kg-min or less in oxygen uptake values during this time (Cunningham,

MacFarlane, Van Waterschoot, Paterson, Lefcoe and Sangal, p. 211, 1977).

Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider (1978) used a test protocol to elicit maximal oxygen uptake that increased the grade by 2 1/2% every minute. The results showed that the group of subjects who attained a plateau in maximal oxygen uptake had higher values in oxygen uptake, heart rate, ventilation, respiratory quotient and validity coefficients between three distance runs. However, the group of subjects who did not attain a plateau in maximal oxygen uptake achieved lower values in the same variables, but these values followed a similar trend to the group who attained a plateau. In addition, correlations obtained between maximal oxygen uptake without a plateau and maximal oxygen uptake with a plateau and the 1600 metre run were both significant ($p < .01$) for males and females.

Cunningham, MacFarlane, Van Waterschoot, Paterson, Lefcoe and Sangal (1977) found that maximal oxygen uptake in young boys was reproducible whether a plateau in the maximal oxygen uptake values was reached or not. However, the reliability coefficient appeared to depend upon whether a plateau was reached. In addition, comparable levels of maximal oxygen uptake were attained whether a plateau was reached or not. The differences in the subjects who attained a plateau and those who did not appeared to be in factors that were indicative of the level of anaerobic metabolism. The maximal heart rate and minute ventilations attained were not dependent upon the presence of a plateau in maximal oxygen uptake.

Before the existence of a plateau in maximal oxygen uptake can be used as a criterion for determining whether the true maximal oxygen uptake was attained in children, more research needs to be done.

Other criteria used to determine if maximal oxygen uptake was attained included high levels of heart rate that levelled off, respiratory exchange

ratio approaching a value of 1.0 and a high ventilation rate. In the present study the mean heart rate reached at peak oxygen uptake was higher than values reported for other children, including those who reached plateaus in oxygen uptake values (Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider, 1978; Cunningham, MacFarlane, Van Waterschool, Paterson, Lefcoe and Sangal, 1977). The mean respiratory quotient reached at peak oxygen uptake was lower than that reported in other studies, while the respiratory exchange ratio was equivalent to those in other studies. The average ventilation rate achieved at peak oxygen uptake was much higher than values reported by Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider (1978), but lower than values reported by Cunningham, MacFarlane, Van Waterschoot, Paterson, Lefcoe and Sangal (1977). Consequently the results obtained by the young girls in the present study demonstrated that they exercised on the treadmill until they were exhausted and achieved high work levels. Due to the controversy regarding the achievement of a true maximal oxygen uptake value, the investigator of the present study chose to use peak oxygen uptake rather than maximal oxygen uptake in the validation of the distance runs.

Upon examination of the data collected during the treadmill test it appeared that many of the young girls may have been able to achieve higher oxygen uptake values if they could have continued to run on the treadmill. This was demonstrated by the 5 to 10 ml/kg-min increases that occurred in oxygen uptake over the 3 minute intervals after the grade increment had been increased. The 3 minute time interval between grade increases was chosen to allow the subject time to physiologically adjust to the new workload before it was increased again. However this time interval also considerably increased the total time of the test rather than the workload imposed on the subjects. Possibly by decreasing the time interval between grade changes

from 3 to 2 minutes, the total time of the test would be decreased while a higher percent grade increment and therefore physiological workload would be present earlier (see Table 10 for comparison). This shorter treadmill test might enable a higher percentage of subjects to attain their true peak oxygen uptake.

Table 10

Comparison of Treadmill Protocols

Test Protocol Used in Present Study			Proposed New Protocol		
Time (minutes)	Grade (percent)	Speed (m.p.h.)	Time (minutes)	Grade (percent)	Speed (m.p.h.)
0	3	4.5	0	3	4.5
1	3	4.5	1	3	4.5
2	3	4.5	2	6	4.5
3	6	4.5	3	6	4.5
4	6	4.5	4	9	4.5
5	6	4.5	5	9	4.5
6	9	4.5	6	12	4.5
7	9	4.5	7	12	4.5
8	9	4.5	8	15	4.5
9	12	4.5	9	15	4.5
10	12	4.5	10	18	4.5
11	12	4.5	11	18	4.5

As seen in Table 5 all three timed distance runs, the 9 minute run, the 12 minute run and the 1600 metre run were significantly related to peak oxygen uptake. The 9 minute run exhibited the highest correlation with peak oxygen uptake, followed by the 1600 metre run and then the 12 minute run. The high intercorrelations between the three timed distance runs illustrated that the three runs were likely to be measuring similar factors. In the multiple linear regression analysis, the 12 minute run and the 1600 metre run exhibited very low partial correlations when the 9 minute run was partialled out ($r = 0.24385$, and $r = 0.05538$, respectively).

This showed that the variance accounted for by both the 12 minute run and the 1600 metre run that was not in common with the 9 minute run, was not significantly related to peak oxygen uptake. Likewise the variance accounted for by the 12 minute and 1600 metre runs that was in common with the 9 minute run was significantly related to peak oxygen uptake. Consequently, it appeared from these results that the 9 minute run was the most valid of the three tests with respect to the prediction of peak oxygen uptake.

The stepwise multiple linear regression analyses allowed the investigator to examine additional variables in the prediction of peak oxygen uptake.

The variable of percentage body fat exhibited the second highest correlation with peak oxygen uptake when compared to all the other variables including the 3 timed/distance runs. Few studies to date have utilized percentage body fat as a descriptive statistic in the field estimation of cardiorespiratory fitness in children. Consequently it was difficult to discuss both body weight and percentage body fat of the subjects in relation to norm values and to peak oxygen uptake.

In determining percentage body fat, skinfold readings were taken at 4 body sites; triceps, biceps, subscapular and suprailiac. The body density was determined by a regression equation produced by Durnin and Rahaman (1967) and the percentage of body fat was calculated using a formula derived by Siri (1956). Similar body density values were produced when the regression equations derived by Parizkova (1961) were used. However Parizkova (1961) expressed the skinfold thickness results in density units and did not use them to predict body fat percentages. In the theoretical derivation of percentage body fat from measurements of body density there were no special equations available for use with children and adolescents.

This was due mainly to the lack of knowledge of the body composition of children, specifically in regard to the differences in muscle composition, bone and skeleton composition and their relative mass in relation to body fat. It was felt, however, that since the correlation between body density and skinfold thickness was high, the relationship between body density and percentage of fat in children would be very close to the relationship found in adults (Parizkova, 1961). Under this assumption, the investigator of the present study converted body density values into percentage body fat for ease of comparison and meaningfulness.

As seen in the zero-order correlation matrix, the percentage body fat was significantly ($p < .01$) related to body weight ($r = 0.78$), peak oxygen uptake ($r = -0.79$), the 9 minute run ($r = -0.77$), the 12 minute run ($r = -0.75$) and the 1600 metre run ($r = 0.74$). Body weight was also significantly related to peak oxygen uptake ($r = -0.61$), the 9 minute run ($r = -0.55$), the 12 minute run ($r = -0.51$) and the 1600 metre run ($r = 0.47$). Since body weight and percentage body fat were quite highly correlated ($r = 0.78$), accounting for 60% of the variance, they were essentially contributing similar information. The percentage body fat had a consistently higher correlation with peak oxygen uptake and the three timed/distance runs, therefore it was reasonable to choose percentage body fat over body weight as the variable that would contribute more information in predicting peak oxygen uptake and cardiorespiratory endurance.

Krahenbuhl, Pangrazi, Burkett, Schneider and Petersen (1977) and Mayhew and Gifford (1975) found that body fat represented by skinfold measurements contributed significantly to the prediction of maximal oxygen uptake (ml/kg-min) in children.

The negative correlation between peak oxygen uptake and percentage body fat ($r = -0.79$) illustrated that as the percentage of body fat increased,

peak oxygen uptake decreased and as peak oxygen uptake increased, the percentage of body fat decreased. Body weight was also negatively correlated to peak oxygen uptake. This result was in agreement with most of the studies completed using adults as subjects. Cureton, Boileau, Lohman and Misner (1978) stated however that "low maximal oxygen uptake (ml/kg-B.W.·min) and poor distance running performance capability due to excess body fat was not necessarily indicative of poor cardiovascular-respiratory function due to inactivity or pathology" (p. 277). Morrow, Jackson and Bell (1978) reported that the body mass index (B.M.I.) which was a field method of measuring body composition, was related to distance running performance in both the 9 minute and the 12 minute runs for boys and girls ages 10 to 12 years. It was concluded that the "B.M.I. was a more important determinant of distance running performance than age" (Morrow, Jackson and Bell, 1978, p.495). For the female subjects tested in the 12 minute run, the B.M.I. accounted for the negative age-performance relationship, that is, as age increased, running performance decreased. These findings seem to support the work of Cureton, Boileau, Lohman and Misner (1978).

Percentage body fat was not significantly correlated with chrono-logical age or body height but was significantly correlated with body weight. Body weight represented the total body composition of muscle, bone, connective tissue and body fat. Therefore it is reasonable that body weight was found to be significantly correlated with age, height, and percentage body fat. Body weight was also significantly related to peak oxygen uptake and the 3 runs, however chronological age and body height were not.

It has been demonstrated in adults that age was negatively weighted with maximal oxygen uptake showing a decrease in maximal oxygen uptake with

age. In studies on children, age, height and weight have been positively correlated with maximal oxygen uptake and each other. This was in agreement with the literature which stated that maximal oxygen uptake increased proportionately with growth and maturation to a certain age (Astrand and Rodahl, 1970; Bonen, Heyward, Cureton, Boileau and Massey, 1979). In the present study, age was positively correlated with peak oxygen uptake, weight and height, but weight and height were negatively correlated with peak oxygen uptake. Therefore, as the subjects were getting older, their capacity for oxygen uptake was increasing but at the same time as their weight and height increased their capacity for oxygen uptake was decreasing.

It would appear from these results that anthropometric variables play an important role in the oxygen uptake capacity of young girls.

In addition to the correlation matrix, the data was also entered into multiple regression procedures to develop prediction equations of peak oxygen uptake for young girls. These procedures selected predictors from a mathematical rather than a physiological consideration. Comparisons between different predictions were not based only on the size of the correlation coefficients since these could be influenced by the distribution of the data. Instead comparisons were done on the basis of the prediction accuracy as reflected by the standard error of estimate (S.E.E.). An additonal measure of prediction accuracy that was reported in the literature (Bonen, Heyward, Cureton, Boileau and Massey, 1979) was the calculation of the coefficient of variation (C.V. = $\bar{x}$/S.E.E. ×100).

Based on the standard error of estimate, the regression equation shown in Table 6 was the preferred equation for predicting peak oxygen uptake. The prediction accuracy of this equation was similar to those reported in previous studies using different subjects (Bonen, Heyward, Cureton, Boileau and Massey, 1979).

The regression equation as seen in Table 6, slightly underestimated the subjects with high peak oxygen uptake, but overestimated the subjects with low peak oxygen uptake (Table 11).

Table 11

Observed versus Predicted Peak Oxygen Uptake Values
Using the Preferred Regression Equation

	Peak Oxygen Uptake (ml/kg-min)		
Subject No.	Observed Values (ml/kg-min)	Predicted Values (ml/kg-min)	Residual (ml/kg-min)
11	60.050	56.59	3.46
10	57.090	54.46	2.62
1	55.730	54.36	1.37
12	55.720	53.48	2.23
15	55.070	53.10	1.96
18	54.570	53.45	1.01
17	53.140	55.17	-2.03
20	51.700	48.42	3.27
13	51.540	48.10	2.43
8	50.600	57.00	-6.40
19	50.090	51.14	-1.05
14	48.320	45.90	2.42
3	48.000	50.62	-2.62
4	47.400	41.90	5.49
16	46.790	49.70	-2.91
7	41.260	43.95	-2.69
6	40.760	35.50	5.26
9	38.500	41.77	-3.27
2	35.200	34.86	0.34
5	30.010	41.00	-10.99

It is important to note that owing to the small sample, caution should be taken when using the equations to predict peak oxygen uptake, owing to the specificity of the group of subjects. However the results based on this sample demonstrated that the development of regression equations to predict peak oxygen uptake was feasible and the resultant equations were quite accurate.

2. Test-Retest Reliabilities

The second objective of this study was to determine if timed/distance runs were reliable field tests in predicting peak oxygen uptake.

The 12 minute run and the 1600 metre run exhibited significant test-retest reliability correlation coefficients while the 9 minute run did not.

The 1600 metre run had the highest reliability coefficient. During the actual testing of the three timed/distance runs it was observed by the investigator that many of the young female subjects were able to practice the concept of pacing in the 1600 metre run more efficiently and consistently than in the 9 and 12 minute runs. In the 1600 metre run, the subjects knew they had eight laps of a 200 metre track to complete. However in both the 9 and 12 minute timed runs time was intangible, not concrete, and the subjects appeared to find difficulty in relating the time to their running. This ability to relate to concrete information, the distance in the 1600 metre run, versus intangible information, the time in the 9 and 12 minute runs, was reflected in the high reliability of the 1600 metre run. Krahenbuhl, Pangrazi, Petersen, Burkett and Schneider (1978) also reported a high test-retest reliability coefficient for young males and females in the 1600 metre run.

In the 9 minute timed distance run there was a smaller dispersion of scores compared to the 12 minute timed run as noted by the means and standard deviations reported in Trial 1 and 2 (Table 9). It was noted by the investi-

gator that the subjects ran in closer groups in this particular test, there-
fore the individual differences among the subjects did not show as much.
Therefore, because of the smaller dispersal of scores in the 9 minute timed
run, one would expect a lower test-retest reliability. The extra three
minutes run in the 12 minute timed run appeared sufficient to increase the
spread of the subjects in their running performance thereby creating a
larger dispersion of scores attained. This was reflected in the higher test-
retest reliability score.

To date, no studies on the test-retest reliability of the 9 minute run
and the 12 minute run have been performed on young female subjects. Previous
studies (Maksud and Coutts, 1971; Doolittle and Bigbee, 1968) reported high
test-retest reliability correlations for boys 11 to 14 years in the 12 minute
run. The present study reported a reliability correlation of $r = 0.8154$ for
the young female subjects.

The low reliability correlation of the 9 minute run was unexpected. No
studies to date have examined the test-retest reliability of the 9 minute
run in young children. The test-retest reliability correlation is very
sensitive and can be affected by several factors. One of the major factors
affecting this measure was the sample size. In the present study the sample
size was very small. The addition of even one more subject could change the
reliability correlation significantly (Clarke and Clarke, 1970). Reliability
can also be influenced by other extraneous factors such as attitude and
motivation of the subjects, weather conditions, the time of day and equipment.
Many of these factors were difficult to control although efforts were made
during the testing to eliminate as many extraneous factors as possible.

In all 3 time/distance runs there were no significant differences between
the means of Trial 1 and Trial 2 as measured by the t test for correlated
means. This demonstrated that the mean scores of all 3 timed/distance runs
on Trial 1 were reproducible on Trial 2.

Chapter V

SUMMARY AND CONCLUSIONS

A. Summary

Renewed interest in health concerns has been instrumental in the improvement of measurement procedures to evaluate physical fitness status. Cardiorespiratory fitness is a key component of physical fitness and is seen as an important risk reduction measure for coronary heart disease. While maximal oxygen uptake is the most suitable laboratory measure of cardio-respiratory fitness, measurement of maximal oxygen uptake is not feasible for the general public. Although field tests that predict maximal oxygen uptake have been developed for most of the adult population, little research has been initiated in this area for young children, particularly for young females.

The purpose of this study was to investigate:

1. The validity of the 9 minute and 12 minute timed runs and the 1600 metre distance run as predictors of peak oxygen uptake and therefore as measures of cardiorespiratory fitness in girls 8 to 11 years of age.

2. The reliability of the 9 minute and 12 minute timed runs and the 1600 metre distance run as measures of cardiorespiratory endurance.

Sixty female subjects from Crofton House School and St. Patrick's Elementary School, Vancouver, B.C. were tested on the 3 timed distance runs, the 9 minute, 12 minute and 1600 metre runs and a maximal oxygen uptake treadmill test. Anthropometric measures (height, weight, percentage body fat) were also taken. Twenty of the subjects completed all of the testing.

The validity of the 9 minute, the 12 minute and the 1600 metre runs as predictors of peak oxygen uptake and the interrelationships between all the variables were determined by developing a correlation matrix. Stepwise

multiple regression analyses were conducted to select the independent variables (age, height, weight, percentage body fat, 9 minute run, 12 minute run and the 1600 metre run) that best predicted the dependent variable, peak oxygen uptake. The preferred regression equation was:

$$\text{Peak Oxygen Uptake } (ml \cdot kg^{-1} \cdot min^{-1}) = 0.02287 \text{ (9 minute run)} - 0.71217 \text{ (Percent Body Fat)} + 29.788.$$

The reliability of the 9 minute, the 12 minute and the 1600 metre runs was determined by developing test-retest reliability correlation coefficients. The reproducibility of the mean scores of the 9 minute, 12 minute and the 1600 metre runs from Trial 1 to Trial 2 was determined by a t test for correlated means.

B. Conclusions

On the basis of the statistical analyses and within the limitations and delimitations of this study, the following conclusions appear to be justified:

1. With respect to Hypothesis One, the 9 minute and 12 minute timed runs and the 1600 metre distance run showed significant validity correlation coefficients and therefore are valid field measures of cardiorespiratory fitness in girls 8 to 11 years of age.

2. With respect to Hypothesis One, part (a), the 9 minute and 12 minute timed runs and the 1600 metre distance run were significantly related to peak oxygen uptake. Therefore the performance of girls, 8 to 11 years of age, on any of the three specified timed/distance runs could be used to predict peak oxygen uptake.

3. With respect to Hypothesis One, part (b), the results of this study did not support this hypothesis. The 9 minute timed run demonstrated the highest correlation with peak oxygen uptake, followed by the 1600 metre distance run and then the 12 minute timed run.

4. With respect to Hypothesis Two, the results of this study partially support this hypothesis in that both the 12 minute timed run and the 1600 metre distance run exhibited significant test-retest reliability coefficients and therefore are reliable field measures of cardio-respiratory fitness in 8 to 11 year old girls. The 9 minute timed run did not exhibit a significant reliability coefficient.

5. With respect to Sub-Hypothesis One, parts (a), (b) and (c), the results of this study partially support this hypothesis. The 9 minute timed run and the 1600 metre distance run demonstrated the highest inter-correlation, followed by the 12 minute timed run and the 1600 metre distance run and then the 9 minute and 12 minute timed runs.

In conclusion both the 1600 metre distance run and the 12 minute timed run were valid and reliable field tests to predict peak oxygen uptake in girls 8 to 11 years of age. However the 1600 metre distance run demonstrated higher validity and reliability correlation coefficients and therefore would be the preferred field test to measure cardiorespiratory fitness in girls 8 to 11 years of age.

C. Recommendations

Due to the small amount of research in the area of cardiorespiratory fitness in young girls there are many unanswered questions and few definite conclusions concerning their response to cardiorespiratory exercise. The majority of research in the area of cardiorespiratory fitness has been performed on adult males and young boys, therefore it is important that researchers study the female to ensure that the physiological response of a male is not generalized to the female. The research that has been done with young girls has demonstrated that they respond differently than their male counterparts to physical exercise, both quantitatively and qualitatively.

The following areas need to be studied more closely with the young female:

1. The attainment of a true maximal oxygen uptake and the criteria used to determine this, such as, a plateau in oxygen uptake values, heart rate, respiratory rate, respiratory quotient, respiratory exchange ratio, etc.

2. The reliability of maximal oxygen uptake and its relationship to attaining a true maximal oxygen uptake.

3. The treadmill test protocol used to elicit maximal oxygen uptake.

4. The relationship of anthropometric measurements, specifically percentage body fat, with maximal oxygen uptake, running ability and cardio-respiratory fitness. In the prediction of peak oxygen uptake, per-centage body fat played a significant role as demonstrated by its high correlation with peak oxygen uptake and its inclusion in the multiple regression equation (Table 6).

5. The further development of multiple regression equations to predict maximal oxygen uptake. In this study the preferred multiple regression equation for predicting peak oxygen uptake in 8 to 11 year old girls utilized the 9 minute timed run score and percentage body fat. However, since the 1600 metre distance run demonstrated a high degree of test-retest reliability, a multiple regression equation should be developed utilizing it as one of the variables in the equation.

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APPENDIX 1

Consent Forms

THE UNIVERSITY OF BRITISH COLUMBIA

Informed Consent for Participation

in G. McCreight's Physical Education Study

Dear Parent/Guardian:

The students in Grades 3 and 4 at St. Patrick's Elementary School
will be asked to participate in a physical education study conducted by
Geri McCreight, a graduate student in Physical Education at U.B.C. and Dr.
R. Mosher, a professor in the School of Physical Education and Recreation
at U.B.C.

This study will be dealing specifically with the measurement of cardio-
respiratory fitness in young girls. The study will take approximately one
month to complete.

The initial part of the study will be conducted with the cooperation
of the principal and teachers at St. Patrick's Elementary School. Each
student will be asked to perform 5 to 10 minutes of long distance running on
4 separate days during the time period of April 9 to April 15, 1980. These
same students will perform 3 different timed/distance runs (9 minutes, 12
minutes and a 1600 metre run) between April 16 and April 24, 1980. All of
this will occur during the normal class time.

The final stage of this study will be testing conducted at U.B.C.
during the last week of April 1980. During this week each student will
attend 1 testing session at the J.M. Buchanan Fitness and Research Centre
at U.B.C. This testing session will be arranged during school hours.

In the U.B.C. testing session each child will perform a graded exercise
test on a motor-driven treadmill. The exercise test consists of running for
3 minutes at 4.5 m.p.h. at 3% grade followed by increases in the grade every
3 minutes to the point of voluntary fatigue. Heart rate, blood pressure,
oxygen consumption and expired carbon dioxide will be monitored throughout
the test. The height and weight of each child will also be recorded along
with an estimation of per cent body fat.

CONSENT FORM

PLEASE SIGN AND RETURN THIS SHEET TO YOUR CHILD"S TEACHER AS SOON AS

POSSIBLE.

I have read the enclosed consent form and I understand all of the test

procedures that my child will be asked to perform.

(Please SIGN ONE of the following)

I give my consent for _____ to participate in the
(name of child)

testing conducted at St. Patrick's School and U.B.C.

SIGNATURE OF PARENT/GUARDIAN: _____

I do not give my consent for _____ to participate
(name of child)

in the testing conducted at St. Patrick's School and U.B.C.

SIGNATURE OF PARENT/GUARDIAN: _____

DATE: _____

ADDRESS: _____   TELEPHONE: _____

_____

CHILD'S MEDICAL BACKGROUND

Does your child have any history of heart or lung related disease?

_____

Are there any other problems that you think we should know about?

_____

THE UNIVERSITY OF BRITISH COLUMBIA

Informed Consent for Participation
in G. McCreight's Physical Education Study

Dear Parent/Guardian:

The students in Grade 4 and 5 at Crofton House School will be asked
to participate in a physical education study conducted by Geri McCreight,
a graduate student in Physical Education at U.B.C. and Dr. R. Mosher, a
professor in the School of Physical Education and Recreation at U.B.C.

This study will be dealing specifically with the measurement of
cardiorespiratory fitness in young girls. The study will take approximately
one month to complete.

The initial part of the study will be conducted with the cooperation
of Miss Addison and the physical education teachers at Crofton House School.
Each student will be asked to perform 5 to 10 minutes of long distance
running on 4 separate days during the week of May 28 to June 1, 1979.
During the weeks of June 4 to June 15, 1979, these same students will
perform 3 different timed/distance runs (9 minute, 12 minute, and a 1600
metre run). All of this will occur during the normal Physical Education
class time at Crofton House.

The final stage of this study will be testing conducted at U.B.C. in
the last 2 weeks of June (18-29), 1979. During this 2 week period, each
student will be asked to attend 1 testing session lasting approximately .
1 hour at the J.M. Buchanan Fitness and Research Centre at U.B.C. This
testing session will be arranged after school hours at both the student's
and parent's convenience. An attempt will be made to test students in
groups of twos and threes. Transportation will be available for those who
need it.

In the U.B.C. testing session each child will perform a graded
exercise test on a motor-driven treadmill. The exercise consists of running
for 3 minutes at 4.5 m.p.h. at 3 per cent grade followed by increases in
the grade every 3 minutes to the point of voluntary fatigue. Heart rate,
blood pressure, oxygen consumption and expired carbon dioxide will be
monitored throughout the test. The height and weight of each child will

CONSENT FORM

PLEASE SIGN AND RETURN THIS SHEET TO YOUR CHILD'S TEACHER AS SOON AS
POSSIBLE.

I have read the enclosed consent form and I understand all of the
test procedures that my child will be asked to perform.
(Please SIGN ONE of the following)

I give my consent for _____ to participate in
                              (name of child)

the testing conducted at Crofton House and the testing session at U.B.C.

SIGNATURE OF PARENT/GUARDIAN: _____

I do not give my consent for _____ to participate
                              (name of child)

in the testing conducted at Crofton House and the testing session at U.B.C.

SIGNATURE OF PARENT/GUARDIAN: _____

DATE: _____

ADDRESS: _____ TELEPHONE: _____

_____

CHILD'S MEDICAL BACKGROUND

Does your child have any history of heart or lung related disease?

_____

Are there any other problems that you think we should know about?

_____

APPENDIX 2

TIMED AND DISTANCE RUN DATA SHEETS

Group 1

Test: _____

Date: _____

Tester's Name: _____

School: _____

Individual Code	Laps Completed															Additional Distance
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
11	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
21	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
22	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
23	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
25	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
26	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
27	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
29	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____

TIMED AND DISTANCE RUN DATA SHEETS

Group 1   Tester's Name: _____

Test: _____   School: _____

Date: _____

Individual Code	Laps Completed															Additional Distance
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
32	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
33	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
34	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
35	1	2	3	4	5	6	7	8	9	10	11	12.	13	14	15	1 + _____
36	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
37	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
38	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
39	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
40	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
41	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
42	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
43	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
44	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
45	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
46	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
47	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
49	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
50	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
51	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
54	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
55	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
56	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
57	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
58	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
59	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____
60	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	+ _____

ANTHROPOMETRIC DATA SHEET

Individual Subject Code: _____

Name: _____   Birthdate: _____

School: _____

Group: _____

Date: _____

Heigth: _____ cm.

Weight: _____ kg.

Skinfolds: Trial 1   Trial 2   Trial 3   Final

  Triceps (mm)   _____   _____   _____   _____

  Biceps (mm)   _____   _____   _____   _____

  Subscapular (mm) _____   _____   _____   _____

  Suprailiac (mm) _____   _____   _____   _____

                                           Total = _____