THE RELATIONSHIP BETWEEN 3-MILE RUN PERFORMANCE AND MAXIMUM OXYGEN UPTAKE IN COLLEGE-AGE STUDENTS

By

LUANN ZIMMICK

Bachelor of Science

Oral Roberts University

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Thesis Approved:

Sandra K. Gangstead
Thesis Adviser

Betty M. Edgley

Paul Paulin

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

A long-held goal of health and physical education has been to enhance the development of total physical fitness among individuals. There has been increasing recognition that cardiorespiratory fitness, the ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscle (deVries, 1966), is a principal component in what professionals deem to define as physical fitness. Physical fitness has been defined as the total functional capacity to perform some specified task requiring muscular effort (deVries, 1966).

Saltin (1969) stated that an individual's capacity to perform prolonged heavy exercise is increased by training and this improvement is the result of two physiological changes within the body. These are: (1) improvement in the rate at which oxygen can be consumed (oxygen uptake) and (2) improvement in heart rate and the quantity of blood ejected with each stroke of the heart (cardiac output). Research has supported the supposition that increases in cardiac output correspond directly with increases in maximal oxygen uptake (Astrand & Rodahl, 1970; Saltin, 1969). Kasch, Phillips, Carter, and Boyer (1973) also stated that training and physical conditioning programs can make marked improvement in endurance capacity, often expressed in maximum oxygen uptake (maximum VO_2).

Given the profundance of literature supporting physiological changes of maximum oxygen uptake and cardiac output as a result of training, it is logical that physical education programs focus on developing these attributes. Consequently, it is not surprising that an important aspect in the determination of effective physical education programs rests upon both formative and summative evaluations of these physiological capacities conducted vis-a-vis field-based and formal laboratory physical fitness assessments.

Several means of assessing maximum VO_2 have been found to be reliable. Many of these are clinical in nature. They are limited in application, requiring one or more trained administrators with sophisticated equipment and the devotion of a considerable length of time to the testing of each individual. Some tests, such as the maximum treadmill protocols, require an all-out maximal performance. Others require varying degrees of submaximal effort such as submaximal treadmill protocols, bicycle protocols, or step tests.

Within laboratory and field test protocols there are noticeable differences regarding the criterion measure used. Some laboratory procedures estimate maximum VO_2 based upon the maximum heart rate as a result of workload. Others actually measure oxygen uptake either during or following an exercise period. Perhaps the most important of these is the maximum oxygen uptake test (maximum VO_2). The use of maximum VO_2 as a valid, objective measure of physical fitness is well supported in the literature (Astrand, 1956; Falls, Ismail, & MacLeod, 1966; Glassford, Baycroft, Sedgwick, & McNab, 1965; Mitchell, Sproule, & Chapman, 1958; Taylor, Buskirk, & Henschel, 1955). It is accepted that maximum work capacity is one of the most objective measures of physical fitness, as reflected by the capacity for enduring work (Astrand & Rodahl, 1970; Taylor et al., 1955). Astrand, Bengt, and Saltin (1961), Cureton (1951), and deVries (1966) have indicated that maximum VO_2 is superior to any other single item for evaluating physical fitness.

Obviously, sustained tasks such as running require an increased blood flow to the working muscles because of the increased oxygen demands from active muscle tissue. Measurement of this oxygen demand and an accurate assessment of maximum oxygen uptake cannot be done practically in a field situation. The protocol requires high levels of motivation on the part of the subject, since maximum effort must be exerted during the testing. As a result, this method is not feasible for testing large segments of the population. This has led researchers to the development of field tests which serve as indicators of cardiorespiratory fitness.

Much field-based research has been done noting the time at which subjects run various distances (600-yard, 1-mile, and 3-mile runs) (Falls et al., 1966; Doolittle & Bigbee, 1968; Ribisl & Kachadorian, 1969; Wiley & Shaver, 1972). Other researchers have collected data regarding total distance covered within a prescribed time unit, such as the 12-minute run (Maksud & Coutts, 1971; Cooper, 1968; Dorociak, 1981). The results of such investigations indicate that as the distance is increased, the correlation between the performance time and maximum VO_2 becomes stronger. Logically, it would appear that longer distances (beyond one and one-half miles) would perhaps more accurately assess cardiorespiratory fitness situations.

To date, few researchers have utilized the 3-mile run field test as an indicator of cardiorespiratory fitness. The limited evidence supporting the 3-mile run performance time as a valid measure of fitness indicates a need to establish its relationship to physiological work capacity. The paucity of validation efforts regarding the 3-mile run provided the impetus for this study.

Statement of the Problem

The purpose of this study was to determine the relationship between maximum oxygen uptake and 3-mile run performance in college adults. Two subproblems of the study were: (1) to determine the relationship of various physiological measures (height, weight, percent body fat, resting and maximum heart rate, resting and maximum systolic blood pressure, and resting and maximum diastolic blood pressure) between maximum O_2 uptake and 3-mile run performance; and (2) to identify notable differences, if any, between male subject and female subject performance correlates on the various dependent variables.

Delimitations

The study was delimited to:

1. A sample of 34 college adults, ages 18-21, from Oral Roberts University in Tulsa, Oklahoma.

2. Maximum oxygen uptake levels as measured by the "Bruce Treadmill Test" (Bruce, 1971).

Limitations

The results of the study may have been affected by the following limitations:

1. Only one trial per subject was allowed during the treadmill and 3-mile run.

2. The "Bruce Treadmill Protocol" was used without gas analysis.

Assumptions

The following assumptions were made:

1. The "Bruce Treadmill Protocol" was a valid test for the assessment of maximum VO_2.

2. The subjects involved were medically healthy within "normal" ranges for their age groups.

3. The subjects were highly motivated.

Hypotheses

The following hypotheses were tested at the .05 level of significance:

1. It was hypothesized that there would be no significant relationship between maximum oxygen uptake and 3-mile run performance.

2. It was hypothesized that there would be no significant relationship between or among the specified physiological measures of height, weight, percent body fat, resting and maximum heart rate, resting and maximum systolic blood pressure, and resting and maximum diastolic blood pressure. Nor would there be any significant relationship between any pairwise comparison of these to maximum oxygen uptake or 3-mile run performance.

3. It was hypothesized that there would be no notable differences between male subject and female subject performance correlates on the various dependent variables.

Definitions

For the purposes of this study, the following definitions were separated into two categories: conceptual and functional. Conceptual definitions include those terms defined by authorities. The functional definitions consisted of those terms which held special meaning for this study.

Conceptual Definitions

Aerobic Capacity. Aerobic capacity is an individual's ability for enduring work (Matthews and Fox, 1976).

Cardiac Output. Cardiac output is the primary indicator of the functional capacity of the circulation to meet the demands of physical activity, determined by the rate of pumping (heart rate) and by the quantity of blood ejected with each stroke (stroke volume), resulting in the volume of blood pumped per minute into the blood vessels (McArdle, Katch, & Katch, 1981).

Cardiorespiratory Fitness. Cardiorespiratory fitness is the ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscles, allowing activities that involve large muscle masses to be performed over long periods of time (Matthews and Fox, 1976).

Maximum Oxygen Uptake (max VO_2). Maximum oxygen uptake is the maximal rate at which oxygen can be consumed per minute; the power or capacity of the aerobic or oxygen system (Matthews and Fox, 1976).

ml/kg/min. ml/kg/min is milliliters per kilogram per minute--the measurement of max VO_2 - the milliliters of oxygen that can be taken up per kilogram of body weight each minute (deVries, 1966).

Physical Fitness. Physical fitness is work capacity; the total functional capacity to perform some specified task requiring muscular effort (Matthews and Fox, 1976).

Functional Definitions

Maximum Oxygen Uptake. Maximum oxygen uptake is the rate at which oxygen is consumed (ml/kg/min) as estimated by time in seconds measured by the "Bruce Treadmill Protocol."

Resting Blood Pressure. Resting blood pressure is the outward pushing force of the blood measured in milliliters of mercury over the brachial artery when the subject is standing on the treadmill.

Resting Heart Rate. Resting heart rate is the beats per minute of the heart measured when the subject is standing on the treadmill.

Skinfold. A skinfold consists of a "pinch" of skin composed of two layers of skin and an intervening layer of fat.

3-Mile Run Performance. The 3-mile run performance is the time in seconds to complete three miles on a one-sixth of a mile, slightly banked, indoor track.

Research Design and Statistical Analyses

The research design was correlational. The Pearson-Product-Moment Correlation was the statistical analyses used for pairwise comparison among the entire group between all dependent variables. The Spearman Rank-Order correlation was implemented for the pairwise analyses of the data using separate groups (male and female).

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of related literature in this chapter consists of four major sections. These sections are: (1) studies concerning the 600-yard run, (2) studies concerning the 12-minute run, (3) studies concerning other field tests of running performance, and (4) a summary.

Studies Concerning the 600-Yard Run

Much research has been done comparing oxygen uptake to running performance. Several studies have determined the correlation between maximum VO_2 expressed in ml/kg/min and the 600-yard run. Using 87 male Purdue University staff and faculty members between the ages of 13 and 58 years, Falls et al. (1966) reported a correlation coefficient of r=-.64 between the two tests. The subjects were participants in a five-month fitness program. In order to measure maximum VO_2, each subject rode a bicycle ergometer at a pedal frequency of 50 rpm timed by a metronome. For the first two minutes, the subject rode at a work load of 150 kpm/min. Each minute thereafter the work load was increased by 150 kpm. The subject continued the ride until exhaustion. The 600-yard run was administered according to the directions in the AAHPER Youth Fitness Test Manual (American Association for Health, Physical Education, and Recreation, 1962).

Doolittle and Bigbee (1968) compared running scores of nine randomly selected, ninth-grade males of Luther Burbank Junior High School, Burbank, California. The maximum oxygen intake phase of the study was conducted in the Human Performance Laboratory at California State College, Los Angeles. This was completed on a Monarch bicycle ergometer utilizing the following protocol:

> 3 min. - no load - 20 kph
> 5 min. - rest (on bicycle)
> 3 min. - no load - 20 kph
> 3 min. - 1 kilo - 20 kph
> 3 min. - 2 kilos - 20 kph
> All-out - 2 kilos - 'all-out' sprint
> (Doolittle and Bigbee, 1968, p. 493).

The 600-yard run was administered on a quarter-mile grass track. The Spearman Rank-Difference Correlation Coefficient reported between the variables of interest was $r=-.62$.

Metz and Alexander (1970) also investigated the relationship between maximum VO_2 and 600-yard run performance. Subjects were two groups of boys ranging in age from 12 to 15 years. Group I consisted of 30 12 to 13-year old boys, and Group II consisted of 30 14 to 15-year-old boys. All 60 boys were randomly selected from the required physical education classes at the University of Minnesota Campus High School. Within a four-week period, each subject was administered the 600-yard run according to the <u>AAHPER Youth Fitness Test Manual</u> (AAHPER, 1962) and a series of treadmill tests designed to elicit maximum VO_2 measures. On the first laboratory visit, the subject walked on the treadmill at 3.5 mph and a 10% grade for 10 minutes. Following a sitting period of four minutes, the subject ran at either a speed of 5 mph (12 to 13-year-olds) or 6 mph (14 to 15-year-olds) for 3 minutes, 45 seconds. The first level of work was selected to allow the subject to finish without undue fatigue. During the second test session, the entire procedure was repeated with the grade level during the run being increased by 2.5%. This intermittent work procedure was continued until two successive grade levels yielded oxygen uptake values which were different by less than 2.1 ml/kg/min. The larger of these two values was taken to be the maximum VO_2. The correlation coefficients found were r=-.66 for 13 to 14-year-old boys and r=-.27 for 14 to 15-year-old boys. An explanation of the differences in correlation coefficients may be attributed to lower motivation (excessive walking) from certain 14 to 15-year-old subjects. One might further suggest that these differences are related to growth and development factors due to the onset of puberty.

These findings suggest that distance runs of short duration (such as 600 yards) measure aerobic capacity to some extent, but it appears that other factors such as running speed and general athletic skill are also measured during these testing procedures.

Studies Concerning the 12-Minute Run

The relationship between maximum VO_2 and 12-minute run performance has also been investigated. Maksud and Coutts (1971) used 80 boys between the ages of 11 and 14 from the inner-city area of Milwaukee, Wisconsin as subjects. The 12-minute run was performed on a 140-yard indoor track. At the end of 12 minutes, the number of laps, to the nearest one-quarter lap, was recorded. The subjects were also tested on a treadmill under laboratory conditions to determine maximum VO_2 levels. Each work load consisted of running on the treadmill for three minutes at 6 mph. The grade was increased by 2-1/2% on subsequent work loads until the oxygen uptake appeared to plateau, or it was apparent that the subject could not tolerate further increases in grade. A correlation of r=.65 was noted.

Doolittle and Bigbee (1968), in their study of ninth grade boys, reported a correlation of r=.90 for the two variables. The 12-minute run performance test was also performed on a quarter-mile grass track.

Cooper (1968) evaluated 115 U.S. Air Force male officers and airmen, aged 17-52, on a 12-minute field performance test and a treadmill maximal oxygen uptake test. The 12-minute performance test was accomplished first on all subjects using a flat, accurately measured 1.0 mile, hard-surfaced course. The interval between the 12-minute test and the treadmill evaluation was no longer than three days. In the treadmill evaluation, the subjects were started at 4 miles/hour on a 4% grade up to 6 miles/hour on a 6% grade, according to the initial level of fitness of the subject. After the initial run, the speed was increased by half, or 1 mile/hour, and the grade by 0.5%, or 1%. Each test consisted of several three-minute runs separated by ten-minute rest periods. An attempt was made to exhaust all subjects within three or four three-minute run periods. The correlations coefficient for this data was r=.90.

Kearney and Byrnes (1974) also investigated the relationship between the same variables among college adults. The population included representatives from three diverse ability subgroups of college undergraduate males. These were: (1) nonathletic students, (2) physical education majors, and (3) varsity cross-country runners. The "Bicycle Ergometer Test," as described by Astrand and Rodahl (1970), was the first test administered to each subject. The distance covered during the 12-minute run was recorded to the nearest one-eighth of a lap on a 440-yard all-weather track. Within the composite group (N=34), the relationship between estimated oxygen uptake and 12-minute run performance was reported as r=.63.

Forty-eight females served as the subjects (17 beginning joggers, 19 intermediate joggers, and 12 track team members) in a study completed by Dorociak (1981). The following significant correlation coefficients were obtained between maximum VO_2 and the 12-minute run performance: (1) beginning joggers, r=.77 ($\underline{p} < .05$); (2) intermediate joggers, r=.68 ($\underline{p} < .01$); and (3) track runners, r=.65 ($\underline{p} < .05$). When the data from all three groups were pooled, the correlation between maximum VO_2 and the 12-minute run was r=.89 ($\underline{p} < .01$).

In another investigation involving college women, Taylor (1980) tested 22 female subject volunteers. The 12-minute run was significantly associated with the actually determined VO_2 maximum (r=.47, $\underline{p} < .05$), but below the generally acceptable level indicative of strong test validity.

Running tests of longer distances such as the 12-minute run tend to show significant relationships with maximal oxygen uptake. This is particularly true when relatively compared with the mixed and lower trends in relationships noted when maximum VO_2 and performance on shorter running events are correlated.

Other Studies Concerning Field Tests

Based on data from 11 trained college-age males, Ribisl and Kachadorian (1969) obtained correlation coefficients between a treadmill test of maximum VO_2 and performance-based field tests. The coefficients were r=-.67 and r=-.85 for the 1-mile and 2-mile runs, respectively.

Getchell, Kirkendall, and Rabbins (1977) conducted a study to evaluate the predictability of VO_2 maximum from a 1.5-mile performance of young adult women joggers. Twenty-one healthy women ($\overline{X}$ = 20.1 years of age) volunteered as subjects. They were experienced joggers, with some of the group having just completed a ten-week conditioning course with jogging as the main mode of activity. A continuous, multigraded treadmill test was used to assess the maximal oxygen uptake. The 1.5-mile run was conducted on a 220-yard, indoor dirt track within five days after the treadmill test. The results indicated that VO_2 maximum expressed as ml/kg/min provided a correlation of r=.92 with the running times for 1.5 miles.

In another investigation by Wiley and Shaver (1972), a group of 35 untrained male volunteers, 18 to 25 years of age, was tested on 1/4, 1, 2, and 3-mile runs and for maximum oxygen uptake. The subjects were enrolled in the Physical Education Basic Instruction Program at the University of South Alabama. None of the subjects were trained endurance runners. The subjects performed the 440-yard run, followed by the 1-mile, then the 2-mile, and finally the 3-mile run. At least one day of rest was given between performances. A treadmill was used to determine maximum VO_2. The subjects ran at 7 mph, 8.6% grade, and were instructed to run for as long as possible. Trends were noted by the investigators in the correlations between running times and maximum oxygen uptake. Maximum VO_2 tended to increase as the running distances increased: 440 yards, r=-.22; 1 mile, r=-.29; 2 miles, r=-.47; and 3 miles, r=-.43. These trends were in agreement with Ribisl and Kachadorian (1969). Only the correlations between maximum VO_2 and the 2-mile run (r=-.47), and the 3-mile run (r=-.43) were significant at the .05 level.

This trend was again shown when Kearney and Byrnes (1974) studied the relationship between running performance and predicted maximum VO_2 among male physical education majors. All field tests were completed on a 440-yard, all-weather track. Correlation coefficients between maximum VO_2 and the field test were as follows: 1/2-mile, r=-.30; 1-mile, r=-.59; and 12-minute run, r=.64.

Contradiction of results among similar studies regarding the relationship between various field test measures and clinical observations abound. A number of factors, such as level of skill and training in running and motivation, may account for such variability.

Summary

The review of literature indicated contradictions of results among similar studies regarding the relationship between various field test measures and clinical observations. Findings in the 600-yard run investigations suggested that distance runs of short duration (such as 600 yards) measure aerobic capacity to some extent, but it appears that other factors are also measured during these testing procedures, such as: (1) growth and development factors due to the onset of puberty, (2) running speed, (3) general athletic skill, and (4) motivation.

Running tests of longer distances such as the 12-minute run tend to show significant relationships with maximal oxygen uptake. This is particularly true when relatively compared with the mixed and lower trends in relationships noted when maximum VO_2 and performance on shorter running events are correlated.

Contradictions of results among similar studies abound. A number of factors may account for such variability: (1) level of running skill, (2) level of training in running, (3) motivation, (4) use of different testing procedures to determine maximum VO_2, and (5) use of different testing procedures in determining running performance. The procedures and data analyses of several studies may have led to variability in correlational findings. In some studies, very low numbers of subjects were used; in other studies, researchers investigated highly trained athletes. In these studies, the ranges of performances on field and laboratory tests were somewhat limited. Such truncation of the range may have led to somewhat spurious correlation coefficients.

CHAPTER III

PROCEDURES

The procedures utilized in the present study are described in this chapter. The chapter is categorized into two sections: subjects and instrumentation. The subjects section consists of discussion regarding the selection of subjects. The instrumentation section includes the 3-mile run, the "Bruce Treadmill Test," (Bruce, 1971), and other testing procedures conducted during the study.

Subjects

A total of 34 undergraduate students from Oral Roberts University, Tulsa, Oklahoma, volunteered as subjects for determining the relationship between the 3-mile run and maximum VO_2. Of the 34 subjects, 17 were males and 17 were females, ranging in age from 18-21. All the subjects were involved in an aerobics fitness program and were enrolled in the Health Fitness Class required by the University. The 3-mile run field test was administered initially to all subjects. The elapsed time between the 3-mile run and the "Bruce Treadmill Test" (Bruce, 1971) was not less than one week. The subjects were advised not to eat for three hours prior to testing times. Informed written consent to participate in the study was obtained prior to administration of the "3-Mile Run Test" (Appendix A). A medical release form (Appendix B) was completed by each subject and subsequently evaluated by the principal investigator prior to the administration of the "Bruce Treadmill Test" (Bruce, 1971).

Instrumentation

3-Mile Run

An indoor track, one-sixth of a mile in length with slight banking, was utilized by the subjects during the run. Outside environmental elements such as wind and temperature were therefore uniform for each subject. The subjects were divided into two testing groups on the basis of gender. Each male subject was assigned a female partner. The male subjects ran during the first administration period. Each female subject observed and recorded the laps completed by her male partner during the actual testing time. The same procedure was utilized when the female subjects were tested.

To start the run, the investigator sounded a horn. A large, overhead digital clock, located at the finish line, was started simultaneously. The observing partner recorded lap times for his/her partner as each lap was completed. The subjects were able to see the time elapsed on the overhead clock as each lap was completed. The observing partners noted the finishing time to the nearest second and the time was recorded by the investigator. Upon completion of the run, the subjects were instructed to continue jogging or walking for at least one lap in order to cool down and regain normal breathing rates.

The Bruce Treadmill Test

All subjects performed an exercise test using the Bruce (1971) protocol on a calibrated Quinton Model 24-72 treadmill. (For speeds and gradations utilized in the study, see Appendix C.) The testing sessions were conducted in the reasonable environmental stability of the Human Performance Laboratory at Oral Roberts University. Subjects were instructed to maintain current daily activity and dietary habits, but not to eat for three hours prior to testing. Upon entering the laboratory, subjects were taken into a preparatory room. Height, weight, and skinfold measures were obtained. The treadmill testing procedures were explained as each subject was hooked up to a 5-lead electrocardiogram (EKG) cord. The subject then went into the treadmill testing room and stood on the treadmill. The EKG cord was plugged into a Hewlett-Packard 15008 Electriocardiograph and standing resting heart rate was recorded after a period of three minutes. Next, the tester measured resting blood pressure at the brachial artery of the subject's right arm. Each subject was then instructed to hold onto the side railings and to straddle the treadmill belt, which was started and set at the appropriate speed (1.7 mph) and elevation (10% grade) for stage I. Performance time started when the subject let go of the side railings and began to walk on the treadmill.

Every three minutes, the speed and elevation of the treadmill was increased (Appendix C), until the subject reached exhaustion and the test was terminated. Heart rate and EKG were monitored throughout the test. Each subject was encouraged verbally throughout the test to continue until volitional exhaustion. The subject was instructed to grab the side railings and straddle the treadmill when total exhaustion was reached. The time clock and treadmill was stopped immediately. Duration time of the performance was recorded by the investigator. The belt slowed to a stop and the elevation was quickly lowered by the research assistant. Each subject immediately laid down on the treadmill belt and maximum blood pressure was recorded. Each subject remained in the supine position for several minutes, then was allowed to sit up on the edge of the treadmill until each was able to comfortably stand. Each subject was then allowed to walk around the room until a feeling of comfortable recovery was expressed. Upon examination by the investigator, each subject was allowed to exit the testing area. Maximum VO_2 was estimated from duration of performance time based upon normative data (Appendix D) reported by Bruce (1971).

Skinfold Measurements

Skinfolds were measured using the Harpenden caliper with a pressure of 10 g/mm^2. All measurements were taken to the nearest 0.5 mm. On the dominant side of the body, the fold was lifted with the thumb and index finger, followed by the application of the caliper at a point 1.0 to 1.5 centimeters below the fingers. All readings were taken within five seconds from the time of caliper contact. The following skinfolds were measured according to the locations cited by Golding, Myers, and Sinning (1982). Percent fat estimates for men used the sum of these six skinfolds and percent fat estimates for women included the six skinfolds cited below, with the exception of the chest skinfold.

1. Chest (pectoral): A diagonal fold on the pectoral line midway between the axillary fold and the nipple.

2. Abdomen (umbilicus): A vertical fold approximately one inch to the right of the umbilicus.

3. Hip (ilium or suprailium): A diagonal fold just above the crest of the ilium (highest peak on the side of the pelvic girdle on the mid-axillary line).

4. Arm (tricep): A vertical fold on the back of the upper arm, midway between the shoulder and elbow joints.

5. Back (scapula, subscapula): A diagonal fold just below the inferior angle of the scapula.

6. Thigh (leg): A vertical fold on the front of the thigh, midway between the groin line and the tip of the patella.

Resting Blood Pressure

The subject stood upright on the treadmill. The right arm was relaxed and comfortable at the subject's side. The subject was allowed to relax for a few minutes in this position. Conversation was discouraged. The blood pressure was measured with a sphygmomanometer and a stethoscope. A wide, adjustable cuff was placed around the subject's upper right arm, approximately even with the heart level. Air was pumped into this cuff, which then expanded and pressed against the arm to close off the brachial artery, which ran along the inside of the arm. Once this artery had been closed off, air was slowly released from the cuff and the tester listened for the moment at which the resumption of blood flow could be heard. This resumed flow was characterized by a distinctive sound (systolic pressure). The pressure in the cuff was further reduced until blood ran freely through the artery. This point is characterized by the complete disappearance of sound (diastolic pressure). Systolic pressure and diastolic pressure was recorded in millimeters of mercury (mmhg), as indicated on the sphygomomanometer scale.

CHAPTER IV

ANALYSIS OF DATA

In the preceding chapter, the procedures for data collection were described. This chapter has been organized to facilitate discussion of the statistical data relative to the previously stated hypotheses. The following sections are included in this chapter: (1) analysis of data according to hypotheses and (2) discussion of results.

Analysis of Data According to Hypotheses

Three hypotheses were evaluated in this investigation. The following is a statistical response to the hypotheses which were tested at the .05 level of significance:

Hypothesis 1

Hypothesis 1 stated that there would be no significant relationship between maximum oxygen uptake and 3-mile run performance. Means for maximum VO_2 and 3-mile run were $\bar{X}$ = 47.03 ml/kg/min and $\bar{X}$ = 1482.06 (24.70 min), respectively. An analysis of the Pearson Product-Moment Correlation between maximum VO_2 and 3-mile run performance, $r=-.91$, indicated a significant relationship ($p < .001$) (Table I). Therefore, the null hypothesis was rejected.

TABLE I

CORRELATIONAL MATRIX OF DATA
(N=34)

	1	2	3	4	5	6	7	8	9	10	11	12
Est. Max. VO_2	--	1.00	-.91***	.55***	.29*	.89***	-.13	.34*	.35*	.25	.51***	-.23
Treadmill		--	-.91***	.55***	.29*	.89***	-.13	.34*	.35*	.25	.51***	-.23
3-Mile Run			--	-.53***	-.20	.85***	.15	-.25	-.38*	-.26	-.46***	.22
Height				--	.79***	-.59***	.05	.24	.40**	.11	.57***	-.25
Weight					--	-.27	.03	.16	.43***	.08	.51***	-.17
Skinfold						--	.10	-.28	-.27	-.16	-.60***	.39*
Resting HR							--	.54***	.04	.01	.05	.25
Max. HR								--	.30*	.09	.14	.01
Resting SBP									--	.38*	.23	-.27
Resting DBP										--	.19	-.06
Max. SBP											--	-.20
Max. DBP												--

*$p < .05$

**$p < .01$

***$p < .005$

Hypothesis 2

Hypothesis 2 stated that there would be no significant relationship between or among the specified physiological measures of height, weight, percent fat, resting and maximum heart rate, resting and maximum systolic blood pressure, and resting and maximum diastolic blood pressure. Nor would there be any significant relationship between any pairwise comparison of these measures with maximum oxygen uptake or 3-mile run.

Mean performance scores and standard deviations are reported in Table II. Pearson Product-Moment Correlations are indicated in Table I, the correlational matrix computed for all pairwise comparisons across male and female subjects. Significant pairwise relationships and respective correlation coefficients among the various physiological measures are noted (Table III).

Hypothesis 3

Hypothesis 3 stated that there would be no notable differences between male subject and female subject performance correlates on the various dependent variables. A Spearman Rank-Order Correlation was utilized to examine the unique pairing of these dependent variables. Tables IV and V display the resultant correlation matrices from these analyses. The significant relationships that showed notable differences between male subject and female subject performance correlates on the various dependent variables are noted in Tables VI and VII.

Discussion of Results

This section has been organized to include a general discussion

TABLE II

MEAN PERFORMANCE SCORES AND STANDARD DEVIATIONS

		Total Group (N=34)	Males (N=17)	Females (N=17)
Est. Max VO_2	$\bar{X}$	47.03	54.18	39.89
(ml/kg/min)	SD	8.60	3.00	5.93
Treadmill Time	$\bar{X}$	797.53	901.41	693.65
(sec)	SD	133.57	51.63	105.82
3-Mile Run	$\bar{X}$	1482.06	1262.71	1701.41
(sec)	SD	305.33	122.27	274.01
Skinfold	$\bar{X}$	14.62	7.73	21.51
(% fat)	SD	7.76	2.01	4.40
Height	$\bar{X}$	68.91	71.47	66.35
(in)	SD	3.94	2.70	3.28
Weight	$\bar{X}$	150.71	161.47	139.94
(lbs)	SD	21.85	16.52	21.56
Resting HR	$\bar{X}$	84.47	83.47	85.47
(bpm)	SD	14.91	14.61	15.59
Max HR	$\bar{X}$	199.27	201.77	196.77
(bpm)	SD	8.45	7.69	8.65
Resting SBP	$\bar{X}$	118.32	122.29	114.35
(mm Hg)	SD	9.65	9.33	8.46
Resting DBP	$\bar{X}$	77.24	78.94	75.53
(mm Hg)	SD	8.67	8.95	8.29
Max SBP	$\bar{X}$	191.47	207.59	175.35
(mm Hg)	SD	26.13	22.85	18.29
Max DBP	$\bar{X}$	58.06	52.71	63.41
(mm Hg)	SD	14.06	12.98	13.35

TABLE III

SIGNIFICANT RELATIONSHIPS IN TOTAL GROUP DATA

Dependent Variables	r*
max VO_2 and 3-mile run	-.91
max VO_2 and height	.55
max VO_2 and weight	.29
max VO_2 and skinfold	.89
max VO_2 and max HR	.34
max VO_2 and resting SBP	.35
max VO_2 and max SBP	.51
treadmill time and 3-mile run	-.91
treadmill time and height	.55
treadmill time and weight	.29
treadmill time and skinfold	.89
treadmill time and max HR	.34
treadmill time and resting SBP	.35
treadmill time and max SBP	.51
3-mile run and height	-.53
3-mile run and skinfold	.85
3-mile run and resting SBP	-.38
3-mile run and max SBP	-.46
height and weight	.79
height and skinfold	-.59
height and resting SBP	.40
height and max SBP	-.59
weight and resting SBP	.43
weight and max SBP	.51
skinfold and max SBP	-.60
resting HR and max HR	.54
max HR and resting SBP	.30
resting SBP and resting DBP	.38

*p < .05

TABLE IV

CORRELATIONAL MATRIX OF MALE DATA
(N=17)

	1	2	3	4	5	6	7	8	9	10	11	12
Est. Max. VO_2	--	1.00	-.66**	.12	.22	-.33	-.19	-.26	-.08	.07	.47*	-.05
Treadmill		--	-.66**	.12	.22	-.33	-.19	-.26	-.08	.07	.47*	-.05
3-Mile Run			--	-.10	-.10	.26	.15	.38	-.32	.01	-.02	.25
Height				--	.78***	.19	-.19	.33	.39	-.04	.30	-.20
Weight					--	.33	-.21	.13	.43*	-.19	.27	.00
Skinfold						--	.03	.41*	.35	-.25	-.49*	.53*
Resting HR							--	.58**	.18	.29	-.11	.52*
Max. HR								--	.21	.13	-.07	.34
Resting SBP									--	.23	-.17	.14
Resting DBP										--	.36	.15
Max. SBP											--	-.07
Max. DBP												--

*$p < .05$

**$p < .01$

***$p < .005$

TABLE V

CORRELATIONAL MATRIX OF FEMALE DATA
(N=17)

	1	2	3	4	5	6	7	8	9	10	11	12
Est. Max VO_2	--	1.00	-.85***	.04	-.38	-.66**	-.06	.35	.21	.20	-.17	.18
Treadmill		--	-.85***	.04	-.38	-.66**	-.06	.35	.21	.20	-.17	.18
3-Mile Run			--	-.05	.39	.63**	.35	.08	-.12	-.21	.04	-.25
Height				--	.75***	-.08	.24	.04	.28	.02	.25	.09
Weight					--	.51*	.33	-.02	.28	.06	.36	.09
Skinfold						--	.09	-.21	.19	.24	.23	-.04
Resting HR							--	.64**	.13	-.18	-.10	.06
Max. HR								--	.19	.05	-.18	.00
Resting SBP									--	.23	.08	-.50*
Resting DBP										--	-.16	-.07
Max. SBP											--	.38
Max. DBP												--

*p < .05

**p < .01

***p < .005

TABLE VI

RELATIONSHIPS SIGNIFICANT ONLY IN MALES

Pairwise Comparisons	Spearman Rank-Order Correlation (r_s)
max VO_2 and max SBP	.41
treadmill and max SBP	.43
weight and resting SBP	.47
skinfold and max HR	.47
skinfold and max SBP	-.49
skinfold and max DBP	.53
resting HR and max DBP	.52

($p < .05$)

TABLE VII

RELATIONSHIPS SIGNIFICANT ONLY IN FEMALES

Pairwise Comparisons	Spearman Rank-Order Correlation (r_s)
max VO_2 and skinfold	-.66
treadmill time and skinfold	-.66
3-mile run and skinfold	.63
weight and skinfold	.51
resting SBP and max DBP	-.50

($p < .05$)

of results obtained in this study. A correlational matrix was generated from total group data in which maximum VO_2 and 3-mile run performances were correlated to each other, as well as all other dependent variables. Within the parameters of this study, the results of this analysis indicated that maximum VO_2 and 3-mile run performance were highly related ($r=-.91$, $p < .001$), accounting for 83% of the shared variance (r^2).

There is an apparent lack of empirical validation regarding the 3-mile run field test, particularly supporting the supposition of its primary purpose. That is, the field test's ability to predict an individual's aerobic capacity and maximum oxygen uptake. The only study readily found in the literature was conducted by Wiley and Shaver (1972) on 35 untrained male volunteers, 18 to 25 years of age. A correlation coefficient of $r=-.43$ ($p < .05$) was reported, which was considerably lower than that noted by the present investigator. A number of factors could account for this lower coefficient. In Wiley and Shaver's study, the subjects ran the 440-yard, 1-mile, 2-mile, and the 3-mile runs, with at least one day of rest given between runs. That is not a sufficient time period for recovery. Also, all the subjects involved were untrained. Discrepancies between the present study and Wiley and Shaver's study may be partially explained by this difference in the homogeneity of the populations samples. Wiley and Shaver's group of subjects was quite homogeneous in that all were untrained. The trend toward greater homogeneity may have tended to restrict the magnitude of the correlation.

Reliability is the basic prerequisite for this research procedure and validity is the most important characteristic for the procedure to possess. Validity deals with the relationship of the data obtained to the purpose for which it was collected. The most powerful evidence for validity is predictive validity. Predictive validity is the degree to which the predictions made by a test are confirmed by the later behavior of the subjects tested.

The correlation between maximum VO_2 and the 3-mile run performance gives a measure of the predictive validity of the 3-mile run performance. The researcher has used data obtained from the relationship between maximum VO_2 and the 3-mile run performance to develop the following regression equation: $y = bx_1 + a$ or:

$$\text{Predicted maximum } VO_2 = -.40x + 1389.22$$

(where x equals the time to run three miles expressed as a decimal in seconds).

Skinfold measures correlated highest with maximum VO_2 and 3-mile run performance. The mean and standard deviation for skinfold measures were $\bar{X}$ = 14.62% and SD = 7.76%, using the YMCA skinfold formula (Golding et al., 1982). This high correlation is understandable in that the lower the percent body fat, the higher the lean muscle mass. This would enable the subject to reach a higher performance level. Excessive body fat increases total body weight, which, in turn, increases the energy demand without a corresponding increase in maximum VO_2. From a theoretical standpoint, an individual might have average absolute maximum VO_2, yet the running performance could be low because of excess body fat. When multiple regression procedures are used (for predicting maximum VO_2) involving the variables of 3-mile run performance and skinfold measures, a multiple $\underline{R}$=.938, or 87.13%, of the shared variance resulted. The following is a multiple regression formula for predicting maximum VO_2 based on the 3-mile run performance and the skinfold measures:

$$Y = -.248X_1 + -6.99X_2 + 1267.86$$

(where X_1 equals the time to run three miles expressed as a decimal in seconds and X_2 equals the skinfold measure in percent fat).

Due to smaller subject numbers, the male and female groups' data were independently analyzed utilizing the Spearman Rank-Order Correlational Method (Fox, 1969). The relationship between maximum VO_2 and 3-mile run performance remained among the highest correlation in the male group and female group; $r_s = -.66$ ($\underline{p} < .01$) and $r_s = -.85$ ($\underline{p} < .005$), respectively. However, they were lower correlations than the total group correlation between maximum VO_2 and 3-mile run performance. This may be partially explained by differences in the homomgeneity of the populations sampled. The magnitude of the correlation coefficient is partially a function of the variability of the measures and sample size. Therefore, the correlation coefficient calculated from the total group having a wide range of cardiorespiratory fitness will be larger than that from the separate gender groups, which are quite hommogeneous on the variables.

It is also possible that as the skill level increases, psychological factors such as motivation and pain tolerance become more critical determinants of performance. In the group investigated, the skill level was relatively high.

Cooper (1968) discussed the importance of subject motivation for the 12-minute run to serve as an accurate predictor of aerobic capacity.

The rather high correlations obtained in this study tend to substantiate the subjective analysis of the investigator collecting the data; that the subjects were indeed well motivated.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

In the preceding chapters, the problem was introduced, the related literature was reviewed, the procedures were discussed, and an analysis of the data was presented. This chapter includes a summary of the study, the findings derived from the analysis of the data collected, conclusions, and recommendations for further study.

Summary

A review of literature relevant to the relationship between various field test measures and maximum oxygen uptake showed that running tests of longer duration tend to have higher significant relationships with maximum oxygen uptake. The purposes of this study were to: (1) determine the relationship between maximum oxygen uptake and 3-mile run performance, (2) determine the relationship of various physiological measures between maximum VO_2 and 3-mile run performance in college adults, and (3) identify any notable differences between male subject and female subject performance.

Thirty-four undergraduates from Oral Roberts University, Tulsa, Oklahoma, volunteered for this study. All subjects were involved in a 3-mile performance run and a "Bruce Treadmill Test." Both tests were maximal and required an all-out effort from the subjects.

Findings

The data collected in this study were analyzed and yielded the following findings:

1. There was a significant relationship between maximum oxygen uptake and 3-mile run performance ($p < .001$).

2. There were a number of significant pairwise relationships among the various physiological measures ($p < .05$). The particularly high relationships were those involving body type demographics: maximum VO and skinfold, and height and weight. There were also a number of pairwise relationships among the physiological measures that were not significant ($p > .05$).

3. Trends in the data appear to show notable differences between male subject and female subject performance correlates on some of the various dependent variables. Some of these significant pairwise correlates which differed among male and female subjects were: maximum VO_2 and maximum SBP, skinfold and maximum SBP, maximum VO_2 and skinfold, and 3-mile run performance and skinfold.

Conclusions

Based on the findings and limitations of this study, the following conclusions seemed warranted:

1. The time it takes an individual to run three miles was a highly reliable and valid indicator of his cardiorespiratory fitness.

2. When compared with treadmill performance utilizing the "Bruce Treadmill Test" and the population studied, the 3-mile run performance appears to be a better estimation of maximum oxygen uptake than other field and laboratory test comparisons reported in the literature.

3. In general, tests of longer duration seem to be the better measures of aerobic power.

4. Skinfold measures, in conjunction with 3-mile run performance, were highly reliable and valid indicators of cardiorespiratory fitness.

5. Subjects need to be well motivated in order to obtain a high relationship between 3-mile run performance and estimated maximum VO_2.

6. When viewing gender, female performance was a better predictor of maximum VO_2.

Recommendations

Based upon the results of this study, the following recommendations for further study are suggested:

1. Another study should be conducted using gas analysis to determine actual maximum oxygen uptake.

2. Several studies should be conducted to cross-validate the equations derived from this investigation.

3. A study should be conducted similar to this study utilizing a larger sample size.

4. A similar study should be conducted utilizing various age groups and fitness levels among subjects.

A SELECTED BIBLIOGRAPHY

American Association for Health, Physical Education and Recreation (AAHPER). (1962). AAHPER youth fitness test manual. Washington, D.C.: AAHPER.

American College of Sports Medicine. (1980). Guidelines for graded exercise testing and exercise prescription. Philadelphia: Lea and Febiger.

Astrand, P. O. (1956). Human physical fitness with special reference to sex and age. Physiological Review, 36, 307-335.

Astrand, P. O., Bengt, H., & Saltin, B. (1961). Maximal oxygen uptake and heart rate in various types of muscular activity. Journal of Applied Physiology, 16, 977-981.

Astrand, P. O., & Rodahl, K. (1970). Textbook of work physiology. New York: McGraw-Hill.

Bruce, R. A. (1971). Exercise testing of patients with coronary artery disease. Annals of Clinical Research, 3, 323.

Cooper, K. (1968). Correlation between field and treadmill testing as a means of assessing maximum oxygen uptake. Journal of the American Medical Association, 203, 135-138.

Cureton, K. (1951). Physical fitness of champion athletes. Urbana, Illinois: University of Illinois Press.

Custer, S. J., & Chaloupka, E. C. (1977). Relationship between predicted maximal oxygen consumption and performance of college females. Research Quarterly, 48(1), 47-50.

deVries, H. (1966). Physiology of exercise for physical education and athletics. Dubuque, Iowa: William C. Brown.

Doolittle, T. L., & Bigbee, R. (1968). The twelve-minute run-walk: a test of cardiorespiratory fitness of adolescent boys. Research Quarterly, 39(3), 491-495.

Dorociak, J. (1981). Validity of running tests of 4, 8, and 12 minutes duration in estimating aerobic power for college women of different fitness levels. (Unpub. Ph.D. dissertation, Louisiana State University.)

Falls, H. B., Ismail, A. G., & MacLeod, D. R. (1966). Estimation of maximum oxygen uptake in adults from AAHPER youth fitness items. Research Quarterly, 37(2), 192-201.

Fox, D. J. (1969). The research process in education. San Francisco: Rinehart and Winston.

Getchell, L. H., Kirkendall, P., & Rabbins, G. (1977). Prediction of maximal oxygen uptake in young adult women joggers. Research Quarterly, 41(1), 61-67.

Glassford, R. G., Baycroft, G. Y., Sedgwick, A. W., & Macnab, R. J. (1965). Comparison of maximum oxygen uptake values determined by predicted and actual methods. Journal of Applied Physiology, 20(3), 509-513.

Golding, L. A., Myers, C. R., & Sinning, W. E. (Eds.). (1982). The Y's way to physical fitness. Chicago: National Board of the YMCA.

Kasch, F. W., Phillips, W. H., Carter, J. E. L., & Boyer, J. L. (1973). Cardiovascular changes in middle-aged men during two years of training. Journal of Applied Physiology, 34, 53-57.

Kearney, J. T., & Byrnes, W. C. (1974). Relationship between running performance and predicted maximum oxygen uptake among divergent ability groups. Research Quarterly, 45(1), 9-15.

Maksud, M. G., & Coutts, K. D. (1971). Application of the Cooper 12-minute run-walk test to young males. Research Quarterly, 42(1), 54-59.

Matthews, D. K., & Fox, E. (1976). The physiological basis of physical education and athletics. Philadelphia: Saunders College Press.

McArdle, W. D., Katch, F., & Katch, V. (1981). Exercise physiology. Philadelphia: Lea and Febinger.

Metz, K. E., & Alexander, J. F. (1970). An investigation of the relationship between maximum aerobic work capacity and physical fitness in twelve- to fifteen-year-old boys. Research Quarterly, 41(1), 75-81.

Mitchell, J. M., Sproule, B. F., & Chapman, C. (1958). The physiological meaning of the maximum oxygen intake test. Journal of Clinical Investigation, 37, 538-547.

Policy statement regarding the use of human subjects and informed consent. (1985). Medicine and Science in Sports and Exercise, 17(1), v.

Ribisl, P. M., & Kachadorian, W. (1969). Maximal oxygen intake prediction in young and middle-aged males. Journal of Sports Medicine and Physical Fitness, 9, 17-22.

Roscoe, J. T. (1969). Fundamental research statistics for the behavioral sciences. New York: Holt, Rinehart, & Winston.

Saltin, B. (1969). Physiological effects of physical conditioning. Medicine and Science in Sports, 1, 50-56.

Taylor, R. L. (1980). The validity of predicting the maximal oxygen uptake of young females using selected submaximal estimators. Dissertation Abstracts International, 41(3), 984A. (University Microfilms No. 0419-4209.)

Taylor, H. L., Buskirk, E., & Henschel, A. (1955). Maximum oxygen intake as an objective measure of cardiorespiratory performance. Journal of Applied Physiology, 8, 73-80.

Wiley, J. F., & Shaver, L. G. (1972). Prediction of maximum oxygen intake from running performances of untrained young men. Research Quarterly, 43, 89-93.

APPENDIXES

APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

I hereby authorize LuAnn Zimmick to perform the following procedures and investigations:

A field and laboratory physical fitness evaluation, including a 3-mile run and a Bruce Treadmill Test, to predict maximal oxygen intake.

The procedures and investigations have been explained by LuAnn Zimmick. I understand that the procedures and investigations involve the following possible risks and discomforts:

The 3-mile run involves the subject to put forth a maximum effort throughout and to the completion of the field test. The treadmill test involves walking/running at a gradually increasing grade and speed until exhaustion. The subject is free to terminate the test and/or withdraw consent and to discontinue participation in the testing at any time without prejudice to the subject.

I also understand that all test records will be kept confidential and will not be released to anyone without permission of myself. Test results will be tabulated for research purposes as group data and in no case will a subject's personal identity be associated with his test results without his express permission.

Copies of the test will be made available upon request.

I have read this statement fully and understand its content.

Date________________ Subject's Signature__________________________

Principal Investigator: LuAnn Zimmick

Office: A.C. 107; 495-6835

Participant:_______________________________

Phone Number:______________________

Date:___________________

APPENDIX B

MEDICAL RELEASE FORM

MEDICAL RELEASE FORM

Subject's Name______________________________

The purpose of the exercise test is to determine your work capacity, which is expressed in terms of maximum oxygen intake or aerobic capacity. This is generally predicted from the length of time you remain on the treadmill.

PLEASE ANSWER THE FOLLOWING AS ACCURATELY AS POSSIBLE:

1. Have you ever had a heart attack? Yes____ No____
2. Have you ever had heart surgery? Yes____ No____
3. Do you ever experience chest pain? Yes____ No____
4. Are you aware of any other heart-related problems?

   a) Murmur____ b) Palpitations____ c) EKG Abnormalities____
5. Do you have low blood pressure? Yes____ No____
6. Do you have high blood pressure? Yes____ No____
7. Do you ever experience shortness of breath? Yes____ No____
8. Do you have diabetes? Yes____ No____
9. Do you experience any other physical disorders which may affect the type or amount of exercise in which you should participate (e.g., back problems, knee or ankle injuries, etc.)? If so, explain.

   ____

   ____

I understand that by affixing my signature below, the tester does not assume any legal liability for incidents arising from the fitness evaluation.

Date:______________________ Subject's Signature________________________

APPENDIX C

BRUCE TREADMILL TEST PROTOCOL

TABLE VIII

BRUCE TREADMILL TEST PROTOCOL

Stage	Speed mph	Grade %	Duration (min)	VO_2 (ml/kg/min)	Mets
I	1.7	10	3	16.5	4.7
II	2.5	12	3	24.8	7.1
III	3.4	14	3	35.7	10.2
IV	4.2	16	3	47.3	13.5
V	5.0	18	3	60.5	17.3
VI	5.5	20	3	71.4	20.4
VII	6.0	22	3	83.3	23.8

APPENDIX D

ESTIMATED MAXIMUM VO_2 FROM TREADMILL TIME

PERFORMANCE ON BRUCE TREADMILL TEST

TABLE IX

ESTIMATED MAXIMUM VO2 FROM TREADMILL TIME
PERFORMANCE ON BRUCE TREADMILL TEST
(min)

TNTIME	MALES	FEMALES	TNTIME	MALES	FEMALES
20.00	21.1	68.3	16.50	59.3	56.5
19.92	70.8	68.0	16.42	59.0	56.2
19.83	70.5	67.7	16.33	58.8	55.9
19.75	70.2	67.4	16.25	58.5	55.7
19.67	70.0	67.1	16.17	58.2	55.4
19.58	69.7	66.9	16.08	57.9	55.1
19.50	69.4	66.6	16.00	57.6	54.8
19.42	69.1	66.3	15.92	57.4	54.5
19.33	68.8	66.0	15.83	57.1	54.3
19.25	68.6	65.7	15.75	56.8	54.0
19.17	68.3	65.5	15.67	56.5	53.7
19.08	68.0	65.2	15.58	56.2	53.4
19.00	67.7	64.9	15.50	56.0	53.1
18.92	67.4	64.6	15.42	55.7	52.9
18.83	67.2	64.3	15.33	55.4	52.6
18.75	66.9	64.1	15.25	55.1	52.3
18.67	66.6	63.8	15.17	54.8	52.0
18.58	66.3	63.5	15.08	54.6	51.7
18.50	66.0	63.2	15.00	54.3	51.5
18.42	65.8	62.9	14.92	54.0	51.2
18.33	65.5	62.7	14.83	53.7	50.9
18.25	65.2	62.4	14.75	53.4	50.6
18.17	64.9	62.1	14.67	53.2	50.3
18.08	64.6	61.8	14.58	52.9	50.1
18.00	64.4	61.5	14.50	52.6	49.8
17.92	64.1	61.3	14.42	52.3	49.5
17.83	63.8	61.0	14.33	52.0	49.2
17.67	63.2	60.4	14.25	51.8	48.9
17.58	63.0	60.1	14.17	51.5	48.7
17.50	62.7	59.9	14.08	51.2	48.4
17.42	62.4	59.6	14.00	50.9	48.1
17.33	62.1	59.3	13.92	50.6	47.8
17.25	61.8	59.0	13.83	50.4	47.5
17.17	61.6	58.7	13.75	50.1	47.3
17.08	61.3	58.5	13.67	49.8	47.0
17.00	61.0	58.2	13.58	49.5	46.7
16.92	60.7	57.9	13.50	49.2	46.4
16.83	60.4	57.6	13.42	49.0	46.1
16.75	60.2	57.3	13.33	48.7	45.9
16.67	59.9	57.1	13.25	48.4	45.6
16.58	59.6	56.8	13.17	48.1	45.3

TABLE IX (Continued)

TNTIME	MALES	FEMALES	TNTIME	MALES	FEMALES
13.08	47.8	45.0	9.25	35.0	32.1
13.00	47.6	44.7	9.17	34.7	31.9
12.92	47.3	44.5	9.08	34.4	31.6
12.83	47.0	44.2	9.00	34.1	31.3
12.75	46.7	43.9	8.92	33.8	31.0
12.67	46.4	43.6	8.83	33.6	30.7
12.58	46.2	43.3	8.75	33.3	30.5
12.50	45.9	43.1	8.67	33.0	30.2
12.42	45.6	42.8	8.58	32.7	29.9
12.33	45.3	42.5	8.50	32.4	29.6
12.25	45.0	42.2	8.42	32.2	29.3
12.17	44.8	41.9	8.33	31.9	29.1
12.08	44.5	41.7	8.25	31.6	28.8
12.00	44.2	41.4	8.17	31.3	28.5
11.92	43.9	41.1	8.08	31.0	28.2
11.83	43.6	40.8	8.00	30.8	27.9
11.75	43.4	40.5	7.92	30.5	27.7
11.67	43.1	40.3	7.83	30.2	27.4
11.58	42.8	40.0	7.75	29.9	27.1
11.50	42.5	39.7	7.67	29.6	26.8
11.42	42.2	39.4	7.58	29.4	26.5
11.33	42.0	39.1	7.50	29.1	26.3
11.25	41.7	38.9	7.42	28.8	26.0
11.17	41.4	38.6	7.33	28.5	25.7
11.08	41.1	38.3	7.25	28.2	25.4
11.00	40.8	38.0	7.17	28.0	25.1
10.92	40.6	37.7	7.08	27.7	24.9
10.83	40.3	37.5	7.00	27.4	24.6
10.75	40.0	37.2	6.92	27.1	24.3
10.67	39.7	36.9	6.83	26.8	24.0
10.58	39.4	36.6	6.75	26.6	23.7
10.50	39.2	36.3	6.67	26.3	23.5
10.42	30.9	36.1	6.58	26.0	23.2
10.33	38.6	35.8	6.50	25.7	22.9
10.25	38.3	35.5	6.42	25.4	22.6
10.17	38.0	35.2	6.33	25.2	22.3
10.08	37.8	34.9	6.25	24.9	22.1
10.00	37.5	34.7	6.17	24.6	21.8
9.92	37.2	34.4	6.08	24.3	21.5
9.83	36.9	34.1	6.00	24.0	21.2
9.75	36.6	33.8			
9.67	36.4	33.5			
9.58	36.2	33.3			
9.50	35.8	33.0			
9.42	35.5	32.7			
9.33	35.2	32.4			

APPENDIX E

ABBREVIATIONS

ABBREVIATIONS

Est. Max. VO_2	--	estimated maximum oxygen uptake
HR	--	heart rate
bpm	--	beats per minute
SBP	--	systolic blood pressure
DBP	--	diastolic blood pressure
mmHG	--	millimeters of mercury
rpm	--	revolutions per minute
mph	--	miles per hour
kpm/min	--	kilopound meters per minute
g/mm^2	--	grams per millimeter squared

VITA

LuAnn Zimmick

Candidate for the Degree of

Master of Science

Thesis: THE RELATIONSHIP BETWEEN 3-MILE RUN PERFORMANCE AND MAXIMUM OXYGEN UPTAKE IN COLLEGE-AGE STUDENTS

Major Field: Health, Physical Education and Leisure Services

Biographical:

Personal Data: Born in Elgin, Illinois, January 17, 1960, the daughter of Harold and Ruth Zimmick.

Education: Graduated from Juda High School, Juda, Wisconsin, in May, 1978; received Bachelor of Science degree in Health and Physical Education from Oral Roberts University, Tulsa, Oklahoma, in May, 1982; completed requirements for the Master of Science degree at Oklahoma State University in July, 1985.

Professional Experience: Graduate Assistant, Department of Health, Physical Education and Recreation, Oral Roberts University, August, 1982 to present.

Professional Organizations: American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD); Oklahoma Association for Health, Physical Education, Recreation and Dance (OAHPERD); Southern District AAHPERD (SDAAHPERD); National Association for Girls and Women in Sports (NAGWS); National Association of Sports and Physical Education (NASPE).