THE EFFECT OF AGE AND ACTIVITY ON MAXIMAL OXYGEN CONSUMPTION AND SELECTED PHYSIOLOGICAL VARIABLES IN ADULT MALES

By

KATHRYN D. CAMPBELL

Bachelor of Science in Education
New Mexico State University
Las Cruces, New Mexico
1972

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1977

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
May, 1987

THE EFFECT OF AGE AND ACTIVITY ON MAXIMAL
OXYGEN CONSUMPTION AND SELECTED
PHYSIOLOGICAL VARIABLES IN
ADULT MALES

Thesis Approved:

A. B. Harrison
Thesis Adviser

Betty Abercrombie

Robert B. Kamm

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The author would like to express her sincere appreciation to Dr. Aix B. Harrison for his advise, assistance, and helpful suggestions during the testing of subjects and preparation of this manuscript. The task would have been impossible without his willingness to share his time and expertise. Recognition and gratitude are also extended to Dr. Betty Abercrombie and Dr. Robert Kamm for their helpful suggestions, thoughtfulness and support. A special thank you is given to Dr. George Oberle for providing added incentive and encouragement throughout the study.

Appreciation is extended to Fehmi Tuncel, Frank Kulling and Robin Purdie who aided in the collection of data and to Iris McPherson who was invaluable in compiling and interpreting the SAS statistical data. Dr. Lowell Caneday also provided support and advice for the statistical analysis. Thanks are also extended to Jandra Pricer for typing the manuscript with special care.

I would also like to express my deepest gratitude to my son, Jarrel, for his unending patience and understanding and to my parents, Mary and W. A. Dunaway for their willingness to stand by me through another degree.

Finally, I would like to thank Dr. Mac McCrory and the OSU Health and Fitness Center for the support that they have shown to this project and for providing the funding which enabled this research to be completed.

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Within the last two decades, the American public has witnessed a revolution in the promotion and marketing of physical fitness programs. Wellness, a term used by exercise physiologists, health professionals and educators to describe a state of physical and mental well-being, has become a popular concept. Wellness programs are beginning to receive national attention which has prompted hospitals, fitness centers, colleges and universities to add their own health and fitness programs as well as update their research and testing facilities. The success of corporate fitness programs in reducing absenteeism and health care costs and increasing productivity (Shephard, 1984) has captured the attention of the business and industrial sector. The American College of Sports Medicine, the Association for Fitness in Business, and the YMCA/YWCA organizations have dramatically increased their membership and expanded their services in the last few years (Golding, 1984; Lupton, Ostrove & Bozzo, 1984; Paolone, 1980; "Sports medicine," 1983). All this activity reflects the interest and changing attitude of many people toward attaining a healthier lifestyle.

Though the target population of many fitness regimens are the "upwardly mobile" young adult and the middle class, programs especially designed for the needs of an older population are becoming a trend. Opportunities for competition among the "over-40" generation have also increased with the addition of Masters swimming and running programs. Gorman and Brown (1986) reported that more than 25 million Americans are over 65 with an average life expectancy of 75 years of age. They stated, "for the first time in history, the number of people over 65 is greater than those under 25" (Gorman & Brown, 1986, p. 50). An inevitable consequence of these statistics is that more and more people will be entering into retirement and looking for ways to improve both the quality and quantity of their lives. The physical, social and psychological well-being of a retired population which is continuously increasing in numbers is becoming an issue of great concern.

Physiological Considerations

It is well accepted that with age comes some degree of physical decline. Age related decreases in certain variables associated with the ability to exercise and do physical work have been thoroughly documented (I. Åstrand, 1960; I. Åstrand, P. O. Åstrand, Hallback & Kilbom, 1973; Bruce, 1984; Cureton, 1973; Higginbotham, Morris, Williams, Coleman, & Cobb, 1986; Hodgson & Buskirk, 1977; Norris, Shock, & Yiengst, 1955; Robinson, 1938; Skinner, Tipton & Vailas, 1982). A gradual reduction in physical strength and the ability to sustain strenuous physical activity has also been shown to be an expected outcome with advancing age (I. Åstrand, 1960; Åstrand & Rodahl, 1977; Bruce, 1984; Higginbotham et al., 1986; McArdle, Katch & Katch, 1986; Piscopo, 1985; Robinson, 1938; Shephard, 1978; Skinner et al., 1982).

Difficulty in assessing the situation arises when determining what declines are age related, which are genetic and which may be caused by disease such as emphysema or coronary heart disease (CHD). Skinner et al. (1982, p. 409) stated, "the effects of aging and of cardiovascular disease on exercise capacity are similar." In addition, genetic influence and environmental factors cannot be under-estimated. However, it may well be that disuse atrophy caused by inactivity is the more prominent factor influencing the aging declines which are normally observed. Numerous studies have shown that training can be successful in increasing the physical work capacity of the older adult (Badenhop, Cleary, Schaal, Fox & Bartels, 1983; Barry et al., 1966; DeVries, 1970; Ehsani, Martin, Heath & Coyle, 1982; Hodgson & Buskirk, 1977; Pollock et al., 1976; Sidney, 1981; Sidney & Shepherd, 1978). Other researchers have concluded that participation in certain types of regular physical activity may slow down or halt some declines in physiological function that accompany aging (Cooper, 1982; Kasch & Wallace, 1976; Stuller, 1986).

H. A. DeVries wrote in 1970 that little evidence existed to support such convictions. In 1984, Stamford commented:

> It is widely believed that physical activity helps protect against cardiovascular diseases and thus may lengthen life but no conclusive scientific evidence supports this. Evidence suggests a connection between inactivity and an increased mortality rate, but the connection is based on statistical relationships, not a cause and effect relationship (p. 209).

In 1987, evidence is still inconclusive as to the value of systematic physical exercise in slowing down the aging process, but its role in reducing risk of cardiovascular disease and improving quality of life has been highly supported (Cooper, Pollock, Martin, White, Linnerud & Jackson, 1976; Ehsani et al., 1982; Froelicher & Oberman, 1972; Holloszy, Skinner, Toro, & Cureton, 1964; Paffenbarger, Laughlin, Gima & Black, 1970; Pollock, Wilmore & Fox, 1978). Today, many researchers are involved with determining the extent to which exercise and modified life-styles can reduce the risk of cardiovascular disease. Through their efforts studies are accumulating that suggest that inactivity itself may be the important factor (Cooper, 1985; Cooper et al., 1976; Kahn, 1963; Morris, Chave, Adams, Sirey, & Epstein, 1973; Morris, Pollard, Everitt, Chave & Demmance, 1980; Paffenbarger, Wing, Hyde, & Jung, 1983; Paffenbarger, Hyde, Wing, & Hsieh, 1986).

Background for the Study

The interest in physical activity as a modality for reducing risk of cardiovascular disease and providing favorable changes in hypertension, hyperlipidemia and obesity received increased national attention in the late 1960s. Before that time physical fitness programs often were equated with calisthenics which were physically taxing and frequently boring. Enjoyable exercise usually involved playing team or individual sports and was not really synonymous with physical fitness. Early research on selected populations began to link activity on the job and at leisure with decreased coronary heart disease (Brown, Davidson, McKeown, & Whitfield, 1957; Kahn, 1963; Morris, Heady, Raffle, Roberts, & Parks, 1953; Paffenbarger et al., 1970). A new focus on fitness in children had been initiated in 1953 as a result of a report that American school children scored below European children on selected fitness variables measured by the Kraus-Weber Tests for Muscular Fitness (Kraus & Hirschland, 1954). In 1956 President Eisenhower responded by organizing the President's Council on Physical Fitness, which later initiated a nation-wide program of physical fitness testing in the public schools (Zingale, 1977).

A major impetus providing strength to the fitness movement came in 1968 with the book, Aerobics, written by Dr.

Kenneth Cooper. He advocated a type of exercise designed to "demand large quantities of oxygen for prolonged periods and place such demands on the body that it would be forced to improve those systems responsible for the transportation of oxygen" (Cooper, 1982, p. 112). Aerobic activities were those identified as having a moderate intensity and relatively long duration using primarily large muscle groups such as the legs. Walking, jogging, swimming and rope-skipping were some of the activities recommended. By assigning points to various activities based on the oxygen consumption involved with performing that activity, the energy expenditure of different modes of exercise could be estimated and a record of exercise could be kept. The quantification of exercise performed was an inticing concept enabling people to keep track of their exercise involvement and improvement.

As Cooper's readers were becoming interested in gathering points, colleges and universities continued to be among the first to become actively involved in assessing fitness levels for individuals and prescribing exercise to promote further improvements in fitness. The number of institutions that sponsored and supervised exercise programs steadily increased as the fitness movement gained momentum.

In 1972 the faculty fitness study at Oklahoma State University was initiated under the direction of Dr. A. B. Harrison. At that time 93 male faculty ($\bar{x}$ age=43) from

OSU volunteered to participate in a longitudinal study of several variables, each of which might be influenced by exercise. The subjects were to be tested each year and their exercise quantified. They did not participate in any supervised exercise program. At the initiation of the program, approximately twenty subjects were non-exercisers. As the years progressed many of the non-exercisers felt the need to add exercise to their own lifestyle which gradually reduced the control group. In 1973 Oldham tested the group (N=85) and found that they were healthier and more fit than average, but there was no relationship between age and fitness levels at that time. He did find a strong relationship between activity level and several fitness variables, expecially maximal oxygen consumption ($\dot{V}O2_{max}$). Mean $\dot{V}O2_{max}$ was reported as 39.5 $ml \cdot kg^{-1} \cdot min^{-1}$. In 1974 Thomas retested 65 of the original subjects at the end of two years in the study. He concluded that an increase in aerobic points earned produced a lowered resting pulse rate. Those subjects had a mean $\dot{V}O2_{max}$ of 37 $ml \cdot kg^{-1} \cdot min^{-1}$.

At the time of the tenth year of testing, over sixty subjects were still participating in the study. In 1982 Harrison concluded that the results of the 10 year study (N=65) showed that maximal oxygen consumption could be maintained as an individual aged through a program of regular aerobic exercise (Harrison, 1984). The mean age of the subjects at that time was 53 years. A complete reevaluation of these subjects has not been done since 1982 although many have still continued with their exercise program.

Since the study was initiated, several subjects had left the area, changed their lifestyles in one way or another, or had otherwise become unavailable for retesting. However, approximately 57 subjects of ages 40 to 72 years of age remained. A reassessment of the original group of subjects provided valuable information as to the effects of exercise on cardiorespiratory function, body composition and respiratory capacities during the aging process. Comparing subjects that continued their exercise programs throughout the last fourteen years to known or predicted declines that occur with aging added information as the effect of exercise on the aging process. Comparing exercisers with non-exercisers provided additional needed insight on the influence of aerobic exercise on risk factors associated with cardiovascular disease.

Epidemiological studies showing less cardiovascular disease among more active populations probably come closest to supporting the theory that inactivity may be an important cardiovascular risk factor (Kahn, 1963; Morris et al., 1973; Morris et al., 1980; Paffenbarger et al., 1970; Paffenbarger et al., 1986; Pollock et al., 1978). But studies such as these often employ a cross-sectional research design and are retrospective in nature. There exists a scarcity of longitudinal studies which might address the topic of aging. The need exists for data that has been collected and accumulated for the same population over extended periods of time. Projections need to be made based on data collected from persons who have actually aged over a period of ten or more years.

Statement of the Problem

The purpose of this study was to reevaluate the available subjects of the Oklahoma State University faculty fitness study on selected physiological variables, including maximal oxygen consumption. They were retested on most of the same variables using the same methods, procedures, and protocols which were originally implemented. The main focus of the study was to compare these variables with the initial data to determine changes that may or may not have occurred. Results were compared to original test results to determine the effects of aging on selected physiological measurements of the subjects.

Subproblems

A secondary purpose of the study was to estimate the influence of physical activity on the physiological variables of the subjects. Physical activity was measured by reported aerobic points or an estimate of aerobics points based on an oral inquiry. A third subproblem was to determine the interaction of age and physical activity on selected physiological measurements. A fourth subproblem was to compare measured declines in aerobic capacity to predicted age related declines as determined from a review of previous investigations. A fifth subproblem was to correlate maximum oxygen consumption with selected physiological measurements that were known to be related to physical fitness. A final subproblem of the study was to compare actual maximal oxygen consumption as measured by indirect calorimetery to predicted maximal oxygen consumption as predicted by the Balke test (Balke & Ware, 1959) and Cooper's data (Cooper, 1968).

Hypotheses

1. There is no significant difference in any physiological variables between the present study and the initial testing in 1972-73 and 1973-74 for the total subject group.

a. There is no significant differences between age groups on the amount of change in any of the physiological variables from the initial test to the present study.

b. There is no significant differences between activity level groups on the amount of change in any of the physiological variables from the initial test to the present study.

2. There is no significant interaction of age and physical activity on any of the physiological measurements.

3. There is no observable difference in age-predicted declines in aerobic capacity (as determined from the literature) between initial values and present values in any of the activity groups. This hypothesis was not to be tested statistically.

4. There is no significant correlation between physical activity patterns as measured by aerobic points and selected physiological measurements.

5. There is no significant correlation between age and selected physiological measurements.

6. There is no significant correlation between maximal oxygen consumption and selected physiological measurements that have been determined to be related to physical fitness.

7. There is no significant correlation between actual maximal oxygen consumption as measured by the metabolic measurement cart and predicted $\dot{V}O2_{max}$ as determined from time on the treadmill and Cooper's tables.

Limitations

1. The subjects were all volunteers.

2. There was no attempt to control diet, sleep or other personal habits.

Delimitations

1. The subjects were all male university faculty and administrators ranging in age from 42 to 72 years.

2. All subjects had been in the previous study since the initial phase of testing in years 1972-1973 and 1973-74.

Assumptions

1. It was assumed that previous tests were valid predictors of the physiological variables they purported to measure.

2. It was assumed that testing procedures remained reliable throughout the length of the longitudinal study due to the participation and supervision by the same primary investigator.

3. It was assumed that subjects made their best effort at recording aerobic points correctly or recalling physical activity to the best of their ability.

4. It was assumed that subjects made their best effort on all fitness tests requiring personal motivation.

5. Metabolic and cardiac variables were measured using different (newer) equipment from previous tests. It was assumed that this difference in equipment did not cause any significant change in test scores than would have occurred had the same equipment been used. In the initial study, subjects were monitored during their treadmill walk using

telemetry electrodes positioned in a bipolar V-5 lead configuration (Thomas, 1976). A physiograph was used to record the exercising electrocardiogram from the telemetry system. Previous to the walk, a three standard lead EKG was recorded with a Birtcher Electrocardiograph recorder. In the present study, a Sensormedics Horizon Metabolic Cart and Electrocardiogram system was used to record all ECG data. A twelve lead direct wire ECG was recorded both at rest and during exercise using this system.

6. During the initial study oxygen consumption was predicted based on the amount of time or workload reached on the treadmill. In the present study, in addition to the predicted values, oxygen consumption was calculated from expired air collected and analyzed as the test was in progress. The collection of expired air involved the subject being required to breath through a nonrebreathing valve during the treadmill walk and recovery. It is assumed that the use of this additional equipment would not decrease the resulting determination of oxygen consumption or would adjust the amount of time that could be completed during the treadmill walk.

Definition of Terms

Aerobic points - a system of quantifying aerobic activity by assigning points according to predicted energy expenditure of the activity.

Balke treadmill test - graded exercise tolerance test whereby workload is increased by raising a treadmill 1% grade each minute while speed is held constant at 3.4 mph.

Diastolic blood pressure - provides an indication of peripheral resistance or of the ease with which blood flows from the arterioles into the capillaries.

Electrocardiogram - record of the electrical impulses (wave of depolarization and repolarization) that stimulate the heart to contract.

Forced expiratory volume (FEV1) - the volume of the vital capacity that can be forcibly expired in one second after a maximal inspiration. This measurement provides an indication of expiratory power and overall resistance to air movement in the lungs.

Forced vital capacity (FVC) - the total volume of air that can be voluntarily moved in one breath, from full inspiration to maximum expiration, or vice versa.

Graded exercise test - a work test on a treadmill or other type of ergometer where the workload starts light and gradually progresses to heavy or maximal.

Heart rate - the number of ventricular beats per minute as counted from the electrocardiogram or as determined by auscultation with a stethoscope or by palpation over the heart, both during rest and exercise.

Indirect calorimetery - determination of energy metabolism during rest and exercise obtained from measurement of oxygen consumed and carbon dioxide produced in expired air.

Maximum breathing capacity (MBC) - the volume of air that can be rapidly and deeply breathed for 15 seconds is extrapolated to the volume that would have been breathed had the subject continued for 1 minute. This test is an indicator of obstructive lung disease.

Maximum heart rate - the highest heart rate attainable during an all-out effort.

Maximum oxygen consumption ($\dot{V}O2_{max}$) - the point at which the oxygen consumption plateaus and shows no further increase with an additional workload (McArdle et al., 1986). This value is assumed to represent a person's capacity for the aerobic resynthesis of ATP and is also termed aerobic capacity or maximal aerobic power. It is the definitive criterion for the termination of a graded exercise test and is normally used as the definitive criterion of functional capacity. In this study, $\dot{V}O2_{max}$ was predicted in all previous test years from maximal treadmill grade reached on a graded exercise test.

Oxygen consumption or oxygen uptake ($\dot{V}O2$) - the volume of oxygen extracted from the inspired air, usually expressed as liters per minute.

Physical activity - increase in physical work over and above resting that can be quantified according to the energy expended to do the activity. When physical activity is described in terms of exercise intensity it can range from very light to very heavy or exhaustive. This term is also used to indicate the amount of aerobic type of exercise attained as determined by Dr. Cooper's aerobic points system (Cooper, 1968).

Physical fitness - "the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unusual situations and unforeseen emergencies" (Clarke, 1977, p. 2).

Predicted maximal oxygen consumption (pred $\dot{V}O2_{max}$) - maximal oxygen consumption that was predicted from maximal treadmill grade reached on a graded exercise test and Cooper's tables which were developed from regression equations using a large number of subjects (Cooper, 1968).

Symptoms limited exercise test - a graded exercise test that is terminated when the subject reaches a voluntary maximal or he exhibits signs and symptoms of exercise intolerance where maximal oxygen consumption may or may not have been reached. Some common symptoms which would necessitate termination of the test might be: signs of exertional intolerance such as dizziness, angina, nausea, dyspnea, severe fatigue or leg pain; electrocardiographic changes, segment displacements, arrhythmias or other abnormalities; unusual blood pressure or heart rate responses; abnormal respiratory responses; or malfunctioning equipment (American College of Sports Medicine, 1980).

Systolic blood pressure - indicates the strain against the arterial walls during ventricular contraction thereby providing an estimate of the work of the heart.

12 lead electrocardiogram - standard electrocardiogram which is composed of 12 separate leads, 6 chest leads and 6 limb leads. The purpose is to detect contraindications to exercise testing and provide a baseline for comparing similar tracings taken during exercise and recovery.

Vital capacity (VC) - the maximal volume of air that can be expired following a maximal inspiration.

Significance of the Study

Many short term studies exist which suggest that exercise can beneficially influence oxygen intake, blood pressure, cholesterol levels and body composition as previously discussed. These studies are normally well controlled and strictly supervised. Variables are assessed after a limited time on a structured training program. In cross-sectional, retrospective studies where large numbers of subjects have been observed, often there is little or no control over the subjects. Some of this research has implied that declines associated with aging may be slowed as a result of properly implemented aerobic exercise programs. Bone and joint function, muscular strength and flexibility may be positively and, in some cases, negatively affected by exercise. However, short term studies that have indicated that there may be benefits in these areas are limited in scope and do not conclusively confirm that these benefits would persist over longer periods of time.

There is a need for longitudinal studies whose purpose it is to look at the effects of physical activity on age related declines in physical function. This study would be a valuable addition to the dearth of information that is presently available.

CHAPTER II

REVIEW OF LITERATURE

Raymond Harris, the President of the Center for the Study of Aging has stated "the value of physical exercise and activity for improving the physical and mental well-being of the elderly has been recognized intuitively, but there has been a paucity of good research to prove this value and practical programs to demonstrate it" (Smith, 1981, p. 7). Skinner et al. (1982) have recommended the need for more longitudinal and fewer cross-sectional studies on the relationships among exercise, training and the aging process. There exists much controversy over the role that exercise plays in the pathology of cardiovascular diseases and in longevity (McArdle, et al., 1986).

In recent years, authors such as Soloman (The Exercise Myth, Harcourt Brace Jovanovich, Pub., 1984) have questioned the value of physical exercise and the absence of hard evidence for claims that have been made (Legwold, 1985). Epidemiologists have scrutinized the emphasis of aerobic conditioning programs designed to improve cardiovascular fitness over lifestyles which incorporate increased physical activity (LaPorte, Dearwater, Cauley, Slemenda & Cook, 1985). In fact they have implied that prescribed exercise may not be as important as the public has been led to believe, but that remaining active through the elderly years is the key factor (LaPorte et al., 1985).

It has been substantially shown that with advancing age, there is a reduction in physical strength and the ability to sustain strenuous physical exercise (Åstrand, 1960; Grimby, Nilsson & Saltin, 1966; Hodgson and Buskirk, 1977; Robinson, 1938; Skinner, 1970; Strandell, 1964). There are many factors that influence how an individual ages of which the most obvious are the debilitating effects of disease. Julius, Amery, Whitlock and Conway (1967, p. 222) stated, "Aging is a complex process involving subtle changes in function of many systems, but in man the most frequent failure is in the cardiovascular system."

An added complication is the effect of exercise on this total process. Skinner et al. (1982) cited other factors that could affect the response to exercise, e.g. hormonal, nutritional and health status, distribution of muscle fiber types, skill proficiency levels, degree of training and the external conditions prevailing when exercise is performed. Indeed, the interaction of physical activity, intense physical training and the presence of disease complicate the study of the aging process.

This review addressed the changes expected in physiological variables due to age. A discussion of the influences of physical activity and training provided a look at how aging declines are affected by these factors. It was also pertinent to this study to examine the epidemiological evidence supporting physical activity as a modality for reduction of risk of coronary heart disease. A brief presentation of controversy associated with the effects of physical conditioning on aging will follow. A comparison of cross sectional versus longitudinal research is also presented.

The Effect of Aging on Physiological Variables

Oxygen Transport System

The most noted of observable physiological changes that occur with increasing age is probably that of the maximum attainable heart rate. At a given work load or oxygen uptake, the older individual attains on the average the same heart rate as the younger one (Åstrand, 1960; Granath, Jonsson and Strandell, 1970; Piscopo, 1985; Skinner et al., 1982). However, the heart rate that can be reached during maximal exercise decreases with age (Åstrand et al., 1973; Åstrand and Rodahl, 1977, Higginbotham et al., 1986; Londeree and Moeschberger, 1982; McKardle et al., 1986; Robinson, 1938; Skinner et al., 1982). Age-related declines in maximal heart rate have been attributed to increases in fat and connective tissue in the sinoatrial node and internodal tracts (Davis and Pomerance, 1972), declines in heart muscle mass (Skinner et al., 1982), greater stiffness of the heart wall (Shephard, 1978) and a reduced sympathetic drive to the heart (Conway, Wheeler & Sannerstedt, 1971). The sympathetic nervous system is responsible for the release of epinephrine and norepinephrine, which act to accelerate the heart rate and increase myocardial contractility (McArdle et al., 1986). Evidence has pointed to this reduced sympathetic drive making it a frequently cited explanation for the changes in maximal heart rate that are observed with aging (Rodeheffer, Gerstenblith, Becker, Flag, Weisfeldt & Lakatta, 1984; Shephard, 1978; Skinner et al., 1982).

The maximum tolerated exercise of an individual is indicated by the highest achieved level of oxygen consumption and is termed the maximal oxygen consumption ($\dot{V}O2_{max}$) (Julius et al., 1967). Bruce (1984) described $\dot{V}O2_{max}$ as the best single variable to define the changes in functional limits of aerobic metabolism and the cardio-vascular system which occur with aging. This variable has been identified as the definitive criterion for the determination of functional capacity (Åstrand et al., 1973; Mitchell, Sproule & Chapman, 1958) and has been used synonymously with aerobic power, aerobic capacity and physical fitness. Studies have shown that this measurement is also reduced with increasing age (Åstrand et al., 1973; Higginbotham et al., 1986; McArdle et al., 1986; Piscopo, 1985; Shephard, 1978; and Skinner et al., 1982).

Maximal oxygen consumption is dependant on two other variables, cardiac output and arteriovenous oxygen difference (McArdle et al., 1986; Mitchell et al., 1958). Cardiac output ($\dot{Q}$) is the amount of blood ejected by ventricular contraction per minute. Quantitatively, $\dot{Q}$ is a function of stroke volume (SV), the volume of blood pumped with each beat and heart rate (HR), the number of beats per minute ($\dot{Q}$ = SV x HR). Additionally with cardiac output the amount of oxygen consumed to do physical work is dependant on the arteriovenous oxygen difference (a-vO2 diff). This measurement is defined as the difference in oxygen content of arterial and mixed venous blood (McArdle et al., 1986) and represents the amount of oxygen extracted from the blood to be used by the muscle.

Early studies showed a reduced resting cardiac output and stroke volume in older men as compared to young men (Åstrand, 1968; Brandfonbrener, Landowne & Shock, 1955; Granath et al., 1970; McArdle et al., 1986; Skinner et al., 1982; Strandell, 1964). The lowered cardiac output was usually attributed to declines in stroke volume and heart rate associated with aging. A corresponding high a-vO2 difference was postulated (Granath et al., 1970). Skinner et al. (1982) reported that cardiac output at rest decreased only slightly with age and recent authors have reported that possibly there are no age-related declines in resting cardiac output (Higginbotham et al., 1986; Jones & Campbell, 1982; Rodeheffer et al., 1984; Shephard, 1978). Rodefeller and associates (1984) theorized that aging altered the means by which cardiac output was maintained. They postulated that a switch from the sympathetic nervous system to another control mechanism might possibly occur. Rodenfeller et al. (1984) in fact reported an age related increase in stroke volume.

Strandell (1964) found that the cardiac output at a given workload was about 2 L/min lower in sixty to eighty year old men at any level of oxygen uptake compared with the young. Granath et al. (1970) and Skinner (1970) also described lowered stroke volumes during exercise with age. Skinner (1970) and Niinimaa and Shephard (1978) added that a higher a-vO2 difference was observed during submaximal exercise in the older person. The maximum value for a-v02 difference also diminished with age (Niinimaa and Shephard, 1978).

During exhausting work, the stroke volume has been reported to be 10 to 20 percent smaller in the elderly as opposed to the young adult (Åstrand, 1968; Granath et al., 1970; Grimby et al., 1966; Strandell, 1964). There has been general agreement that as exercise approaches maximal, cardiac output increases, but with aging that increase is slightly lower (Julius et al., 1967; Skinner, 1970). Julius (1967) also found that at the point of maximal effort, cardiac output was lower in the older subjects, and that this was a linear decline over the age span. Piscopo (1985) mentioned loss of heart muscle tissue, diminished contractile power and elasticity, stiffening of heart valves and fatty increments as factors that tended to reduce cardiac output. He added, "these changes are accelerated with illness and gross physical inactivity" (Piscopo, 1985, p. 124).

A lowered cardiac output and a-vO2 difference result in a lowered $\dot{V}O2_{max}$ with advancing age. Smith and Serfass (1981) reported this decline to be approximately .75% to 1.0% per year after about age 30. Åstrand (1968) observed that $\dot{V}O2_{max}$ peaked at about 18-20 years of age, then gradually declined. He found that at age 65 the mean value was about 70% of what it was for a 25 year old individual.

Many explanations for these changes in cardiovascular function have been presented in the literature. It appears that the more recent the study, the more likely that the decreased $\dot{V}O2_{max}$ seen with advancing age is attributed wholly to the decreased maximal heart rate (Higgenbotham et al., 1986; Jones and Campbell, 1982). Higgenbotham and others (1986) utilized right-sided cardiac catheterization, arterial cannulation and radionucleotide angiography to evaluate central and peripheral cardiovascular function during submaximal and maximal exercise. These researchers found no age related declines in several factors using these methods. They concluded that any age related declines in aerobic work performance among men 20 - 50 years resulted primarily from a reduced exercise heart rate in older subjects rather than from a reduction in stroke volume or peripheral oxygen utilization.

With age a tendency for resting blood pressure to increase has been reported (Åstrand, 1968; Piscopo, 1985; Rodeheffer, 1984; Shephard, 1978; Skinner et al., 1982), but with wide individual differences among populations (Piscopo, 1985). Blood pressure increases also under submaximal and maximal conditions and even more so with age (Julius et al., 1967; Skinner et al., 1982). Smith and Serfass (1981) noted that the increased blood pressure was due to increased resistance to blood flow with age. They surmised that it could be related to the stiffening of the vessels and/or fatty deposits on the walls of the vessels.

Pulmonary Function

Changes in pulmonary function that occur with aging often are not seen at rest. Most of these changes are normally attibuted to anatomical and physiological alterations in the lungs and thoracic cavity that occur with aging. Piscopo (1985) stated that the thoracic cage and chest wall decreased in pliability and elasticity directly reducing the respiration efficiency of the lungs. Some of the resting variables that are decreased with age include vital capacity, forced expiratory volume, maximal ventilation and peak expiratory volume, maximal ventilation and peak expiratory flow rate (Clarke, 1977; Shephard, 1978). Functional residual capacity, residual volume and physiological dead space all have been found to increase with age (Clarke, 1977; Shephard, 1978).

Once the older individual begins to exercise, the limitations placed on the respiratory system become more evident. The amount of oxygen consumed remains the same when performing the same submaximal work, but a greater ventilation is observed due primarily to a higher respiratory rate (Brischetto, Millman, Peterson, Silage and Pack, 1984; Shephard, 1978; Skinner et al., 1982). Brischetto et al. (1984) suggested that the increased ventilation was to compensate for the greater physiological dead space observed with age. Skinner et al. (1982) described the result as a less "efficient" respiratory system.

Body Composition

Research has shown that there is a gradual increase in body fat with age (Matter, Stamford & Weltman, 1980; McArdle et al., 1986; Pollock, Wilmore & Fox, 1978; Shephard, 1978; Smith & Zook, 1986). Pollock, Wilmore and Fox (1978) reported that the average individual over 25 years of age gains approximatly one pound of added weight per year. They also stated that at the same time bone and muscle mass decreased by approximately .25 to .5 pound per year. Shephard (1978) reported that weight increased to about 50 years of age, then progressively declined accompanied by an increase in body fat and decrease in lean body mass. The decrease in lean body mass that occurs with aging has been reported in numerous cases (McArdle et al., 1986; Shephard, 1978; Storer, Davis, Carozzo, Berund, Fowler & Pollock, 1985). McArdle et al., (1986, p. 567) explained that "higher relative fat values could be in part due to the fact that aging causes the skeleton to become demineralized and porous, thereby reducing the body density because of the decrease in bone density." Some research has shown that gains in body fat with age can be reduced significantly in older men and women who maintain active lifestyles (Pollock, Miller & Wilmore, 1974; Vaccaro, Vandervelder, Goldfarb, Dummer, & Clarke, 1984; Wilmore, Miller & Pollock, 1974).

Aging and Physical Training

Several studies have shown that older individuals can improve their physical condition thru exercise training (Adams & DeVries, 1973; Badenhop et al., 1983; Barry et al., 1966; DeVries, 1970; Hartley et al., 1969; Orlander & Aniansson, 1980). Barry and others (1966) reported significant increases in $\dot{V}O2_{max}$ (38%), pulmonary ventilation

(50%), pulse rate during work, post exercise systolic blood pressure and blood lactate concentration in older individuals ($\overline{x}$ age = 72) after three months of rhythmic endurance training on a stationary bicycle ergometer.

DeVries (1970) tested a large group (N=112) of older men ($\overline{x}$ age = 70 yrs) after a 6 week training program and found significant improvement in oxygen transport capacity. Oxygen pulse and minute ventilation at heart rate 145 improved by 29.4% and 35.2% respectively and vital capacity improved by 19.6%. Significant improvements were realized in percentage of body fat, physical work capacity, and both systolic and diastolic blood pressure. DeVries (1970, p. 335) concluded, "the trainability of older men with respect to physical work capacity is probably greater than had been suspected and not dependant upon having trained vigorously in youth." A similar study conducted on older women yielded comparable results; $\dot{V}O2_{max}$, physical work capacity and oxygen pulse improved significantly after a 3 month program of calisthenics and walk-jogging (Adams & DeVries, 1973).

Seals, Hagberg, Hurley, Ehsani & Holloszy (1984) found that $\dot{V}O2_{max}$ could be improved by 30% in a small sample (N=11) of elderly men and women ($\overline{x}$ age = 63 years) after a year of training. Their study was interesting in that the training program consisted of six months of low intensity training followed by six months of high intensity training. A slightly significant increase in $\dot{V}O2_{max}$ was realized after the first stage (28.2 ± 5.2 $ml \cdot kg^{-1} \cdot min^{-1}$) as compared to initial levels (25.4 ± 4.6 $ml \cdot kg^{-1} \cdot min^{-1}$); however, the overall increase of 30% (32.9 ± 7.6 $ml \cdot kg^{-1} \cdot min^{-1}$) at the end of the training was highly significant. Seals and his co-workers concluded that the increase in $\dot{V}O2_{max}$ in response to training was due primarily to an observed increase in maximal a-vO2 difference. Small insignificant differences were shown for stroke volume and cardiac output.

A recent study by Thomas, Cunningham, Rechnitzer, Donner & Howard (1985) showed that one year of a walk-jogging program performed three times a week resulted in improvements in $\dot{V}O2_{max}$ of 12% in 88 elderly males ($\bar{x}$ age = 62.9). These researchers using regression methods reported that 10% of the variance incurred in $\dot{V}O2_{max}$ with aging could be explained by intensity and frequency of training. Their results also described an association between lung function and $\dot{V}O2$ (r=.33). They determined that the best predictor of $\dot{V}O2_{max}$ in elderly males after one year of training was the initial $\dot{V}O2_{max}$ determined at the beginning of the training program.

After two years of training, three days a week of 60 minutes duration, Kasch, Phillips, Carter and Boyer (1973) realized significant improvements in the oxygen transport system in a group of 15 sedentary middle aged men ($\bar{x}$ age = 47) which they had divided into an exercise and non exercise control group. $\dot{V}O2_{max}$ increased 22% from 32.6 $ml \cdot kg^{-1} \cdot min$

$^{-1}$, maximal pulmonary ventilation increased 7%, maximal heart rate decreased and oxygen pulse improved 21%.

A few studies have shown only slight or no increases in aerobic capacity ($\dot{V}O2_{max}$) in older individuals with training (Benestad, 1965; Niinimaa and Shephard, 1978). The overwhelming evidence though has pointed to increases of up to 42% in $\dot{V}O2_{max}$ in the elderly depending upon their initial level of fitness, length of the training program and intensity of the exercise (Barry et al., 1966; Ehsani et al., 1982; Pollock et al., 1976; Seals et al., 1984; Sidney and Shephard, 1978; Suominen, Heibbinen & Parkatti, 1977; Tzankoff, Robinson, Pyke & Brown, 1972). Other changes that take place with training in addition to an increased $\dot{V}O2_{max}$ include a lowered heart rate at specified submaximal levels (Hartley et al., 1969; Niinimaa and Shephard, 1978; Pollock et al., 1976; Seals et al., 1984; Stamford, 1972) and increased cardiac output and stroke volume (Hartley et al., 1969). Seals and co-workers (1984) also reported an increased a-vO2 difference in the elderly after training. They concluded that increases in $\dot{V}O2_{max}$ that occurred with training appeared to have been primarily due to adaptations in the skeletal muscles that resulted in an improvement in the ability to extract oxygen as reflected by a higher a-vO2 difference.

A number of studies have reported significant decreases in mean systolic and/or diastolic blood pressure in the older individual with training (DeVries, 1970; Ehsani et al., 1982; Hartley et al., 1969; Pollock et al., 1976; Seals et al., 1984). Some research has also shown increased ventilation at maximal levels following a training program in the elderly (Barry et al., 1966; Pollock, Miller, Janeway, Linnerud, Robertson & Valentino, 1971; Pollock et al., 1976; Seals et al., 1984; Tzankoff et al., 1972). In addition to changes in the cardiorespiratory system seen with training in the older subject, there are also favorable improvements in body composition (DeVries, 1970; Pollock et al., 1971; Pollock et al., 1976; Seals et al., 1984), vital capacity (DeVries, 1970), skeletal muscle metabolism (Orlander and Aniansson, 1980; Suominen et al., 1977), muscle fiber composition (Larsson, 1982) and strength (Moritani, 1981).

Long term training studies have been few. Some researchers attempted to look retrospectively at groups who had kept up a training regimen over a period of years. Pollock, Miller and Wilmore (1974) investigated a group of Master's runners (N=25) of ages 40-75 years and discovered that, although maximal performance and oxygen intake decreased with age, a dramatic reduction did not occur until after age 60. Grimby and others (1966) compared well trained cross country runners and skiers (45-55 years) to their younger counterparts and found that values differed only slightly. They concluded that training in youth gave rise to a widening of the maximal a-vO2 difference and an increase in stroke volume that persisted into middle age. However, Barnard, Grimditch and Wilmore (1979) did a cross-sectional study on elderly masters track athletes (ages 40-78) and found a decrease in $\dot{V}O2_{max}$ of 34.5% from age 40 to 70 in spite of a continued intense training program. These authors postulated that the myocardium was no longer capable of responding to training after 70 years of age. Benestad (1965) recorded similar results when he studied the trainability of men aged 70 to 80 years.

A somewhat different trend was found by Pollock and his colleagues (Stuller, 1986). These researchers found that highly competitive Masters runners studied over a span of 10 years (ages 40-75) showed no loss of aerobic capacity compared to runners in the same group who were not quite as competitive. Those who had eased up on training intensity suffered losses in $\dot{V}O2_{max}$ of approximately 9% per decade, a value probably exaggerated due to their high initial fitness levels. Intensity seemed to be the key to maintaining fitness in this study.

A longitudinal study by Kasch and Wallace (1976) is one of the few studies that has demonstrated the changes that might be expected after 10 years of exercise training. The study was significant in that the researchers followed the progress of 16 middle aged men ($\bar{x}$ age = 44.6 at the start of the study) who were actively involved in a supervised endurance exercise program for a period of 10 years. The results showed that $\dot{V}O2_{max}$ as measured on a treadmill had not declined during the course of the study. In addition, their subjects increased maximal pulmonary ventilation and showed no gain in body weight. They concluded that the usual 9-15% decline in $\dot{V}O2_{max}$ and 10% gain in body weight from ages 45 to 55 years could be forestalled by regular endurance exercise.

A ten year longitudinal study by Harrison (1984) also showed no declines in $\dot{V}O2_{max}$ for subjects ($\bar{x}$ age = 43 at the start of the study) over a 10 year period who had performed adequate amounts of aerobic type activity as determined by aerobic points earned per week. These subjects were not on a supervised exercise program and were only motivated by their own desire to improve their health and fitness.

Studies such as those cited above demonstrate that older subjects could improve their aerobic capacity with training, at least up until approximately 65-70 years of age. Evidence has been inconclusive as to gains that can be realized beyond that point. Skinner (1973) stated that decreases in $\dot{V}O2_{max}$ of both athletes and nonathletes begins around the age of 25-30 years and drops at about the same rate until 65 years of age. It appears that although older subjects demonstrate a training effect, their response tends to be less than in younger men; therefore, some aging effect is apparent (DeVries, 1970; Pollock et al., 1971; Skinner, 1973; Skinner et al., 1972). Even a moderate increase in physical activity has been shown, however, to result in small but significant gains in aerobic capacity (Badenhop et al., 1983; Seals et al., 1984).

Aging, Physical Activity and Coronary Heart Disease

Atherosclerosis and coronary heart disease (CHD) complicate the study of the aging process. Shephard (1978) commented that a majority of authors regarded athlerosclerosis as a pathological condition rather than a normal consequence of aging. "Nevertheless," Shephard stated, "by 65 years the majority of the population have at least mild vascular changes and as many as 30% develop some myocardial ischemia during exercise" (Shephard, 1978, p. 107).

Atherosclerosis is the precursor to most forms of CHD, a primary cause of death in middle aged men in the United States (Bruce, 1981). The severity of the condition or the predisposal of a certain individual to developing atherosclerosis is compounded by the presence of "risk factors" which act alone or collectively to add to the problem. The value of physical activity in reducing these factors has been investigated in the last few years.

Studies have shown that regular physical activity can promote favorable changes in work capacity, blood pressure, body composition and blood lipids (Holloszy et al., 1964). Cooper and associates (1976) documented a significant relationship between measured levels of cardiorespiratory fitness and five risk factors: elevated triglycerides, blood sugar, systolic and diastolic blood pressure and cholesterol. The authors suggested that those individuals with the higher levels of fitness were at a lower risk for the premature development of CHD.

Epidemiological research has indicated a relationship between physical activity and the risk of CHD for a number of years. Early occupational studies indicated that men in sedentary occupations were more likely to develop CHD than those whose jobs required moderate to heavy physical activity (Taylor, Klepetar, Keys, Parten, Blackburn and Puckner, 1962). Morris et al. (1953) found that physically more active London bus conductors had a 30% lesser occurrance of manifestations of CHD and 50% fewer myocardial infarctions than the bus drivers. Similar studies of postal carriers and clerks (Kahn, 1963), longshoremen (Paffenbarger et al., 1970), and railroad yard workers (Taylor et al., 1962) have yielded comparable results. After following a group of longshoremen for 22 years, Paffenbarger and Hale (1975) discovered that the age-adjusted coronary death rate for high activity workers was significantly less than that for medium and low activity workers.

A number of studies have focused on the physical activity engaged in by their subjects during leisure time as well as on the job. Morris et al. (1973) found that men who spent their leisure time engaged in vigorous exercise had one-third the risk of developing CHD of those who did not. A later study by Morris and co-workers (1980) concluded that men who engaged in vigorous sports or otherwise kept fit had an incidence of CHD in the following 8 1/2 years somewhat less than half that of their colleagues. Paffenbarger, Wing and Hyde (1978) discovered that the risk of first heart attack was greater in inactive men; specifically, those men whose energy expenditure was less than approximately 2000 kcal per week.

Paffenbarger's most recent study dealt with the same 16,936 Harvard alumni (ages 35-74 years) that he and his colleagues had observed for a number of years (Paffenbarger et al., 1986). The results of this study provided outstanding support to the theory that physical activity could reduce mortality rates. The researchers found that subjects who expended more than an estimated 2000 kilocalories per week had death rates 25 to 33% lower than those whose caloric expenditure was less than 2000 kilocalories per week. Another interesting result was that no additional benefits at above 3500 kcal per week were found, implicating that physical activity and not necessarily intense physical training was the modality to a reduction of heart disease mortality.

LaPorte, Adams, Savage, Brenes, Dearwater and Cook (1984) postulated a direct and an indirect model to explain the reduced risk of heart attack associated with physical activity. The direct model provided that intense increased physical activity directly produced changes in the heart and cardiovascular system. The indirect model stated that physical activity produced changes in risk factors and these changes were associated with the reduced risk of heart attack. Research has supported both models.

Hollozsy (1983) stated that exercise provided a stimulus for the maintenance of structural and functional integrity of the cardiovascular system. Clarke (1977) listed some of the changes that could be expected with an endurance exercise regimen: reduction in serum cholesterol and triglyceride levels; development of collateral circulation around coronary artery restrictions; improvement in myocardial vascularization, increase in red blood cells and blood volume, improved fibrinolytic capability and reduction in blood pressure. Kannel (1970) stated that physical activity benefited the cardiovascular apparatus primarily by promoting collaterals to compensate for a compromised coronary circulation. Other studies that have demonstrated beneficial improvements in cardiovascular function with training have been previously discussed.

Considering the indirect model, many studies have shown that regularly performed exercise may protect against some of the risk factors that play major roles in the development of atherosclerosis (Blair, Cooper, Gibbons, Gettman, Lewis & Goodyear, 1983; Bonnano & Lies, 1974; Boyer & Kasch, 1970; Holloszy et al., 1964; Meyer, 1979; Osness, 1980; Paffenbarger et al., 1983). Osness (1980) stated that physical exercise had been used successfully as a means of reducing the incidence of arterial rigidity and plaqueing that contributed to hypertension. Bonnano (1974) concluded that a physical training program was valuable adjunctive therapy in patients at high risk of coronary disease who had hypertension or hypertriglyceridemia. Blair et al., (1983) found that increased performance time on a treadmill was associated with improvements in blood lipoprotein concentrations and body composition.

Another indirect factor that can be substantially influenced by exercise is obesity. Herbert, Feinleib, McNamara and Castelli (1983) found when reexamining men and women of the Framingham study, that the degree of obesity was an important long term predictor of cardiovascular disease incidence. Weight loss has been shown in a number of instances to be associated with improvements in CHD risk factors (Blair et al., 1983; Herbert et al., 1983; Paffenbarger et al., 1983).

Among older individuals with known coronary risk factors, studies have indicated that endurance training programs have increased $\dot{V}O2_{max}$, reduced systolic and diastolic blood pressure and decreased serum triglycerides (Bonanno and Lies, 1974; Boyer and Kasch, 1970; Holloszy et al., 1964). Ehsani and others (1982) studied the effects of intense and prolonged exercise training on the heart using echocardiography on a small group (N=8) of middle aged men ($\bar{x}$ age = 52 years) with coronary artery disease. In this study, $\dot{V}O2_{max}$ increased by 42 percent and systolic pressure at a given work rate was significantly lowered after training. These researchers concluded that prolonged and vigorous exercise training in selected patients with coronary artery disease could elicit cardiac adaptations.

Montoye (1975) commented that people who are more active can tolerate coronary atherosclerosis better than those who are less active. Clarke (1977) reported that regular physical activity would not prevent a heart attack, but could make its occurrence much less likely; and in the event that it did occur, it tended to be less severe and the likelihood of survival was greater. Evidence generally has supported this assumption (Kannel, 1970; Montoye, 1975; Paffenbarger et al., 1986; Siscovik, Weiss, Fletcher & Lasky, 1984).

Case studies by Cureton have shown that men well into their seventies could maintain and even improve performance and fitness variables (Clarke, 1977). Adult exercise programs at the University of Illinois have provided an example for development of similar programs throughout the

United States. Cureton has made a lifelong study of physical fitness, the last 27 years at the University of Illinois, with graduates teaching and researching internationally in the area of exercise and aging. Cureton (1970, p. v) stated, "continuous, rhythmic physical activity tends to prevent and ameliorate coronary and ischemic heart disease, if the exercise is regular and reaches an average of 300-500 Calories of heat-work per day."

Physical Activity vs Physical Fitness

LaPorte and others (1984) have stated that it is physical activity, not physical fitness, that has been associated with decreased cardiovascular risk. They postulated that, although it is likely that fitness is beneficial, it could be theorized that "activity" is equally or more beneficial. LaPorte, in a recent article discussing the pros and cons of the matter, pointed out that research did not support the conclusion that if an activity program was not defined for aerobic conditioning, it would not reap health benefits (LaPorte, 1985). He added that increased activity without an increase in fitness was clearly beneficial and perhaps more applicable for the groups who could benefit the most from physical activity.

If this seems like a question of semantics, a reviewer must recall what the epidemiological research has demonstrated; that it is physical activity that has been associated with decreased risk of coronary heart disease and not physical fitness. One could argue, however, that the more physically active a person becomes, the better the fitness level would be. In fact, Paffenbarger's latest study appeared to support this. Decreased mortality was shown in those subjects whose energy expenditure was greater than 2000 kcal/week. This researcher would theorize that individuals in that category, if given a test of functional capacity, would generally score significantly higher than sedentary controls, thus exhibiting a higher degree of physical fitness. Most of the population studies of Paffenbarger, Morris and others were observational type studies. The researchers divided the subjects into groups dependant upon activity levels either on the job or at leisure and they observed the onset of coronary heart disease or its symptoms. It could be postulated that, had these researchers gone to the expense of doing a maximal stress test on each subject of their study, more conclusive evidence could have been provided to link physical activity to physical fitness. The relative importance of cardiorespiratory fitness over physical activity as an adjunct in the treatment of CHD might have been further supported.

Cross-Sectional Versus Longitudinal Research

Most cross sectional and longitudinal studies of men and women ages 20-60 years have clearly indicated a decline in aerobic capacity regardless of activity level (Åstrand, 1960; Åstrand et al., 1973). Åstrand et al. (1973) showed declines in $\dot{V}O2_{max}$ of 10% per decade. Bruce (1984) stated that the rate of decline in $\dot{V}O2_{max}$ was substantially lower with aging when based upon cross-sectional sampling. When longitudinal observations were obtained on the same men who remained healthy for several years the coefficient was about twice that for cross-sectional data. This viewpoint has generally been supported by others (Cress, Smith, Smith & Gilligan, 1985; Dehn and Bruce, 1972).

Stamford (1984) and Charness (1985) have alluded to many problems when examining the two types of research. Cross-sectional studies are confounded with uncontrollable cultural and generational variables that each subject brings into the study (Charness, 1985). Stamford (1984) added that conclusions were based on statistical relationships, not cause and effect relationships. Longitudinal studies are marred by selective attrition resulting in an unrepresentative population (Charness, 1985; Stamford, 1984). Despite the problems, researchers have suggested that longitudinal studies are more likely to indicate the true changes that would occur with aging.

Summary

Smith and Serfass (1981) reported that current research suggests that 50% of the decline frequently attributed to physiological aging is, in reality, disuse atrophy resulting from inactivity in an industrialized world. It would appear from the investigation of epidemiological research that inactivity, itself, could be considered a risk factor for coronary heart disease. Evidence seems highly supportive of physical activity as a modality to decreasing risk of coronary heart disease, either directly or indirectly. It is also apparent that physical activity causes favorable improvements in the heart and vascular system as evidenced by increased aerobic capacity, improved vascular function and decreased blood pressure and that these changes can take place even in those subjects with known coronary heart disease. It would seem accurate to say that physical activity can reduce the risk of cardiovascular disease by decreasing the etiology of certain risk factors: hypertension, hyperlipidemia and excess body weight. In a final analysis, if a person who has been active does have some type of cardiac event, it is proposed that the attack would be less severe and the individual would enjoy a better chance of survival.

Skinner (1970) summarized the subject by stating that the present evidence suggested that cardiac or respiratory systems were not responsible for the decline in the capacity for physical work with age. He stated limitation should be sought either in the central nervous system or in the peripheral tissues. Grimby et al. (1966) stated that the ability of the muscles to extract oxygen might be an important factor limiting oxygen uptake. Clearly training, physical activity and the effects of cardiovascular disease interact in a complicated manner to influence quality and quantity of life.

The amount of physical activity needed to yield the desired results is questionable. It therefore appears that further study into the amount and intensity of physical activity that is needed to prevent CHD mortality is in order. However longterm studies, complete with randomization to insure that they are representative of larger populations and well controlled so that extraneous variables can be eliminated are almost impossible due to expense and problems of controlling subject behavior over a number of years. Studies with laboratory animals, though valuable, are always questioned when inference to humans is suggested.

Data presented by Bruce (1984) has indicated the rate of decline in weight adjusted $\dot{V}O2_{max}$ with aging was not the same in habitually active vs sedentary men. He predicted a decline of $-.65 \pm 1.51$ $ml \cdot kg^{-1} \cdot min^{-1}$ yr^{-1} for the physically active to $-1.32 \pm .85$ $ml \cdot min^{-1} \cdot kg^{-1}$ yr^{-1} for sedentary.

Dehn and Bruce (1972) calculated decline rates from a met-analysis of 17 studies and calculated the decline in $\dot{V}O2_{max}$ with age in the nonactive subject at approximately .398 $ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$. Kasch and Wallace (1976) and Harrison (1984) observed no decline in aerobic capacity in active subjects studied for ten years.

This type of research clearly raises the question of whether the onset of clinical symptoms and signs of cardiovascular disease may indeed be delayed or postponed in individuals who adapt to an active lifestyle. The question definitely warrants further investigation.

CHAPTER III

METHODS AND PROCEDURES

Selection of Subjects

The subjects were fifty-one male faculty and administrators at Oklahoma State University with varied fitness levels and exercise habits. They had been participants in the Harrison longitudinal study since the initial phase of testing during 1972-73 and 1973-74. The mean age of the subjects at that time was 42.3 years ranging from 28 to 59 years of age. The age of the subjects in the present study ranged from 42 to 72 years with a mean age of 55.76 years. All subjects included in the present study were participants in the longitudinal research for a minimum of twelve years. The subjects were all volunteers for the original 10 year longitudinal study and recalled to participate in this study. For inclusion in the present study, the subject must have been tested initially in the first two years of the original longitudinal research.

Personal Data Collected

A complete medical history was taken for each subject. This included family history of coronary heart disease and a risk appraisal of the subject. From this information, a determination was made of the subject's current medical condition by Dr. A. B. Harrison. Any condition that would contraindicate participation in an exercise tolerance test was included in this information. Medications that could affect exercise response were recorded. Questions on personal health habits, lifestyle and exercise habits were also included.

Analysis of data required that subjects be grouped by physical activity level. Physical activity level was determined by the amount of aerobic points earned per week. It was assumed that subjects responded truthfully as to exercise habits. Aerobic points were recorded as reported for those that had kept a record. For those who did not keep a record of aerobic points, an inquiry as to physical activity and exercise habits was made. Points were assigned to activity based on the subjects' response to the questions and utilizing the aerobic point value system described by Cooper (1970).

After recording the previous information, the subject was reminded of all procedures, and any risks associated with the testing were explained. The subject then signed an informed consent as required by Oklahoma State University and the Health and Fitness Center. The consent confirmed that the subject understood the procedure, was aware of risks, and agreed to the tests.

Administration of the Test

Subjects were tested on all variables at one testing session. All testing took place in the Health and Fitness Center laboratory in the School of HPELS at Oklahoma State University. The subjects reported dressed in workout clothes and tennis shoes.

Body Composition

Height and weight were measured on a Detecto scale. Skinfold fat determinations at seven skinfold sites were measured with Lange skinfold calipers and recorded to the nearest millimeter according to procedures described by Jackson and Pollock (1985). Skinfold measurements were taken by the same investigator that took them each year throughout the longitudinal study. Skinfold measurements were taken at the triceps, chest, subscapular, mid-axillary, abdominal, suprailium, and thigh. Calculation of percent body fat was done by two methods. The total of the seven measurements was used to determine percent body fat by the "sum of seven" method. Three skinfold sites (triceps, abdomen, and chest) were used to calculate percent body fat using the Best nomogram regression equation. Since percent body fat in the first few years of the longitudinal study was determined using the Best nomogram, it was necessary for comparison purposes that percent body fat be computed based on that method. Research in the OSU Health and Fitness Center has shown that the Best formula underpredicts body fat by approximately 8%. The Best formula does not apply to the middle aged individual and more valid formulas for percent body fat were utilized as the years of the longitudinal study progressed. Percent body fat was also calculated by the sum of seven procedure so that the more recent formula could be used for correlational computations involving the present data.

Pulmonary Function

A Collins 9-liter respirometer was used to determine vital capacity, forced vital capacity, and forced expiratory volume for 1 second. The subject was seated and breathed through a mouth piece which was connected to the respirometer by a valve system. The respirometer cannister was filled with oxygen, and the speed of a recording drum was set at 32mm/min. A nose clip was placed on the subject prior to beginning the test, and the subject was given directions as to how to perform the test. The subject was instructed to inhale as much air as possible, then maximally exhale for the measurement of vital capacity. The subject was then instructed to take a maximum inspiration and hold momentarily while the drum speed was increased to 1920 mm/min. The subject then forcibly exhaled as much air as quickly as possible into the tank.

Vital capacity was taken as the difference between the maximal and minimal reading on the kymograph and corrected to BTPS. Forced expiratory volume for one second (FEV1) was taken as the difference in the maximal and minimal reading on the kymograph for one second during the forced exhalation. Forced vital capacity was taken as the difference between the maximal reading at the beginning of the forced exhalation and the minimal reading at the conclusion of the forced exhalation. Both of these values were also corrected to BTPS.

Maximal breathing capacity was measured on a 100 liter Collins tissot tank. The subject was in a standing position, and a nose clip was attached to the subject prior to beginning the test. The subject was instructed to breathe forcefully and quickly into the tank by way of a one-way breathing valve attached to a hose connected to the tank. The subject was encouraged to adjust his breathing rate and depth of breathing so as to force as much air as possible in the tank for 15 seconds. The volume of air was recorded on a kymograph drum. A score was obtained by taking the difference between the initial reading and the final reading on the kymograph drum and multiplying by 4 to obtain liters per minute. Maximal breathing capacity was taken as the obtained score multiplied by a correction factor of 1.332 for the Tissot tank and then further corrected to BTPS.

Resting Measurements

Resting measurements were taken so that baseline values could be established and any contraindications to the testing procedure would be identified. Disposable EKG electrodes were affixed to the subject in positions for leads 1, 2, 3, avr, avl, avf and chest leads 1 through 6 (V1-V6). An exercise cable was connected to a Sensor-medics 3-channel electrocardiogram system which was used to monitor the heart rate during the treadmill walk. The subject was asked to lie on an examining table so that a resting 12-lead electrocardiogram could be obtained. Blood pressure was taken with the subject in the supine position using a mercury sphygmomanometer. The first Korotkoff sound was recorded as the systolic pressure. The fourth Korotkoff sound or the disappearance of sound was recorded as the diastolic pressure. Resting systolic blood pressure of over 150 mm Hg was taken as a contraindication for completing the exercise tolerance test pending a physician's approval or supervision.

The 12-lead resting electrocardiogram was checked for abnormalities which might contraindicate participation in an exercise test. A determination of the subject's ability to successfully engage in the exercise tolerance test was made by Dr. A. B. Harrison, ACSM certified program director. A licensed cardiac nurse was also available to assist with procedures if necessary.

Exercise Tolerance Test

The subject was asked to stand briefly while an ECG was recorded and a standing blood pressure taken. The subject was then asked to stand on the treadmill while the apparatus for collecting expired air was positioned. The subject was continuously monitored throughout the exercise test with a 12 lead ECG. Leads 2, aVf, and V5 were displayed continuously on the scope and any abnormalities were recorded. A 12-lead ECG was recorded at the end of each 3 minutes of the test. Blood pressure was monitored at frequent intervals, approximately every 5 minutes, to ensure that the subject's blood pressure responded as expected.

Expired air was collected during the test using a Rudolph nonrebreathing valve and analyzed by a Sensor-medics Horizon Metabolic Measurement Cart (MMC), with updates being continuously displayed as well as printed out every 15 seconds. The subject breathed into the MMC via the non-rebreathing valve which routed room air to the subject and the subject's expired air into the MMC. Within the MMC, the expired air was routed to a 3-liter mixing chamber which mixes the gases from several successive breaths to form an average concentration of mixed expired gases which was sampled by analyzers contained within the MMC. Expired breaths flowed through the mixing chamber and out through a turbine and breath switch system which determined volume.

The mixed expired air was subsequently analyzed for CO_2 and O_2. The Beckman OM11 oxygen analyzer utilizes the polarographic oxygen analysis technique for measurement of oxygen concentration in expired air. The Beckman LB2 carbon dioxide analyzer uses the nondispersive infrared analysis technique for determination of CO_2 concentration (Beckman Instruments, Inc., 1983). Data from the analyzers were continually submitted to a computer which performed the necessary calculations and printed out physiological data every 15 seconds. Results were also printed for each minute in the summary report after the test. The gas analyzers were calibrated before each test using medical calibration gases of known concentrations (Sensor-medics).

The Balke (Balke and Ware, 1959) treadmill protocol was used for the graded exercise test on all subjects. This protocol called for a treadmill speed of 3.4 miles per hour and a gradually increasing elevation of 1% each minute after the first two minutes. The test was terminated according to American College of Sports Medicine guidelines for a symptoms limited exercise test (ACSM, 1980). These guidelines included:

1. Maximum oxygen intake has been reached as evidenced by a leveling off or decrease in oxygen intake with further increase in exercise intensity or workload.

2. The subject has reached a voluntary maximal and does not want to continue.

3. Signs and symptoms of exertional intolerance which might include: dizziness or near syncope, angina, nausea, dyspnea (breathlessness), unusual or severe fatigue, pain, unsteadiness, mental confusion, loss of pulse, lack of return to color of skin when briefly compressed.

4. Electrocardiographic changes which might include: S-T segment depression, ventricular arrhythmia, conduction disturbances, pre-ventricular contractions that are increasing and in groups.

5. Blood pressure responses that would include: a systolic pressure of greater than 250 mm Hg, a systolic pressure that fails to rise with increased exercise intensity, a falling systolic pressure of 10 mm or more, or a diastolic pressure rise of more than 20 mm Hg or a rise above 120 mm Hg.

6. Heart rate responses that would include: unusually high heart rate for the age or a heart rate that does not increase with increasing intensity. A previously determined maximal heart rate could be used as a guide to the heart rate that might be reached on this test.

7. Respiratory responses that would include breathlessness or cyanosis.

8. Malfunctioning equipment.

At the termination of the test, the subject began 2 minutes of active recovery during which elevation was reduced to 0% and speed reduced to 2.4 mph. This was followed by at least 3 minutes of sitting recovery. The subject was monitored until his heart rate and blood pressure returned to normal post exercise levels.

Maximal oxygen consumption on the MMC was taken at the point at which the oxygen consumption value seemed to be leveling off. In the absence of this criterion the highest point it reached prior to dropping was taken as the maximal oxygen consumption. The number of minutes completed on the test was used to determine predicted maximal oxygen consumption from the Cooper chart. All data was transferred to a data collection form (Appendix C) to later be entered onto computer.

Analysis of Data

Statistical analysis of all data was completed on the IBM 3081 mainframe computer at the Oklahoma State University computer center using the SAS data analysis system statistical package (SAS Institute, 1982). Means and standard deviations were computed for all physiological variables of interest in both the initial phase of testing during 1972-73 and 1973-74 and for the present 1986 test year. Those variables included: height, weight, aerobic points, lying and standing pulse rates, lying systolic and diastolic blood pressures, standing systolic and diastolic blood pressures, resting oxygen intake, vital capacity, maximal breathing capacity, percent body fat as predicted by the Best nomogram, percent grade completed on the Balke treadmill test, predicted maximal oxygen consumption ($\dot{V}O2_{max}$) in $ml \cdot kg^{-1} \cdot min^{-1}$, post-exercise heart rates at three and five minutes and post-exercise systolic and diastolic blood pressures at three and five minutes. Means and standard deviations were also computed for the 1986 test year for the following variables: maximal heart rate, body fat as measured by the sum of 7 procedure, and actual maximal oxygen consumption ($\dot{V}O2_{max}$) in $ml \cdot kg^{-1} \cdot min^{-1}$, as measured by the metabolic cart.

The subjects were grouped by activity level and age for purposes of statistical analysis. The determination of activity level was made on the basis of an average of points earned per week from the initial phase of testing to the present testing. In order that the resulting average would represent the entire period of the study up to present, the years 1974, 1978, 1982 and 1986 were selected as representative of the period of time under investigation. The aerobics points earned during these test years were averaged to yield an average aerobic point value per week for the entire time period. The number of points needed to reach a minimal fitness level according to Cooper (Cooper, 1970, p. 19) is 30 points per week. A subject could exercise slightly (i.e. walking a mile each day) and still not earn sufficient points to maintain or improve their fitness level; however, he would not be classified as sedentary.

Therefore, subjects earning 10 or fewer points per week were classified in the low activity group (N=14). Subjects earning 11 to 29 points per week were classified in the moderate activity group (N=22), and subjects earning 30 to 99 points were classified as active (N=12). Three subjects were highly trained, earning over 100 points per week, and were subsequently assigned to a very active group (N=3).

The subjects were also assigned to age groups for purpose of statistical analysis. The youngest subject of the group was 42 years of age and the oldest subject was 72 years of age. It therefore seemed logical to divide the subjects into groups at 10 year intervals. Therefore, those subjects who were 42 years through 51 years were assigned to group 1. Those subjects who were 52 years through 61 years were assigned to group 2, and subjects who were 62 years through 72 years were assigned to group 3. The number of subjects per group were 21, 15 and 15 in groups 1, 2 and 3 respectively.

Hypothesis one stated that there is no significant difference in any of the physiological variables between the present study and the initial testing for the total subject group. To test this hypothesis, a t-test for paired comparisons was used for each physiological variable. The null hypothesis was rejected if the T value was significant at the .05 level.

Hypotheses 1a, 1b, and 2 stated that there is no significant differences between age groups or activity level or the interaction of age and activity level on the amount of change in any of the physiological variables from the initial study to the present study. The amount of change for each variable was calculated and used as the dependant variable in a 4 by 3 analysis of variance. The three age groups represented the three levels of the first classification variable, age group, and the four activity level groups represented the four levels of the classification variable, activity group. A significant F value indicated that a significant difference existed between groups for certain variables from the initial test to the present test year. The Duncan's Multiple Range statistic was used to test for significant differences of the variables for the main effects of age and activity level and of the interaction of age and activity level.

Age related declines in maximal oxygen consumption and body composition (increase in body weight) were reported in the review of literature. Hypothesis three stated that there is no difference between those observations and the differences shown in the present study for any of the four activity level groups. This hypothesis was not tested statistically. The expected decline in $\dot{V}O2_{max}$ reported in the literature was compared with the declines which were observed in the present study.

Hypothesis four stated that there is no significant correlation between physical activity as indicated by aerobics points and selected physiological measurements. Hypothesis five stated that there is no significant correlation between age and selected physiological measurements. These two hypotheses were tested with the Pearson Product Moment Correlation statistic. Significance was established with an alpha at the .05 level.

Hypothesis six stated that there is no significant correlation between maximal oxygen consumption and selected physiological measurements that are related to physical fitness. Maximal oxygen consumption as measured by the metabolic cart was correlated with the following variables: aerobics points, lying and standing pulse rates, lying and standing systolic blood pressures, vital capacity, maximal breathing capacity, percent body fat as predicted by the sum of 7 skinfold procedure, percent grade completed on the Balke treadmill test, and post exercise heart rates at three and five minutes. The hypothesis was tested using the Pearson Product Moment Correlation statistic and significance was established with an alpha at the .05 level.

Hypothesis seven stated that there is no significant correlation between actual maximal oxygen consumption as measured by the metabolic measurement cart and predicted $\dot{V}O2_{max}$ as determined from time on the treadmill and Cooper's tables. This hypothesis was tested with the Pearson Product

Moment Correlation and significance was established with an alpha at the .05 level.

The use of the computer in making statistical calculations made possible a determination of the level at which significance would be accepted for the various F and T values. These values are also reported.

CHAPTER IV

RESULTS AND DISCUSSION

Fifty-one male faculty and administrators at Oklahoma State University who were participants in a ten year longitudinal fitness study were reassessed on physiological variables. The subjects were initially tested during 1972-73 or during 1973-74 and retested each year during the original longitudinal study for ten years. Thirteen to fourteen years have elapsed since the beginning of the study. For simplification of discussion, the initial testing that took place during 1972-73 and 1973-74 will be referred to as the initial study or pretest. Testing that took place in 1986-87 for this study will be referred to as the present study or posttest. This chapter presents the results of the testing and discusses the implications of changes that have taken place from the initial to the present study.

Description of the Subjects

Subjects were divided into age groups and activity groups to determine the effect of these two factors on the change of physiological variables from the initial study to the present. The method of assigning subjects to groups was described in Chapter Three. Assignment of subjects to groups is shown in detail in Table I. Physical characteristics of these groups are shown in Table II.

TABLE I

ASSIGNMENT OF SUBJECTS TO GROUPS

Group	Description	Number of Subjects
Total Subject Group	All Subjects	51
Age Groups		
Group 1	Ages 42 through 51	21
Group 2	Ages 52 through 61	15
Group 3	Ages 62 through 72	15
Activity Groups		
Low Activity	Average Aerobic Points = 10 or less per week	14
Moderately Active	Average Aerobic Points = 11 to 29 per week	22
Active	Average Aerobic Points = 30 to 99 per week	12
Very Active	Average Aerobic Points = 100 or more per week	3

TABLE II

PHYSICAL CHARACTERISTICS OF THE GROUPS

Grouping	N		Age	Height	Weight	Present Aerobic Points	Average Aerobic Points
Total Subject Group	51	Mean	55.76	70.34	180.53	36.78	34.45
		SD	9.29	2.49	29.02	66.11	59.94
		Range	42.00-72	64.75-76	132-256	0-300	0-314
Age Group 1 (42-51 years)	21	Mean	46.71	70.76	184.71	52.86	43.90
		SD	3.16	2.50	30.61	82.78	66.06
		Range	42-51	67.5-76.0	150-256	0-300	0-278
Age Group 2 (52-61 years)	15	Mean	56.53	71.23	187.4	37.8	40.5
		SD	3.14	1.95	30.52	68.25	76.51
		Range	52-61	67.5-74.5	141-247	6-280	2-314
Age Group 3	15	Mean	67.67	68.85	167.80	13.27	15.13
		SD	2.94	2.43	22.09	13.45	13.05
		Range	62.72	64.75-73.75	132-218	0-40	0-50
Low Activity Group (0-10 points)	14	Mean	59.43	70.80	193.0	4.5	3.64
		SD	10.0	2.99	31.94	5.72	3.4
		Range	43-71	64.75-76	145-247	0-18	0-9.0
Moderate Activity Group (11-29 points)	22	Mean	56.59	69.86	179.59	16	19.23
		SD	9.16	2.44	29.75	11.82	5.29
		Range	42-72	66.25-76	132-256	0-40	11-29
Active Group (30-99 points)	12	Mean	51.42	70.85	173.67	53.42	43.0
		SD	7.50	2.14	22.18	40.5	14.88
		Range	43-64	67-73.5	150-228	8-160	30-74
Very Active (100 points or more)	3	Mean	50.0	69.58	156.67	273.33	255.67
		SD	7.21	1.70	13.80	30.55	72.14
		Range	44-58	68.25-71.5	141-167	240-300	175-314

The original subject group tested during 1972-73 contained 93 volunteer subjects ($\bar{x}$ age = 39 years) who had agreed to a yearly fitness test. They were not subjected to a training program, nor were they divided into exercise and control groups. Their activity was recorded throughout the years of the study from their reports of aerobic points. The subject group had been reduced over time because some subjects moved from the area, some were affected by chronic illness, some lost interest and three subjects died. Many were nontenured faculty members who subsequently left the university for career reasons. It is beyond the scope of this study to examine whether subjects dropped out because of poor performance (ie. selective attrition) or whether a random decrease in the number of participants had occurred during the past 14 years. However, it is of interest to determine whether the present subject group is representative of the original participants, at least on some selected variables. Table III shows a comparison of the initial test data on the fifty-one subjects that remained in the study throughout the 14 years and the original 93 subjects who participated during that first year of testing.

The mean age of the original 93 subject group was 39.2 years. The initial mean age of the present 51 subject group was 42.3 years. The original subjects' $\dot{V}O2_{max}$ was 38.89 ml$\cdot$kg$^{-1}\cdot$min^{-1} whereas the initial $\dot{V}O2_{max}$ of the subjects in the present study was 39.55 $ml \cdot kg^{-1} \cdot min^{-1}$. It appears from examination of the data in Table III that group data on the subjects who continued to participate in the study throughout the years do not differ much from the group that started the study. Therefore, it is logical to infer that attrition which occurred during the longitudinal study was due to random factors rather than a selective process based on poor performance. This would indicate that the group of 51 subjects in the present study are likely representative of the original group of 93 volunteers.

TABLE III

COMPARISON OF 1972 DATA OF PRESENT TEST GROUP TO 1972 DATA OF ORIGINAL GROUP OF 93 SUBJECTS

Variable	Units	Original Group	Present Group	Difference
Age	years	39.2	42.3	2.9
Weight	pounds	173.72	176.31	+2.59
Body Fat	percent	11.46	10.69	- .77
Heart Rate				
Lying	$b \cdot min^{-1}$	64.7	65.39	+ .69
Standing	$b \cdot min^{-1}$	75.4	76.22	+ .82
Blood Pressure				
Systolic	mm Hg	122	122	0
Diastolic	mm Hg	74	75	+1.0
$\dot{V}O2_{max}$	$ml \cdot kg^{-1} \cdot min^{-1}$	38.9	39.55	+ .65

Differences in Physiological Variables From the Initial Study to Present

Hypothesis one stated that there is no difference in any of the physiological variables from the initial study to the present study. A correlated T test was performed on all variables using the initial testing phase as the pretest and the present study as the posttest. Means, standard deviations and results of the T-Test are presented in Table IV.

The mean maximal oxygen consumption ($\dot{V}O2_{max}$) for the subjects in this study was 38.63 $\pm$ 9.13 $ml \cdot kg^{-1} \cdot min^{-1}$. This value is slightly lower than the values reported by Kasch et al. (1973) for middle aged subjects that had undergone two years of endurance training but higher than the initial values of the subjects in the Kasch study (32.6 $ml \cdot kg^{-1} \cdot min^{-1}$). The $\dot{V}O2_{max}$ of the present group was considerably lower than the initial values of the Kasch and Wallace (1976) subjects who underwent ten years of endurance exercise. These values were comparable to data gathered by Robinson et al. (1975) for middle aged men, however, the present group was slightly older than their group. They reported a $\dot{V}O2_{max}$ of 37-38 $ml \cdot kg^{-1} \cdot min^{-1}$ for men 40-44 years of age. Hodgson and Buskirk reported $\dot{V}O2_{max}$ values ranging from 30.9 $ml \cdot kg^{-1} \cdot min^{-1}$ to 34.4 $ml \cdot kg^{-1} \cdot min^{-1}$ for men 40 to 60 years of age who were not exercising, and DeVries (1970) reported values

TABLE IV

VARIABLES FROM PRETEST TO POSTTEST MEANS, STANDARD DEVIATIONS AND T - TEST

Variable	Units	Initial Mean	SD	Range	Present Mean	SD	Range	Difference	Std. Err.	Value of T	Sig. at .05 Level	Probability
Age	Years	42.31	9.38	28-59	55.76	9.29	42.72					
Height	Inches	70.24	2.42	65.3-75	70.34	2.49	64.8-76	+ .098	.08	1.19	no	.239
Weight	Pounds	176.31	22.52	130-234	180.53	29.02	132-256	+ 4.22	2.07	2.04	yes	.047
Aerobic Points	Points	20.04	36.99	0-265	36.78	66.11	0-300	+16.75	7.71	2.17	yes	.035
Pulse-lying	$b \cdot min^{-1}$	65.39	11.77	45-114	61.06	10.48	40-91	- 4.33	1.48	-2.92	yes	.005
Pulse-standing	$b \cdot min^{-1}$	76.22	11.74	54-114	72.57	13.48	45-108	- 3.65	1.72	-2.13	yes	.038
Systolic blood pressure-lying	mm Hg	122.27	10.17	100-150	125.24	12.32	105-160	+ 3.02	1.62	1.87	no	.068
Diastolic blood pressure-lying	mm Hg	74.57	7.29	60-90	81.18	7.42	65-95	+ 6.52	1.03	6.31	yes	.0001
Systolic blood pressure-standing	mm Hg	124.88	11.79	100-150	124.84	13.07	105-160	- .04	1.88	- .02	no	.9834
Diastolic blood pressure-standing	mm Hg	79.51	7.36	65-95	83.82	7.52	70-100	+ 4.314	1.15	3.76	yes	.004
Resting oxygen intake	$l \cdot min^{-1}$	.35	.08	.23-.61	.29	.06	.14-.44	- .061	.01	-5.16	yes	.0001
Vital Capacity	liters	4.94	.77	2.85-6.62	4.83	.83	2.64-6.96	- .119	.07	-1.82	no	.0744
Maximal breathing capacity	$l \cdot min^{-1}$	156.54	37.13	66.50-248.6	149.78	35.79	52.8-243	- 6.77	3.64	-1.86	no	.069
Body fat (Best)	percent	8.76	3.58	2.68-18.04	11.39	4.19	5.03-20.68	+ 2.62	.42	-6.3	yes	.0001
Percent grade	percent	16.69	3.71	3-23	16.64	5.77	5-32	- .043	.64	- .07	no	.9466
$\dot{V}O_2max$	$ml \cdot kg^{-1} \cdot min^{-1}$	39.55	6.21	19-50	38.63	9.13	20-61.8	- .92	.99	- .93	no	.359
Recovery heart rate at 3 minutes	$b \cdot min^{-1}$	100.30	11.5	66-120	104.78	16.54	69-148	3.70	2.13	1.73	no	.090
Recovery heart rate at 5 minutes	$b \cdot min^{-1}$	93.35	10.23	66-108	96.76	14.41	65-120	2.30	1.82	1.26	no	.2134

of 33.9 $ml \cdot kg^{-1} \cdot min^{-1}$ for a group of untrained men whose mean age was 69.5 years. Chaiwatcharaporn (1982) reported a mean $\dot{V}O2_{max}$ of 34.76 $ml \cdot kg^{-1} \cdot min^{-1}$ for a mixed group of commercial business subjects in the state of Oklahoma (N=308). The present group therefore seemed to have a slightly higher fitness level than what had been generally reported for middle aged men. This may have to do with the fact that the subjects were highly educated. Data presented by Montoye (1975) suggested that white collar workers which included highly educated professional persons changed very little in the number of hours spent at active leisure as they aged compared with blue collar workers who decreased significantly in hours spent in activity. Those results implied that professional people such as educators would tend to stay fitter as they aged.

There were significant differences at the .05 level from pretest to posttest on the following variables: weight, aerobic points, lying pulse, standing pulse, lying and standing diastolic blood pressures, resting oxygen intake and percent body fat. Hypothesis one was therefore rejected for those variables. There were no significant differences at the .05 level for: height, lying and standing systolic blood pressure, vital capacity, maximal breathing capacity, percent grade reached on the treadmill, maximal oxygen consumption and recovery heart rates at 3 and

5 minutes. The null hypothesis was not rejected for those variables.

Significant increases in weight, body fat and diastolic blood pressure agree with what has been presented in the literature. Pollock et al. (1978) reported that a one pound increase in weight per year could be expected as a person aged. At that rate the subjects in the present study should have gained 13 to 14 pounds from the initial study to present. The present study showed that the subjects gained an average of 4.2 pounds over the 14 year period or .3 pounds per year. This fell considerably below the expected decline based on the literature.

A significant increase was seen in aerobic points earned per week from pretest to posttest. This increase in activity may have accounted for some of the results observed. An increase in maximal oxygen consumption ($\dot{V}O2_{max}$) would be expected from increased activity. $\dot{V}O2_{max}$ remained constant during the length of this study. The literature reported an expected decline in $\dot{V}O2_{max}$ of 1% per year. The total difference from pretest to posttest in this study was -.9 $ml \cdot kg^{-1} \cdot min^{-1}$. Though this change from pretest to posttest was not significant, it does indicate a trend of declining $\dot{V}O2_{max}$. For the 14 years this decline would be approximately .1 $ml \cdot kg^{-1} \cdot min^{-1}$ per year which is considerably less than that predicted in the literature.

A significant increase in diastolic blood pressure was found between groups but not with systolic blood pressure. Blood pressure has been shown to increase with advancing age (Åstrand, 1968; Piscopo, 1985; Skinner et al., 1982). Diastolic blood pressure significantly increased in this study but not systolic pressure. This could be an influence of the activity and age on the total group.

Oxygen intake significantly decreased from pretest to posttest which agreed with what had been reported (Bray & Atkinson, 1977; Robinson, Dill, Tzankoff, Wagner & Robinson, 1975). These results are expected since it has been shown that resting metabolism decreases with age (Bray & Atkinson, 1977).

Decreases were also observed in vital capacity, maximal breathing capacity, maximal heart rate, $\dot{V}O2_{max}$, and recovery heart rates, though these changes were not significant. Decreases in pulmonary function have been observed in other studies, and it is well accepted that there would be a decrease in maximal heart rate with age (Åstrand, 1968; Robinson, 1938; Skinner et al., 1982).

The differences in pre and post tests take into account all subjects at all activity levels. Further interpretation required that results be inspected with regard to the groups. Table V shows a difference in pretest and posttest means broken down into age groups and activity groups. The low activity groups experienced declines in $\dot{V}O2_{max}$ which were greater than the active groups. The active and very active groups experienced an increase in $\dot{V}O2_{max}$, however the very active subjects were younger than the group mean. The increases seen in the more active subjects would affect the interpretation of the significant difference of the total group from pretest to posttest in that the mean would be skewed more toward a higher $\dot{V}O2_{max}$. In general, the low activity groups tended to exhibit declines whereas the active groups did not. The expected decline of $\dot{V}O2_{max}$ is discussed further in a later section of this paper. When results are discussed with respect to the effects of age alone and the effect of activity alone, trends become more specific. The effects of age are discussed further in the next section.

Influence of Age, Activity and Their Interaction on the Change in Physiological Variables from Pretest to Posttest

Hypothesis la and lb stated that there is no significant differences between age groups or activity groups on the amount of change in any of the physiological variables from the initial study to the present study. Hypothesis 2 stated that there is no change in the variables due to an interaction of age and activity.

TABLE V

PRETEST AND POSTTEST MEANS BY GROUPS

	AGE GROUPS							
	1 N = 21		2 N = 15		3 N = 15		all N = 51	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Age (years)	33.29	46.7	42.93	56.53	54.33	67.67	42.31	55.76
Height (inches)	70.44	70.76	71.02	71.23	69.18	68.85	70.24	70.34
Weight (pounds)	175.57	184.71	183.60	187.40	170.07	167.80	176.31	180.53
Aerobic Points (points)	29.04	52.86	14.53	37.80	12.93	13.27	20.04	36.78
Pulse Lying ($b \cdot min^{-1}$)	67.14	61.86	64.20	60.27	64.13	60.73	65.39	61.06
Pulse Standing ($b \cdot min^{-1}$)	78.05	74.33	76.40	69.73	73.47	72.93	76.22	72.57
Systolic Lying (mm Hg)	121.24	122.60	122.40	127.33	123.60	126.67	122.27	125.24
Diastolic Lying (mm Hg)	73.57	81.05	74.13	80.33	76.40	82.20	74.57	81.18
Systolic Standing (mm Hg)	125.38	124.48	126.67	125.20	122.40	125.00	124.88	124.84
Diastolic Standing (mm Hg)	80.14	85.71	79.13	82.00	79.00	83.00	79.51	83.82
Resting Oxygen Intake (1·min-1)	.37	.30	.35	.30	.34	.27	.35	.29
Vital Capacity (liters)	5.17	5.24	5.15	4.97	4.42	4.10	4.94	4.83
Maximum Breathing Capacity (1·min-1)	167.93	162.13	158.84	153.69	138.30	128.56	156.54	149.78
Percentage Grade	18.24	19.64	15.93	17.43	15.27	11.65	16.69	16.64
$\dot{V}O_2max$ (ml·kg-1·min-1)	42.19	43.25	38.40	39.90	37.00	30.89	39.55	38.63
Recovery Heart Rate at 3 minutes (b·min-1)	102.67	110.81	99.23	100.40	98.40	100.73	100.30	104.78
Recovery Heart Rate at 5 minutes (b·min-1)	95.44	103.89	91.54	93.47	92.40	91.00	93.35	96.76
Body Fat (Best) (%)	9.02	11.83	9.10	[illegible].13	8.06	10.0[illegible]	8.76	11.39

TABLE V Continued

	ACTIVITY GROUPS									
	1 N = 14		2 N = 22		3 N = 12		4 N = 3		all N = 51	
Variable	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Age	46.28	59.43	43.04	56.59	37.83	51.42	36.33	50.00	42.31	55.76
Height	70.88	70.80	69.69	69.86	70.67	70.85	69.58	69.58	70.24	70.34
Weight	186.50	193.00	174.00	179.59	173.33	173.67	157.67	156.67	176.31	180.53
Aerobic Points	3.21	4.50	16.05	16.00	24.00	53.42	112.00	273.33	20.04	36.78
Pulse Lying	67.5	65.29	64.18	61.05	66.50	60.17	60.00	45.00	65.39	61.06
Pulse Standing	78.57	77.86	74.27	73.09	78.08	70.00	72.00	54.30	76.22	72.57
Systolic Lying	123.21	127.50	123.18	126.45	120.08	122.08	120.00	115.00	122.27	125.24
Diastolic Lying	77.43	81.79	74.50	82.23	72.50	80.00	70.00	72.50	74.57	81.18
Systolic Standing	122.29	125.00	125.73	127.41	126.50	122.17	124.33	116.00	124.88	124.84
Diastolic Standing	80.57	83.21	80.68	85.91	77.25	82.08	75.00	78.33	79.51	83.82
Resting Oxygen Intake	.33	.29	.37	.29	.36	.28	.31	.31	.35	.29
Vital Capacity	4.70	4.47	4.93	4.79	5.23	5.15	5.08	5.44	4.94	4.83
Max. Breathing Capacity	140.05	128.90	166.87	160.99	154.32	149.72	166.67	165.23	156.54	149.78
Percent Grade	14.43	11.77	17.05	16.11	17.42	19.96	21.67	30.00	16.69	16.64
$\dot{V}O_2max$	35.93	30.76	40.05	37.98	40.79	44.34	47.83	57.23	39.55	38.63
Recovery Heart Rate at 3 Minutes	94.00	105.29	103.89	107.14	102.50	102.50	94.00	94.33	100.30	104.78
Recovery Heart Rate at 5 Minutes	89.23	94.43	96.74	99.68	92.72	96.55	92.00	82.00	93.35	96.76
Body Fat (Best)	9.53	12.31	9.23	12.31	7.83	9.79	5.48	6.70	8.76	11.39

To test these hypotheses a 3 X 4 Analysis of Variance was performed using the three age groups (refer to Table I) as levels of the age variable and the four activity groups as levels of the activity variable. The difference between the initial study and the present study was the dependent variable representing change in that variable. The ANOVA produced an F value for the main effects of age and activity on each variable. It also produced an F value for the interaction of age and activity on the variables. Each main effect and the interaction effect will be discussed separately.

The main effect of age on the variables is presented in Table VI. The results of the ANOVA demonstrated a significant effect of age on height, weight, vital capacity, percent grade, and $\dot{V}O2_{max}$ at the .05 level. Therefore, the null hypothesis was rejected for those variables. The value of F was not significant for the remaining variables, and the null hypothesis was not rejected for them.

For each variable where a significant F value was shown a Duncan's Multiple Range Statistic was computed to determine where differences occurred. The results are presented in Table VII.

The results showed that in almost every variable there was a significant difference between age group 3 (62-72 years) and the other two age groups. No significant differences were found on any variable between the youngest

TABLE VI

MAIN EFFECT OF AGE ON CHANGE IN PHYSIOLOGICAL VARIABLES FROM PRETEST TO POSTTEST (N=51)

Variable	Units	Group Pretest Mean	Group Posttest Mean	Amount of Change	F-Value	Significant at the .05 Level	Probability
Age	years	42.31	55.76	+13.45	not applicable		--
Height	inches	70.24	70.34	+.10	6.65	yes	.0032
Weight	pounds	176.31	180.53	+4.22	3.40	yes	.0432
Aerobic Points	points	20.04	36.78	+16.74	2.06	no	.1407
Pulse Lying	$b \cdot min^{-1}$	65.39	61.06	-4.33	.15	no	.8644
Pulse Standing	$b \cdot min^{-1}$	76.22	72.57	-3.65	.93	no	.4043
Systolic blood pressure lying	mm Hg	122.27	125.24	+2.97	.34	no	.7142
Diastolic blood pressure lying	mm Hg	74.57	81.18	+6.61	.18	no	.8348
Systolic blood pressure standing	mm Hg	124.88	124.84	-.04	.39	no	.6774
Diastolic blood pressure standing	mm Hg	79.51	83.82	+4.31	.47	no	.6289
Resting oxygen intake	$l \cdot min^{-1}$	.35	.29	-.06	.09	no	.9113
Vital capacity	liters	4.94	4.83	-.11	3.36	yes	.0447
Maximum breathing capacity	$l \cdot min^{-1}$	156.54	149.78	-6.76	.12	no	.8871
Percentage grade	percent	16.69	16.64	-.05	12.68	yes	.0001
$\dot{V}O_2max$	$ml \cdot kg^{-1} \cdot min^{-1}$	39.55	38.63	-.92	8.93	yes	.0006
Recovery heart at 3 minutes	$b \cdot min^{-1}$	100.30	104.78	+4.48	1.11	no	.3420
Recovery heart at 5 minutes	$b \cdot min^{-1}$	93.34	96.76	+3.42	1.49	no	.2403
Body fat	percent	8.76	11.39	+2.63	.61	no	.55[illegible]

and the middle group. On height, percent grade and $\dot{V}O2_{max}$ significant differences were found between the older group and both of the younger groups. On weight and vital capacity significant differences were found only between the oldest and youngest groups.

TABLE VII

RESULTS OF DUNCAN'S MULTIPLE RANGE TEST
MAIN EFFECT OF AGE

Age groups Between Group & Group	Does A Significant Difference Exist Between:				
	Height	Weight	Vital Capacity	Percent Grade	$\dot{V}O2_{max}$
1 (42-51) & 2 (52-61)	NO	NO	NO	NO	NO
2 (52-61) & 3 (62-72)	YES	NO	NO	YES	YES
1 (42-51) & 3 (62-72)	YES	YES	YES	YES	YES

The results indicated that as the subjects aged there was a significant change in their scores on some variables over the fourteen year period. This interpretation agrees with what is shown in the literature. However, these results showed that no significant changes took place until the person reached the higher age group. No significant differences were observed between the youngest and the middle group. This would seem to support observations made by Benestad (1965) and Pollock et al. (1974) that reductions of variables such as $\dot{V}O2_{max}$ are not observed until the 6th or 7th decade in some subjects. Barnard et al. (1979) found that $\dot{V}O2_{max}$ decreased in spite of endurance training in subjects up to 78 years of age. Their subjects were highly trained Master's athletes, and it could be that declines which were observed were exaggerated due to the high initial fitness levels of their oldest subjects. The high $\dot{V}O2_{max}$ values shown in the present study were for subjects approximately 50 years of age.

The main effect of activity is presented in Table VIII. Table VIII shows that a significant F value at the .05 level was found for percent grade and $\dot{V}O2_{max}$ for the main effect of activity. In fact, the effect of activity was highly significant. The F value was significant even at the .01 level for these two variables. The null hypothesis was thus rejected for percent grade and $\dot{V}O2_{max}$. The null hypothesis was not rejected for the other variables. Further examination of differences in the two significant variables utilized the Duncan's Multiple Range statistic. These results are shown in Table IX.

TABLE VIII

MAIN EFFECT OF ACTIVITY ON CHANGE IN PHYSIOLOGICAL VARIABLES FROM PRETEST TO POSTTEST (N=51)

Variable	Units	Group Pretest Mean	Group Posttest Mean	Amount of Change	F-Value	Significant at the .05 Level	Probability
Age	years	42.31	55.76	+13.45	not applicable		
Height	inches	70.24	70.34	+.10	.50	no	.6836
Weight	pounds	176.31	180.53	+4.22	2.03	no	.1258
Pulse lying	$b \cdot min^{-1}$	65.39	61.06	-4.33	1.32	no	.2817
Pulse standing	$b \cdot min^{-1}$	76.22	72.57	-3.65	1.97	no	.1336
Systolic blood pressure-lying	mm Hg	122.27	125.24	+2.97	.27	no	.8498
Diastolic blood pressure-lying	mm Hg	74.57	81.18	+6.61	.74	no	.5351
Systolic blood pressure-standing	mm Hg	124.88	124.84	-.04	.81	no	.4936
Diastolic blood pressure-standing	mm Hg	79.51	83.82	+4.31	.29	no	.8290
Resting oxygen intake	$l \cdot min^{-1}$	.35	.29	-.06	1.68	no	.1863
Vital capacity	liters	4.94	4.83	-.11	.76	no	.5256
Maximal breathing capacity	$l \cdot min^{-1}$	156.54	149.78	-6.76	.12	no	.9458
Percent grade	percent	16.69	16.64	-.05	7.55	yes	.0004
$\dot{V}O_2max$	$ml \cdot kg^{-1} \cdot min^{-1}$	39.55	38.63	-.92	5.02	yes	.0048
Recovery heart rate at 3 minutes	$b \cdot min^{-1}$	100.30	104.78	+4.48	1.81	no	.1642
Recovery heart rate at 5 minutes	$b \cdot min^{-1}$	93.34	96.76	+3.42	2.16	no	.1109
Body fat	percent	8.76	11.39	+2.63	1.09	no	.3644

TABLE IX

RESULTS OF DUNCAN'S MULTIPLE RANGE TEST
MAIN EFFECT OF ACTIVITY

Activity Groups Between	Does a Significant Difference Exist Between: Percent Grade	$\dot{V}O2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)
Low Activity (0-10) vs Mod. Active (11-29)	NO	NO
Low Activity (0-10) vs Active (30-99)	YES	YES
Low Activity (0-10) vs Very Active (> 100)	YES	YES
Mod. Active (11-29) vs Active (30-99)	YES	NO
Mod. Active (11-29) vs Very Active (>100)	YES	YES
Active (30-99) vs Very Active (>100)	YES	NO

The results showed that activity is a factor in both percent grade and $\dot{V}O2_{max}$. There were no significant differences in either variable for the low versus the moderately active groups. There were significant differences in both variables for the low activity group compared to the active and very active groups. Significant differences existed between the moderately active and the higher activity groups except in the case of $\dot{V}O2_{max}$ between the moderately active and active. There were no significant differences between the active and very active groups on $\dot{V}O2_{max}$. The very active group was significantly different from the moderately active and low activity group on $\dot{V}O2_{max}$ and significantly different from all other groups on percent grade reached on the treadmill.

The significant difference between active and low active groups was expected. As a subject accumulates points, their fitness level as measured by $\dot{V}O2_{max}$ should increase. The non significant difference between the low and moderate activity group on both fitness variables supported Cooper's contention that 30 points a week was necessary to maintain fitness. No increases in $\dot{V}O2_{max}$ were indicated for subjects with below 30 points per week. One interesting observation was the apparent discrepancy in the moderately active versus the active group and the active versus the very active group on percent grade and $\dot{V}O2_{max}$. The data showed that a difference existed between groups where percent grade was the variable but not when actual $\dot{V}O2$ was the variable. At first glance, this seemed to be an error in the data. However, the Cooper charts were set up based on age so that a young person could walk to a certain percent grade and actually receive a lower value for oxygen consumption than an older subject walking to the same level. Therefore, though a difference between the moderately active and active group and the active versus the very active group appeared to exist, it was only significant for percent grade. When examined in terms of $\dot{V}O2_{max}$, no significant difference existed.

The data of Kasch and Wallace (1976) showed that maximal oxygen intake and body composition could be maintained through a regular program of endurance exercise. The present study provided comparable data in that, for the total group, there were no decreases in $\dot{V}O2_{max}$ or increases in body weight. But the present study goes one step further. When only the activity factor is examined without regard to age, the differences in $\dot{V}O2_{max}$ from pretest to posttest are highly significant. This would indicate that physical activity is a significant factor in the determination of declines associated with $\dot{V}O2_{max}$, at least up to approximately 62 to 72 years of age.

The combined effect of age and activity was not significant on any of the variables. The interaction did approach significance for the variable weight ($F > .0525$). Subsequently, the null hypothesis was not rejected for all variables.

Differences in Maximal Oxygen Consumption in the Present Study and That Reported in the Literature

Bruce (1984) reported a decline of .65 $\pm$ 1.51 $ml \cdot kg^{-1} \cdot min^{-1} \cdot year^{-1}$ for the physically active to 1.32 $\pm$ .85 $ml \cdot kg^{-1} \cdot$

$min^{-1}\cdot year^{-1}$ for the sedentary. The rate of decline of maximal oxygen consumption over the fourteen years for the different activity groups is presented in Table X.

The present $\dot{V}O2_{max}$ of each subject was subtracted from the initial $\dot{V}O2_{max}$ values, and a mean of the differences was computed for the total group and the activity groups. The low activity groups showed a decline of .369 $ml\cdot kg^{-1}\cdot min^{-1}\cdot year^{-1}$ which was somewhat less than what Bruce reported for non active and even physically active groups. The moderate activity group showed a rate of decline of .149 $ml\cdot kg^{-1}\cdot min^{-1}\cdot year^{-1}$ which was also less than those values reported by Bruce. Dehn and Bruce (1972) computed the decline rate of $\dot{V}O2_{max}$ with age at .398 $ml\cdot kg^{-1}\cdot min^{-1}\cdot year^{-1}$ based on data gathered from 17 studies. This value closely approximated the value calculated for the present group of low activity subjects. An increase in $\dot{V}O2_{max}$ over the 14 years was observed for the active and very active groups. It should be noted, however, that these two groups were slightly younger, and an age effect has already been shown to be significant for $\dot{V}O2_{max}$.

Correlations Between Physiological Variables

Hypotheses 4, 5, 6 and 7 dealt with correlations between certain variables in the present study. A Pearson Product Moment Correlation was used to test these

TABLE X

RATE OF DECLINE IN $\dot{V}O2_{MAX}$

Group	Points	Age	N	Init. Mean	Pres. Mean	Mean Diff.	Rate of Change
Total Group		55.76	51	39.55	38.63	.92	$-.066\ ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$
Low Activity	0-10	59.43	14	35.93	30.76	-5.16	$-.369\ ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$
Mod. Activity	11-29	56.59	22	40.05	37.98	-2.09	$-.149\ ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$
Active	30-99	51.42	12	40.79	44.34	+3.55	$+.254\ ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$
Very Active	100	50.00	3	47.83	57.23	+9.40	$+.671\ ml \cdot kg^{-1} \cdot min^{-1} \cdot yr^{-1}$

hypotheses. The results of these computations are presented in Tables XI, XII, and XIII. Statistically an interpretation of the correlation coefficient (r) results in an indication of the amount of relationship between two variables. By convention, certain r values have been classified as very high ($r > .90$), high ($r = .7-.89$) medium ($r = .30-.67$) or low ($r < .30$) (Kirk, 1984). The correlation coefficient squared, r^2, is the proportion of the variance in one variable that can be predicted from another (Ferguson, 1981). However, the significance of the association is often related to what is being correlated. Correlations of .5 or .6 are acceptable in many psychological studies; but when $r = .5$, only 25% of the variance in one variable can be accounted for by the other variable. This is unacceptable for many physiological studies. In reliability measures a correlation of .9 or greater is advised. An r of .7 would be necessary for 49% of the variance in one variable to be explained by the other. Consequently, in this study the author used an r value of .7 to .9 to indicate a moderate relationship and above .9 as a high relationship. Low relationships were indicated by r values less than .7.

The correlation between age and certain physiological variables are presented in Table XI.

TABLE XI

CORRELATIONS BETWEEN AGE AND SELECTED PHYSIOLOGICAL VARIABLES

Variable	R-Value	Relationship	Sig. at .05 Level	Prob-ability
Pulse lying	-.102	low	no	.476
Pulse standing	-.088	low	no	.540
Systolic blood pressure				
Lying	.111	low	no	.443
Standing	.014	low	no	.921
Diastolic blood pressure				
Lying	.033	low	no	.819
Standing	-.150	low	no	.293
Resting O2 intake	-.254	low	no	.075
Vital capacity	-.586	low	yes	.0001
Maximal breathing capacity	-.372	low	yes	.0071
Percent grade	-.577	low	yes	.0001
$\dot{V}O2_{max}$	-.570	low	yes	.0001
Body fat	.068	low	no	.638

Table XI shows that only low, insignificant relationships existed between age and most of the variables. A significant relationship did exist for the following variables: vital capacity, maximal breathing capacity, percent grade reached on the treadmill and $\dot{V}O2_{max}$. The null hypothesis was thus rejected for those variables. However the relationships, though significant, were low. The null hypothesis was not rejected for the remaining variables.

A somewhat similar trend was shown between activity level and physiological variables. The data is presented in Table XII. A significant correlation was shown for the following variables: pulse lying, pulse standing, diastolic pressure while lying, percent grade reached on the treadmill, $\dot{V}O2_{max}$ and percent body fat. Though significant, all correlations were low to moderate. The correlation between activity and $\dot{V}O2_{max}$ was the greatest observed ($r = .68$), but by the criteria previously discussed this relationship was low, with 46% of the variance in $\dot{V}O2_{max}$ dependent on age. The null hypothesis was rejected for those variables that were significant at the .05 level and not rejected for the remaining variables.

Significant correlations imply that one variable can be predictive of another. The data would seem to indicate that, though age and activity effects existed over a period of time a prediction of such variables as weight, $\dot{V}O2_{max}$, blood pressure or percent body fat based on age or on

TABLE XII

CORRELATIONS BETWEEN ACTIVITY AS MEASURED BY AEROBIC POINTS AND SELECTED PHYSIOLOGICAL VARIABLES

Variable	R-Value	Relationship	Sig. at .05 level	Prob. ability
Pulse lying	-.409	low	yes	.003
Pulse standing	-.368	low	yes	.008
Systolic blood pressure				
Lying	-.207	low	no	.150
Standing	-.196	low	no	.167
Diastolic blood pressure				
Lying	-.298	low	yes	.035
Standing	-.211	low	no	.138
Resting O2 intake	-.054	low	no	.710
Vital capacity	-.196	low	no	.169
Maximal breathing capacity	-.109	low	no	.448
Percent grade	.677	moderate	yes	.0001
$\dot{V}O2_{max}$	.629	moderate	yes	.0001
Body fat	-.421	low	yes	.002

activity would be highly variable. The closest one could come based on the results of this study would be to predict $\dot{V}O2_{max}$ from activity as determined by aerobics points, and this would only account for 46% of the variance in $\dot{V}O2_{max}$. The reliability of that prediction would be too low to be of value. A trend in increased $\dot{V}O2_{max}$ with an increase in aerobic points would be the most conservative interpretation of the results of the correlations.

Hypothesis six stated that there is no significant correlation between $\dot{V}O2_{max}$ and selected physiological measurements that are related to physical fitness. Table XIII shows the results of the Pearson Product Moment Correlation.

A high correlation existed between actual $\dot{V}O2_{max}$ and $\dot{V}O2_{max}$ as predicted by percent grade reached on the treadmill. This relationship was highly significant at the .05 level indicating that the prediction of $\dot{V}O2_{max}$ using the Cooper tables is highly reliable. Percent grade reached on the treadmill also correlated highly with $\dot{V}O2_{max}$ as measured by the MMC. This would be expected, however, since percent grade was the criterion for determination of predicted $\dot{V}O2_{max}$ utilizing Cooper's data. The null hypothesis was rejected for those two variables.

Significant relationships were shown for other variables when correlated with $\dot{V}O2_{max}$. Though the relationships were low to moderate, the null hypothesis was

TABLE XIII

CORRELATIONS BETWEEN $\dot{V}O2MAX$ AS MEASURED BY THE METABOLIC CART AND SELECTED PHYSIOLOGICAL VARIABLES

Variable	R-Value	Relationship	Sig. at .05 Level	Prob-ability
Aerobic points	.683	moderate	yes	.0001
Pulse lying	-.447	low	yes	.001
Pulse standing	-.354	low	yes	.0107
Systolic blood pressure				
Lying	-.354	low	yes	.0116
Standing	-.230	low	no	.105
Diastolic blood pressure				
Lying	-.305	low	yes	.031
Standing	-.201	low	no	.157
Resting O2 intake	-.005	low	no	.974
Vital capacity	-.395	low	yes	.004
Maximal breathing capacity	.333	low	yes	.017
Percent grade	.947	high	yes	.0001
$\dot{V}O2_{max}$ (predicted)	.962	high	yes	.0001
Body fat	-.517	low	yes	.0001

rejected at the .05 level for the following variables: aerobic points, lying and standing pulse, lying systolic and diastolic pressure, vital capacity, maximal breathing capacity and percent body fat. The null hypothesis was not rejected for standing systolic and diastolic blood pressure, and resting oxygen intake.

Hypothesis seven examined the relationship of the predicted $\dot{V}O2_{max}$ and the actual $\dot{V}O2_{max}$ as measured by the metabolic cart. The Pearson Coefficient for this correlation was also presented in Table XIII. An r value of .96 was computed for this correlation and was significant at the .05 level indicating that a high relationship existed between these two variables. This finding was of interest to the present study since it indicated that values for oxygen consumption predicted throughout the longitudinal study were reliable and not significantly different from values that would have been obtained had actual gas analysis been done in lieu of using the predictions of Cooper.

Summary

Weight, aerobics points, lying pulse rate, standing pulse rate, lying and standing diastolic blood pressure, resting oxygen intake and percent body fat significantly changed from pretest to posttest for the total subject group. Further analysis revealed that age significantly affected height, weight, vital capacity, percent grade and $\dot{V}O2_{max}$. These results are supported by literature which confirmed a decline of physiological measurements with increasing age. However, the declines in such variables as maximal oxygen consumption, body composition, vital capacity, or maximal breathing capacity were not of the magnitude of reported decreases due to aging. One reason could have been that the active groups in this study actually increased in some variables which caused the group mean to regress slightly toward these increases thereby inflating values somewhat. When group data were examined, declines in weight, vital capacity, percent grade and $\dot{V}O2_{max}$ were shown only in the oldest age groups and lowest activity groups. The effects of age were mainly observed between the oldest age group (62-72 years) and the younger groups. A decline of $\dot{V}O2_{max}$ as described in the literature did occur through the years. However, it was interesting to note that there were no significant differences on any variable between the youngest and the middle group. This supported the theory that $\dot{V}O2_{max}$ could be maintained up to at least 62 years before a significant reduction occurred.

The effect of activity level was observed on only two variables: percent grade and $\dot{V}O2_{max}$. No differences were shown for the low (0-10 points) and moderately active (11-29 points) groups. The active group (30-99 points) differed significantly from the moderately active group on percent grade reached on the treadmill but not on $\dot{V}O2_{max}$. The same result was observed for the active and very active group. The high activity group (100 points or more) differed from the other groups on these two variables. The results indicated that low to moderate activity did not have a significant effect on the variables, however in groups with 30 or more points, significance was shown. This is supported by Cooper (1970) who stated that 30 points per week was necessary for maintenance of fitness levels. No interaction effect of age and activity was shown for any of the variables.

A high relationship was found for actual $\dot{V}O2_{max}$ as measured by the metabolic cart and $\dot{V}O2_{max}$ as predicted by percent grade reached on the treadmill. This relationship was significant at the .05 level and indicated the reliability of the Cooper data based on percent grade for predicting $\dot{V}O2_{max}$.

To summarize, the data indicated that significant changes in weight, pulse rate, diastolic blood pressure and body composition occurred during the fourteen years from pretest to posttest. Declines in $\dot{V}O2_{max}$ were apparent, but not significant, and were much less than what was expected from the review of literature. When data were grouped with respect to age and activity level, declines that were observed were mainly in the oldest age groups and lowest activity group.

The data indicated that, in those subjects who attained at least 30 points per week of physical activity, maintenance of aerobic capacity could occur, at least to approximately 62-72 years of age. It also appeared that increases in aerobic capacity could occur in subjects who maintained a high level of aerobic training.

The results of this study indicated that there was a minimal level that had to be achieved to maintain cardiorespiratory fitness. It is still questionable as to whether this would increase longevity. However, the research indicated that those persons who maintained their physical activity patterns did not experience the declines in fitness that had been predicted. The next step in studies such as these will be to show conclusively that maintaining fitness levels will decrease cardiovascular disease risk factors and thereby increase quality and quantity of life.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Fifty-one male faculty and administrators from Oklahoma State University were retested after fourteen years on several variables. Research was presented that indicated that regular physical activity could produce favorable changes in several fitness variables, including body composition and aerobic capacity as indicated by maximal oxygen consumption. Epidemiological research was presented that suggested that physical activity could reduce cardiovascular risk factors. It was the purpose of this study to investigate the changes that had occurred in the past fourteen years for selected variables that are related to physical fitness and examine effects of age and physical activity on those changes.

Discussion of Hypotheses

Hypothesis one stated that there is no difference in any of the physiological variables from the initial study to the present study. A significant difference at the .05 level was found for weight, aerobic points, lying pulse, standing pulse, lying and standing diastolic blood pressures, resting oxygen intake and percent body fat. Hypothesis one was therefore rejected for those variables. There were no significant differences at the .05 level for height, lying and standing systolic blood pressure, vital capacity, maximal breathing capacity, percent grade reached on the treadmill, maximal oxygen consumption and recovery heart rates at 3 and 5 minutes. The hypothesis was not rejected for those variables.

Hypothesis 1a stated that there is no significant differences between age groups on the amount of change in any of the variables from the initial study to the present study. A significant effect of age was found on height, weight, vital capacity, percent grade and $\dot{V}O2_{max}$ at the .05 level. The null hypothesis was rejected for those variables. The null hypothesis was not rejected for the remaining variables.

The results showed that for almost every variable, there was a significant difference between the oldest age group and the other two age groups. No significant differences were found on any variable between the youngest group and the middle group. On height, percent grade and $\dot{V}O2_{max}$, significant differences were found between the older group and both of the younger groups. On weight and vital capacity significant differences were found only between the oldest and the youngest group.

Hypothesis 1b stated that there is no significant differences between activity groups on the amount of change in any of the variables from the initial study to the present study. A significant effect of activity was found on percent grade and $\dot{V}O2_{max}$ at the .05 level. Subsequently, the null hypothesis was rejected for those two variables. The null hypothesis was not rejected on the effect of activity on the remaining variables. Differences existed primarily between low and moderately active groups compared to the active and very active groups. There was no significant difference between the moderately active and the active group on $\dot{V}O2_{max}$ nor was there a significant difference between the active and very active group on $\dot{V}O2_{max}$. The very active group was significantly different from the other lower activity groups on both variables.

Hypothesis two stated that there is no significant differences due to an interaction of age and activity on the amount of change in any of the variables from the initial study to the present study. No significant differences were found between the interaction of age and activity and any of the variables; therefore, the null hypothesis was not rejected for all variables.

Hypothesis three stated that there is no difference in the rate of decline of $\dot{V}O2_{max}$ as reported in the literature and the rate of decline reported in the present study. Though statistical analysis was not performed in this case, there were observable differences. It appeared that the rate of decline in $\dot{V}O2_{max}$ of the subjects in the present study was less than that reported in the literature.

Hypothesis four stated that there is no significant correlation between age and physiological variables measured in the present study. A significant correlation did exist at the .05 level for vital capacity, maximal breathing capacity, percent grade reached on the treadmill and $\dot{V}O2_{max}$. The null hypothesis was rejected for those variables and not rejected for the remaining variables. However, though the relationship was significant, it was low for all variables.

Hypothesis five stated that there is no significant correlation between activity as measured by aerobic points and physiological variables measured in the present study. A significant correlation at the .05 level was shown for the following variables: pulse lying, pulse standing, diastolic pressure while lying, percent grade reached on the treadmill, $\dot{V}O2_{max}$ and percent body fat. Therefore, the null hypothesis was rejected for those variables and not rejected for the remaining variables. Though significant correlations existed, the relationships shown between activity and those variables were low.

Hypothesis six stated that there is no significant correlation between $\dot{V}O2_{max}$ and selected physiological measurements that are related to physical fitness. Significant correlations existed for $\dot{V}O2_{max}$ and percent grade reached on the treadmill. Those variables were highly related; therefore, the null hypothesis was rejected for those two variables.

Hypothesis seven stated that there is no significant correlation between $\dot{V}O2_{max}$ as measured by the metabolic cart and $\dot{V}O2_{max}$ as predicted from Coopers data. The correlation between those two variables was significant at the .05 level, and the null hypothesis was rejected.

Conclusions

The results of the study warrant the following conclusions.

1. There were significant declines in several variables that occurred as the individuals aged. Some physiological changes were favorably affected by activity. It appeared that an age effect existed for height, weight, vital capacity, percent grade and $\dot{V}O2_{max}$. The data showed that $\dot{V}O2_{max}$ could be maintained as an individual aged with a regular program of physical activity that exceeded 30 aerobic points per week.

2. A main effect of activity was shown for two variables: percent grade reached on the treadmill and $\dot{V}O2_{max}$. This conclusion supported the theory that physical activity could forestall the decline of $\dot{V}O2_{max}$ that had been reported for the aging individual.

3. The interaction of age and activity was not a factor contributing to change in any of the variables.

4. The rate of decline of aerobic capacity was similar to what had been reported previously for the low activity groups. However, expected declines that had been reported for $\dot{V}O2_{max}$ were not observed in this study for active and very active groups. In fact, those groups increased their $\dot{V}O2_{max}$ over the fourteen years.

5. There were low correlational relationships between age and variables in the study and between activity and variables in the study. High relationships were shown only for $\dot{V}O2_{max}$ as measured by the metabolic cart and $\dot{V}O2_{max}$ as predicted by percent grade on the treadmill and Coopers data. Though some other correlations were significant, they showed low to moderate relationships.

The data indicated that several variables declined with increased age. The present study showed however that for subjects that had remained physically active over the fourteen years, declines were not significant. In some cases, increases in the variables occurred. Of particular interest was the effect of physical activity and age on $\dot{V}O2_{max}$. The data showed that subjects who were very active improved $\dot{V}O2_{max}$ as they aged and subjects who attained 30 points or more per week could at least expect to maintain their aerobic capacity over the fourteen year period.

Recommendations

1. It is recommended that testing of this subject group continue over another ten years so that the effects of aging past 65 years of age can be examined.

2. It is recommended that more longitudinal data be collected on older groups of subjects. Most of the present literature deals with middle aged subjects. The effect of age and training on persons that are above 70 years of age is not really known.

3. It is recommended that additional data be collected for this subject group including cholesterol and cardiac output, and that this data be analyzed cross-sectionally at present and longitudinally in another 5 years.

4. It is further recommended that skinfold fat formulas be developed specifically for the older individual.

5. Further studies are needed that are well controlled to demonstrate conclusively that physical activity can indeed alter the aging process.

An investigation of the influence of physical activity on cardiovascular risk factors utilizing this group of subjects was beyond the scope of this paper. However, that project would be the next logical step.

REFERENCES

Adams, G. M., & DeVries, H. A. (1973). Physiological Effects of an Exercise Training Regimen Upon Women Aged 52 to 79. Journal of Gerontology, 28(1), 50-55.

American College of Sports Medicine. (1980). Guidelines for Graded Exercise Testing and Exercise Prescription (2nd ed.). Philadelphia: Lea & Febiger.

Åstrand, I. (1960). Aerobic Work Capacity in Men and Women with Special Reference to Age. Acta Physiological Scandinavica, 49 (Suppl), 169.

Åstrand, I., Åstrand, P. O., Hallback, I., & Kilbom, A. (1973). Reduction in Maximal Oxygen Uptake with Age. Journal of Applied Physiology, 35, 649-654.

Åstrand, P. O. (1968). Physical Performance As a Function of Age. Journal of the American Medical Association, 205, 729-733.

Åstrand, P. O., & Rodahl, K. (1977). Textbook of Work Physiology (2nd ed.). New York: McGraw-Hill.

Badenhop, D., Cleary, P. A., Schaal, S. F., Fox, E. L., & Bartels, R. L. (1983). Physiological Adjustments to Higher or Lower Intensity Exercise in Elders. Medicine and Science in Sports and Exercise, 15(6), 496-502.

Balke, B., & Ware, C. W. (1959). An Experimental Study of Physical Fitness of Air Force Personnel. U.S. Armed Forces Medical Journal, 19, 675-683.

Barnard, R. J., Grimditch, G. K., & Wilmore, J. H. (1979). Physiological Characteristics of Sprint and Endurance Master Runners. Medicine and Science in Sport, 11, 167-171.

Barry, A. J., Daly, J. W., Pruett, E. D. R., Steinmetz, J. R., Page, H. F., Birkhead, N. C., & Rodahl, K. (1966). The Effects of Physical Conditioning on Older Individuals. I. Work Capacity, Respiratory Function, and Work Electrocardiogram. Journal of Gerontology, 21(2), 182-191.

Beckman Instruments, Inc. (1983). *MMC Horizon Systems General Operating Instructions*. Anaheim, California: Beckman.

Benestad, A. M. (1965). Trainability of Old Men. *Acta Medica Scandinavica*, *178*, 321-327.

Blair, S. N., Cooper, K. H., Gibbons, L. W., Gettman, L. R., Lewis, S., & Goodyear, N. (1983). Changes in Coronary Heart Disease Risk Factors Associated with Increased Treadmill Time in 753 Men. *American Journal of Epidemiology*, *118*, 352-359.

Bonanno, J. A., & Lies, J. E. (1974). Effects of Physical Training on Coronary Risk Factors. *The American Journal of Cardiology*, *33*, 760-764.

Boyer, J. L., & Kasch, F. W. (1970). Exercise Therapy in Hypertensive Men. *Journal of the American Medical Association*, *111*(Part II), 1668-1671.

Brandfonbrener, M., Landowne, M., & Shock, N. N. (1955). Changes in Cardiac Output with Age. *Circulation*, *12*, 567-576.

Bray, G. A., & Atkinson, R. L. (1977). Factors Affecting Basal Metabolic Rate. *Progressive Food and Nutrition Science*, *2*, 395-403.

Brischetto, M. J., Millman, R. P., Peterson, D. D., Silage, D. A., & Pack, A. I. (1984). Effect of Aging on Ventilatory Response to Exercise and CO2. *Journal of Applied Physiology*, *56*(5), 1143-1150.

Brown, R. G., Davidson, A. G., McKeown, T., & Whitfield, A. G. W. (1957). Coronary Artery Disease: Influences Affecting its Incidence in Males in the Seventh Decade. *Lancet*, *2*, 1073-1077.

Bruce, R. A. (1984). Exercise, Functional Aerobic Capacity, and Aging - Another Viewpoint. *Medicine and Science in Sports and Exercise*, *16*(1), 8-13.

Bruce, R. A. (1981). Primary Intervention Against Coronary Atherosclerosis By Exercise Conditioning? *New England Journal of Medicine*, *25*, 305.

Chaiwatcharaporn, C. (1982). *A Comparison of the Physical Fitness Levels of Selected Oklahoma State University Faculty and Selected Commercial People of the State of Oklahoma*. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, Oklahoma.

Charness, N. (Ed.). (1985). Aging and Human Performance. Chichester, Great Britain: John Wiley & Sons, Ltd.

Clarke, H. H. (Ed.). (1977). Exercise and Aging. Physical Fitness Research Digest, 7(2), 1-27.

Conway, J., Wheeler, R., & Sannerstedt, R. (1971). Sympathetic Activity During Exercise in Relation to Age. Cardiovascular Research, 5, 577-581.

Cooper, K. H. (1968). Aerobics. New York: M. Evans & Co. and Bantam Books.

Cooper, K. H. (1982). The Aerobics Program for Total Well-Being. New York: M. Evans & Co., Inc. and Bantam Books.

Cooper, K. H. (1970). The New Aerobics. New York: M. Evans & Co. and Bantam Books.

Cooper, K. H. (1985). Running Without Risk. Runners World, 20(3), 61-64.

Cooper, K. H., Pollock, M. L., Martin, R. P., White, S. R., Linnerud, A. C., & Jackson, A. (1976). Physical Fitness Levels Versus Selected Coronary Risk Factors: A Cross-sectional Study. Journal of the American Medical Association, 236, 166-169.

Cress, M. E., Smith, P. E., Smith, E. L., & Gilligan, C. (1985). Rates of Fitness Decline in Sedentary Middle-aged Women. Medicine and Science in Sports and Exercise (abstract), 17(2), 215.

Cureton, T. K. (1973). Trends of Research on Prevention of Physiological Aging and the Value of Exercise for Fitness and Health. Washington, D.C.: President's Council on Physical Fitness and Sports. (ERIC Document Reproduction Service No. ED 083 237).

Cureton, T. K. Jr. (1970). Physical Fitness Workbook for Adults. Champaign, Illinois: Stipes Pub. Co.

Davies, M. J., & Pomerance, A. (1972). British Heart Journal, 34, 150-152.

Dehn, M. M., & Bruce, R. A. (1972). Longitudinal Variations in Maximal Oxygen Intake With Age and Activity. Journal of Applied Physiology, 33, 805-807.

DeVries, H. A. (1970). Physiological Effects of an Exercise Training Regimen Upon Men Aged 52-88. Journal of Gerontology, 25(4), 325-336.

Ehsani, A. A., Martin, W. H., Heath, G. W., & Coyle, E. F. (1982). Cardiac Effects of Prolonged and Intense Exercise Training in Patients with Coronary Heart Disease. American Journal of Cardiology, 50, 246-253.

Ferguson, G. A. (1981). Statistical Analysis in Psychology and Education (5th ed.). New York: McGraw-Hill Book Co.

Froelicher, V. F., & Oberman, A. (1972). An Analysis of Epidemiological Studies of Physical Inactivity as a Risk Factor for Coronary Artery Disease. Progressive Cardiovascular Disease, 15, 41-65.

Golding, L. A. (1984). Partnerships for the Fit. Journal of Physical Education, Recreation and Dance, 55(9), 51-53.

Gorman, D. & Brown, B. (1986). Fitness and Aging: An Overview. Journal of Physical Education Recreation and Dance, 57(1), 50-51, 54.

Granath, A., Jonsson, B., & Strandell, T. (1970). Circulation in Healthy Old Men, Studied by Right Heart Catheterization at Rest and During Exercise in Supine and Sitting Position. In D. Brunner & E. Jokl (Eds.), Physical Activity and Aging (pp. 48-79). Baltimore: University Park Press.

Grimby, G., Nilsson, N. J., & Saltin, B. (1966). Cardiac Output During Submaximal and Maximal Exercise in Active Middle-Aged Athletes. Journal of Applied Physiology, 21, 1150-1156.

Harrison, A. B. (1984). A Longitudinal Study of $\dot{V}O2max$ in Aging Males. Medicine and Science in Sports and Exercise (abstract), 16, 124.

Hartley, L. H., Grimby, G., Kilbom, A., Nilsson, N. J., Astrand, I., Bjure, J., Ekblom, B., & Saltin, B. (1969). Physical Training in Sedentary Middle-aged and Older Men. III. Cardiac Output and Gas Exchange at Submaximal and Maximal Exercise. Scandinavian Journal of Clinical Laboratory Investigation, 24, 335-344.

Herbert, H. B., Feinleib, P. H. M., McNamara, P. M., & Castelli, W. P. (1983). Obesity as an Independent Risk Factor for Cardiovascular Disease: a 26 Year Follow Up of the Participants in the Framingham Heart Study. Circulation, 67, 968-977.

Higginbotham, M. B., Morris, K. G., Williams, R. S., Coleman, R. E., & Cobb. (1986). Physiologic Basis for the Age-Related Decline in Aerobic Work Capacity. American Journal of Cardiology, 57(15), 1374-1379.

Hodgson, J. L., & Buskirk, E. R. (1977). Physical Fitness and Age with Emphasis on Cardiovascular Function in the Elderly. Journal of the American Geriatric Society, 25, 385-392.

Holloszy, J. O. (1983). Exercise, Health, and Aging: A Need for More Information. Medicine and Science in Sports and Exercise, 15, 1-5.

Holloszy, J. O., Skinner, J. S., Toro, G., & Cureton, T. K. (1964). Effects of a Six Month Program of Endurance Exercise on the Serum Lipids of Middle-Aged Men. American Journal of Cardiology, 14, 753-760.

Jackson, A. S., & Pollock, M. L. (1985). Practical Assessment of Body Composition. Physician and Sportsmedicine, 13(5), 76-90.

Jones, N. L., & Campbell, E. J. M. (1982). Clinical Exercise Testing. Philadelphia: W. B. Saunders, Co.

Julius, S., Amery, A., Whitlock, L. S., & Conway, J. (1967). Influence of Age on the Hemodynamic Response to Exercise. Circulation, 36, 222-230.

Kahn, H. A. (1963). The Relationship of Reported Coronary Heart Disease Mortality to Physical Activity of Work. American Journal of Public Health, 53(7), 1058-1067.

Kannel, W. B. (1970). Physical Exercise and Lethal Atherosclerotic Disease. New England Journal of Medicine, 282, 1153-1154.

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(1), 53-57.

Kasch, F. W., & Wallace, J. P. (1976). Physiological Variables During 10 Years of Endurance Exercise. Medicine and Science in Sports, 8(1), 5-8.

Kirk, R. E. (1984). Elementary Statistics (2nd ed.). Monterey, California: Brooks/Cole Publishing Co.

Kraus, H., & Hirschland, R. P. (1954). Minimum Muscular Fitness Tests for School Children. Research Quarterly, 25(4), 178-188.

LaPorte, R. E., Adams, L. L., Savage, D. D., Brenes, G., Dearwater, S., & Cook, T. (1984). The Spectrum of Physical Activity and Cardiovascular Disease: an Epidemiological Perspective. American Journal of Epidemiology, 120, 507-517.

LaPorte, R. E., Dearwater, S., Cauley, J. A., Slemenda, C., & Cook, T. (1985). Physical Activity or Cardiovascular Fitness: Which is More Important for Health? Physician and Sportsmedicine, 13(3), 145-150.

Larsson, L. (1982). Physical Training Effects on Muscle Morphology in Sedentary Males at Different Ages. Medicine and Science in Sports and Exercise, 14(3), 203-206.

Legwold, G. (1985). Are We Running From the Truth About the Risks and Benefits of Exercise? Physician and Sportsmedicine, 13(5), 136-148.

Londeree, B. R., & Moeschberger, M. L. (1982). Effect of Age and Other Factors on Maximal Heart Rate. Research Quarterly, 53(4), 297-304.

Lupton, C. H., Ostrove, N. M., & Bozzo, R. M. (1984). Participation in Leisure-Time Physical Activity: A Comparison of the Existing Data. Journal of Physical Education, Recreation and Dance, 55(9), 19-23.

Matter, S., Stamford, B. A., & Weltman, A. (1980). Age, Diet, Maximal Aerobic Capacity and Serum Lipids. Journal of Gerontology, 35, 532-36.

McArdle, W. D., Katch, F. I., & Katch, V. L. (1986). Exercise Physiology: Energy, Nutrition, and Human Performance (2nd ed.). Philadelphia: Lea & Febiger.

Meyer, B. M. (1979). Risk Factor Changes Associated with Improvement in Physical Fitness. Medicine and Science in Sports (abstract), 11, 108.

Mitchell, J., Sproule, B., & Chapman, C. (1958). The Physiological Meaning of the Maximal Oxygen Intake Test. Journal of Clinical Investigation, 37, 538-547.

Montoye, H. J. (1975). Physical Activity and Health: An Epidemiologic Study of an Entire Community. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Moritani, T. (1981). Training Adaptations in the Muscles of Older Men. In E. L. Smith & R. C. Serfass (Eds.), Exercise and Aging (pp. 149-155). Hillside, N.J.: Enstow.

Morris, J. N., Chave, S. P. N., Adams, C., Sirey, C., & Epstein, L. (1973). Vigorous Exercise in Leisure Time and the Incidence of Coronary Heart Disease. Lancet, 2, 333-339.

Morris, J. N., Heady, J. A., Raffle, P. A. B., Roberts, C. J., & Parks, J. W. (1953). Coronary Heart Disease and Physical Activity of Work. Lancet, 2, 1053-1057, 1111-1120.

Morris, J. N., Pollard, R., Everitt, M. G., Chave, S. P. W., & Demmance, A. M. (1980). Vigorous Exercise in Leisure-Time: Protection Against Coronary Heart Disease. Lancet, 2, 1207-1210.

Niinimaa, V., & Shephard, R. J. (1978). Training and Oxygen Conductance in the Elderly. II. The Cardiovascular System. Journal of Gerontology, 33(3), 362-367.

Norris, A. H., Shock, N. W., & Yiengst, M. J. (1955). Age Differences in Ventilatory and Gas Exchange Responses to Graded Exercise in Males. Journal of Gerontology, 10, 145-155.

Oldham, M. D. (1976). The Appraisal of the Current Physical Fitness Status of Eighty-five Volunteer Males of the Oklahoma State University Faculty and Administration. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, Oklahoma.

Orlander, J. & Aniansson, A. (1980). Effects of Physical Training on Skeletal Muscle Metabolism and Ultrastructure in 70 to 75 Year Old Men. Acta Physiological Scandinavica, 109, 149-154.

Osness, W. (1980, April). *Physiological Aging and Exercise*. Paper presented at the annual meeting of the American Alliance for Health, Physical Education, Recreation, and Dance, Detroit, MI.

Paffenbarger, R. S. Jr., & Hale, W. E. (1975). Work Activity and Coronary Heart Mortality. *New England Journal of Medicine*, *292*, 545-550.

Paffenbarger, R. S. Jr., Hyde, R. T., Wing, A. L., & Hsieh, C. (1986). Physical Activity, All-Cause Mortality, and Longevity of College Alumni. *New England Journal of Medicine*, *314*(10), 605-613.

Paffenbarger, R. S. Jr., Laughlin, M. E., Gima, A. S., & Black, R. A. (1970). Work Activity of Longshoremen as Related to Death from Coronary Heart Disease and Stroke. *New England Journal of Medicine*, *20*, 1109-1114.

Paffenbarger, R. S. Jr., Wing, A. L., & Hyde, R. T. (1978). Physical Activity as an Index of Heart Attack Risk in College Alumni. *American Journal of Epidemiology*, *108*, 161-175.

Paffenbarger, R. S. Jr., Wing, A. L., Hyde, R. T., & Jung, D. L. (1983). Physical Activity and Incidence of Hypertension in College Alumni. *American Journal of Epidemiology*, *117*, 245-256.

Paolone, A. M. (1980). Business and Industrial Fitness Programming: The Health Enterprise. In E. J. Burke (Ed.), *Exercise, Science and Fitness* (pp. 79-86). Ithaca, N.Y.: Mouvement Publications.

Piscopo, J. (1985). *Fitness and Aging*. New York: John Wiley & Sons, Inc.

Pollock, M. L., Dawson, G. A., Miller, H. S. Jr., Ward, A., Cooper, D., Headley, W., Linnerud, A. C., & Nomier, M. M. (1976). Physiologic Response of Men 49 to 65 Years of Age to Endurance Training. *Journal of the American Geriatric Society*, *24*, 97-104.

Pollock, M. L., Miller, H. S., Janeway, R., Linnerud, A. C., Robertson, B., & Valentino, R. (1971). Effect of Walking on Body Composition and Cardiovascular Function of Middle-Aged Men. *Journal of Applied Physiology*, *30*, 126-130.

Pollock, M. L., Miller, H. S. Jr., & Wilmore, J. (1974). Physiological Characteristics of Champion American Track Athletes, 40-75 years of age. Journal of Gerontology, 29, 645-649.

Pollock, M. L., Wilmore, J. H., & Fox, S. M. III. (1978). Health and Fitness Through Physical Activity. New York: John Wiley & Sons.

Robinson, S. (1938). Experimental Studies of Physical Fitness in Relation to Age. Arbeitphysiologie, 10, 251-323.

Robinson, S., Dill, D. B., Tzankoff, S., Wagner, J., & Robinson, R. D. (1975). Longitudinal Studies of Aging in 37 Men. Journal of Applied Physiology, 38(2), 263-267.

Rodeheffer, R. J., Gerstenblith, G., Becker, L. C., Flag, J. L., Weisfeldt, M. L., & Lakatta, E. G. (1984). Exercise Cardiac Output is Maintained With Advancing Age in Healthy Human Subjects: Cardiac Dilatation and Increased Stroke Volume Compensate for a Diminished Heart Rate. Circulation, 69, 203-213.

SAS Institute, Inc. (1982). SAS User's Guide: 1982 Edition. Cary, North Carolina: SAS Institute.

Seals, D. R., Hagberg, J. M., Hurley, B. F., Ehsani, A. A., & Holloszy, J. O. (1984). Endurance Training in Older Men and Women. I. Cardiovascular Responses To Exercise. Journal of Applied Physiology, 57(4), 1024-1029.

Shephard, R. J. (1978). Physical Activity and Aging. Chicago: Year Book Medical Publishers, Inc.

Shephard, R. J. (1984). Practical Issues in Employee Fitness Programming. Physician and Sportsmedicine, 12(6), 161-166.

Sidney, K. H. (1981). Cardiovascular Benefits of Physical Activity in the Exercising Aged. In E. L. Smith & R. C. Serfass (Eds.), Exercise and Aging (pp. 131-147). Hillsiide, N.J.: Enstow.

Sidney, K. H., & Shephard, R. J. (1978). Frequency and Intensity of Exercise Testing for Elderly Subjects. Medicine and Science in Sports, 10(2), 125-131.

Siscovick, D. S., Weiss, N. S., Fletcher, R. H., & Lasky, T. (1984). The Incidence of Primary Cardiac Arrest During Vigorous Exercise. New England Journal of Medicine, 311(14), 874-877.

Skinner, J. S. (1973). Age and Performance. In J. Keul (Ed.), Limiting Factors of Physical Performance (pp. 271-282). Stuttgart: George Thieme Publishers.

Skinner, J. S. (1970). The Cardiovascular System with Aging and Exercise. In D. Brunner & E. Jokl (Eds.), Physical Activity and Aging (pp. 100-108). Baltimore: University Park Press.

Skinner, J. S., Tipton, C. M., & Vailas, A. C. (1982). Exercise, Physical Training, and the Ageing Process. In A. Viidik (Ed.), Lectures in Gerontology (pp. 407-439). London: Academic Press.

Smith, E. L. (1981). Age: The Interaction of Nature and Nurture. In E. L. Smith & R. C. Serfass (Eds.), Exercise and Aging: The Scientific Basis (pp. 11-17). Hillside, N.J.: Enslow.

Smith, E. L., & Serfass, R. C. (Eds.). (1981). Exercise and Aging: The Scientific Basis. Hillside, N.J.: Enslow Publishers.

Smith, E. L. & Zook, S. K. (1986). The Aging Process-Benefits of Physical Activity. Journal of Physical Education, Recreation and Dance, 57(1), 32-34.

Solomon, H. A. (1984). The Exercise Myth. Orlando, Florida: Harcourt Brace Jovanovich, Publishers.

Sports Medicine: The Momentum Continues. (1983). Physician and Sportsmedicine, 11(6), 152-63.

Stamford, B. (1972). Physiological Effects of Training Upon Institutionalized Geriatric Men. Journal of Gerontology, 27, 451-455.

Stamford, B. (1984). Exercise and Longevity. Physician and Sportsmedicine, 12(6):209.

Stones, M. J., & Kozma, A. (1985). Physical Performance. In N. Charness (Ed.), Aging and Human Performance. Chichester, Great Britain: John Wiley & Sons, Ltd.

Storer, T. W., Davis, J. A., Carozzo, V. J., Berund, M. J., Fowler, M., & Pollock, M. (1985). Effect of Aging on Lean Body Mass and Aerobic Power. Medicine and Science in Sports and Exercise (abstract), 17(2), 188-189.

Strandell, T. (1964). Circulatory Studies on Healthy Old Men. Acta Medica Scandinavica, 175(Suppl), 414.

Stuller, S. (1986). Run Long and Prosper. Runners World, 21(7), 77-81.

Suominen, H., Heibbinen, E., & Parkatti, L. (1977). Effects of Eight Weeks Physical Training on Muscle and Connective Tissue of the M. Vastus Lateralis in 69-year Old Men and Women. Journal of Gerontology, 32, 33-37.

Taylor, H. L., Klepetar, E., Keys, A., Parten, W., Blackburn, H., & Puckner, L. (1962). Death Rates Among Physically Active and Sedentary Employees of the Railroad Industry. American Journal of Public Health, 52, 1697-1707.

Thomas, D. L. (1976). The Effects of Participating in an Aerobic Training Program on Male Faculty Members and Administrators at Oklahoma State University. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, Oklahoma.

Thomas, S. G., Cunningham, D. A., Rechnitzer, P. A., Donner, A. P., & Howard, J. H. (1985). Determinants of the Training Response in Elderly Men. Medicine and Science in Sports and Exercise, 17(6), 667-672.

Tzankoff, S. P., Robinson, S., Pyke, F. S., & Brown, C. A. (1972). Physiological Adjustments to Work in Older Men as Affected by Physical Training. Journal of Applied Physiology, 33, 346-350.

Vaccaro, P., Ostrove, S. M., Vandervelden, L., Goldfarb, A. H., Dummer, D. M., & Clarke, D. H. (1984). Body Composition and Physiological Responses of Masters Female Swimmers 20 to 70 Years of Age. Research Quarterly for Exercise and Sport, 55, 278-284.

Wilmore, J. H., Miller, H. L., & Pollock, M. L. (1974). Body Composition and Physiological Characteristics of Active Endurance Athletes in Their Eighth Decade of Life. Medicine and Science in Sport, 6(1), 44-48.

Zingale, D. P. (1977). "Ike" Revisited on Sport and National Fitness. Research Quarterly, 48(1), 12-18.

APPENDIXES

APPENDIX A

RAW DATA

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	AGE	HT	WT	BSA	AERO_PTS	PLS_LYN	PLS_STN	SYS_LYN	DIAS_LYN	AVE_PTS
1	1	1	55	67.00	130	1.70	9	48	60	115	70	.
2	1	2	53	65.25	152	1.76	8	72	78	130	75	.
3	1	3	31	68.50	152	1.84	8	72	92	105	65	.
4	1	6	37	68.50	196	2.04	0	72	80	135	85	.
5	1	7	44	70.00	182	2.00	15	72	84	120	70	.
6	1	8	34	73.75	191	2.10	46	60	76	135	75	.
7	1	9	33	70.50	166	1.92	30	66	72	120	80	.
8	1	10	42	70.00	210	2.15	15	66	72	140	70	.
9	1	12	35	68.50	162	1.87	18	66	72	118	60	.
10	1	15	51	67.00	170	1.88	42	48	54	118	70	.
11	1	17	29	67.50	169	1.89	6	60	78	110	75	.
12	1	18	35	71.50	169	1.96	12	66	78	135	90	.
13	1	21	44	68.00	156	1.84	21	66	72	105	60	.
14	1	26	55	70.00	193	2.06	5	66	68	108	75	.
15	1	27	48	67.50	162	1.83	20	54	60	122	82	.
16	1	28	33	73.00	218	2.20	6	114	114	140	80	.
17	1	29	37	67.50	155	1.84	15	78	84	130	75	.
18	1	30	50	67.00	145	1.76	30	72	78	120	75	.
19	1	31	30	67.00	155	1.82	25	72	75	125	70	.
20	1	34	33	71.00	150	1.88	0	72	78	130	80	.
21	1	36	30	75.00	176	2.12	0	78	88	110	65	.
22	1	38	36	68.75	196	2.00	15	51	64	115	70	.
23	1	41	43	71.50	176	2.00	25	54	66	120	75	.
24	1	42	46	72.50	179	2.05	20	54	76	135	80	.
25	1	45	52	69.75	180	2.00	0	72	84	135	85	.
26	1	48	44	70.00	186	2.02	0	57	68	124	80	.
27	1	49	55	67.00	149	1.78	20	78	84	150	90	.
28	1	50	59	71.50	194	2.10	10	78	90	120	80	.
29	1	54	45	70.25	152	1.86	22	72	84	120	75	.
30	1	55	38	70.50	179	1.95	30	48	66	115	70	.
31	1	56	52	71.00	152	1.88	20	68	68	120	80	.
32	1	57	57	68.25	177	1.92	0	60	72	135	82	.
33	1	58	28	75.00	230	2.34	12	54	60	120	80	.
34	1	59	58	72.25	172	2.00	25	66	102	115	70	.
35	1	60	49	66.75	161	1.84	5	54	60	115	70	.
36	1	62	38	71.25	182	2.04	20	66	78	120	70	
37	1	63	38	74.50	210	2.22	0	60	76	120	80	.
38	1	64	43	72.25	174	2.00	20	78	90	110	65	.
39	1	68	37	68.00	160	1.87	30	45	56	115	70	.
40	1	71	40	73.50	200	2.16	0	72	84	135	85	.
41	1	81	30	70.50	163	1.93	50	54	72	130	80	.
42	1	82	30	73.00	207	2.19	15	78	84	123	70	.
43	1	86	57	71.00	176	2.04	20	48	54	120	62	.
44	1	90	39	70.50	183	2.03	15	72	84	120	75	.
45	1	91	38	70.50	163	1.91	12	66	88	100	60	.
46	1	93	40	74.00	234	2.30	10	60	80	125	75	.
47	1	95	50	69.50	168	1.90	15	60	72	120	70	.
48	1	97	55	74.50	213	2.24	0	72	78	130	80	.
49	1	98	30	70.50	176	1.98	15	78	90	110	75	.
50	1	102	57	69.50	187	2.00	0	60	72	123	82	.
51	1	107	35	70.25	154	1.88	265	60	72	125	70	.
52	2	1	69	66.25	132	1.68	10	53	72	110	80	19

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	AGE	HT	WT	BSA	AERO_PTS	PLS_LYN	PLS_STN	SYS_LYN	DIAS_LYN	AVE_PTS
53	2	2	67	64.75	145	1.72	5	85	93	140	80	9
54	2	3	45	68.50	158	1.86	46	56	73	110	75	31
55	2	6	50	68.25	203	2.06	0	60	74	130	80	0
56	2	7	58	70.00	191	2.05	20	64	74	150	90	15
57	2	8	47	73.25	198	2.15	70	58	79	120	85	55
58	2	9	47	71.00	178	2.01	40	59	61	120	85	63
59	2	10	56	71.00	189	2.06	40	55	68	130	80	28
60	2	12	48	68.50	157	1.86	21	55	64	110	65	17
61	2	15	64	67.00	163	1.86	40	40	49	130	80	50
62	2	17	42	67.75	159	1.85	0	64	80	108	75	18
63	2	18	49	71.50	175	2.00	10	62	78	115	78	15
64	2	21	58	68.25	141	1.77	280	42	45	115	65	314
65	2	26	69	68.50	166	1.90	18	63	65	130	90	8
66	2	27	61	67.50	159	1.85	25	54	69	105	75	26
67	2	28	47	72.50	235	2.29	24	74	85	140	90	13
68	2	29	50	68.25	192	2.02	0	80	84	135	90	20
69	2	30	64	67.00	152	1.80	33	66	93	130	83	29
70	2	31	44	67.50	150	1.80	45	72	72	115	75	48
71	2	34	46	72.00	156	1.92	4	57	68	135	90	1
72	2	36	43	76.00	212	2.27	0	63	76	115	70	0
73	2	38	50	69.25	221	2.16	8	64	67	120	85	21
74	2	41	56	72.00	171	1.99	30	58	61	120	75	36
75	2	42	60	72.50	176	2.03	29	51	67	135	90	30
76	2	45	65	69.50	181	1.99	0	91	108	130	90	3
77	2	48	58	70.75	223	2.20	6	55	57	140	80	2
78	2	49	68	66.50	169	1.87	0	64	74	140	90	16
79	2	50	70	71.25	177	2.01	12	60	75	110	70	6
80	2	54	59	70.50	155	1.88	8	62	65	125	80	30
81	2	55	51	71.00	179	2.01	14	53	82	124	78	27
82	2	56	66	70.50	144	1.83	33	54	60	135	85	27
83	2	57	71	68.50	162	1.88	0	55	64	125	80	7
84	2	58	42	76.00	256	2.46	30	57	67	125	80	18
85	2	59	71	71.50	156	1.91	20	59	84	110	75	18
86	2	60	62	67.50	167	1.88	12	49	52	120	85	11
87	2	62	52	71.50	187	2.06	27	70	85	110	70	37
88	2	63	52	74.50	241	2.37	8	62	76	120	85	4
89	2	64	57	72.00	163	1.95	48	55	62	110	70	32
90	2	68	51	69.00	160	1.88	0	56	67	140	90	18
91	2	71	54	73.75	201	2.17	6	75	90	160	95	11
92	2	81	44	71.50	167	1.97	300	43	48	115	80	175
93	2	82	43	73.50	228	2.29	98	80	96	140	90	30
94	2	86	72	71.00	190	2.07	16	48	55	120	75	21
95	2	90	53	71.25	191	2.08	8	76	80	130	85	19
96	2	91	51	70.75	176	1.99	0	75	100	105	75	0
97	2	93	53	73.50	247	2.37	10	64	84	135	85	8
98	2	95	61	69.50	176	1.97	22	61	63	125	80	16
99	2	97	68	73.75	218	2.25	0	67	89	135	75	3
100	2	98	43	71.00	157	1.90	160	61	70	130	85	74
101	2	102	69	69.25	195	2.05	0	57	61	135	95	0
102	2	107	48	69.00	162	1.89	240	50	70	.	.	278

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	SYS_STN	DIAS_STN	O2_IN	FVC	FEV1	VIT_CAP	MBC
1	1	1	105	65	0.30	.	.	4.20	156.1
2	1	2	140	85	0.33	87.00	70.0	3.58	84.2
3	1	3	105	75	0.46	85.00	88.0	4.65	141.6
4	1	6	135	85	0.45	85.00	81.0	4.12	156.1
5	1	7	125	80	0.46	89.00	146.0	5.64	179.2
6	1	8	130	70	0.30	100.00	100.0	5.75	141.6
7	1	9	120	80	0.41	.	.	5.32	133.0
8	1	10	145	80	0.38	98.00	98.0	5.10	156.1
9	1	12	122	75	0.32	110.00	112.0	5.26	165.9
10	1	15	125	70	0.36	89.00	78.0	4.18	112.7
11	1	17	115	75	0.27	96.00	95.0	4.64	161.9
12	1	18	135	90	0.39	93.00	100.0	5.40	199.4
13	1	21	105	65	0.27	106.00	99.0	4.72	132.9
14	1	26	102	70	0.46	87.00	83.0	3.99	104.0
15	1	27	123	85	0.24	101.00	108.0	4.66	199.4
16	1	28	145	95	0.47	112.00	111.0	6.24	190.8
17	1	29	120	85	0.41	114.00	103.0	5.60	164.8
18	1	30	125	80	0.47	93.00	98.0	3.91	150.3
19	1	31	138	80	0.30	89.00	97.0	4.23	205.2
20	1	34	120	73	0.33	87.00	99.0	4.65	190.8
21	1	36	105	70	0.30	101.00	95.0	5.48	159.0
22	1	38	130	80	0.39	83.00	86.0	3.62	211.0
23	1	41	120	75	0.44	113.00	119.0	5.86	130.1
24	1	42	150	87	0.29	87.00	85.0	4.89	185.0
25	1	45	128	80	0.40	88.00	93.0	4.81	147.0
26	1	48	118	75	0.23	84.00	88.0	4.29	156.1
27	1	49	140	90	0.30	126.00	141.0	5.56	170.5
28	1	50	120	90	0.38	115.00	114.0	5.21	163.2
29	1	54	135	80	0.35	108.00	104.0	5.21	196.6
30	1	55	110	80	0.33	100.00	95.0	5.32	144.5
31	1	56	130	80	0.32	98.00	87.0	4.58	159.5
32	1	57	130	85	0.24	94.00	101.0	4.12	138.7
33	1	58	135	90	0.41	.	.	6.62	248.6
34	1	59	100	65	0.40	107.00	102.0	4.99	130.1
35	1	60	118	70	0.29	102.00	112.0	4.72	231.0
36	1	62	125	80	0.28	131.00	118.0	6.40	196.5
37	1	63	132	80	0.39	92.00	92.0	4.95	161.9
38	1	64	115	70	0.40	118.00	110.0	5.56	156.1
39	1	68	130	90	0.47	103.00	105.0	4.90	150.3
40	1	71	140	80	0.61	98.00	73.0	5.50	153.2
41	1	81	130	80	0.33	79.00	77.0	5.02	190.8
42	1	82	130	75	0.36	99.00	106.0	5.20	100.2
43	1	86	118	80	0.27	75.00	61.0	2.85	66.5
44	1	90	125	80	0.30	93.00	124.0	5.21	180.9
45	1	91	115	70	0.35	109.00	105.0	5.60	141.6
46	1	93	112	90	0.24	81.00	137.0	5.29	97.4
47	1	95	130	80	0.36	95.00	92.0	3.91	101.2
48	1	97	135	85	0.32	109.00	106.0	5.78	171.8
49	1	98	125	85	0.32	106.00	100.0	5.50	153.2
50	1	102	120	90	0.24	87.00	101.0	3.87	88.9
51	1	107	138	80	0.33	109.00	102.0	5.51	176.3
52	2	1	105	75	0.20	3.41	2.4	3.72	122.0

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	SYS_STN	DIAS_STN	O2_IN	FVC	FEV1	VIT_CAP	MBC
53	2	2	150	85	0.32	2.63	1.17	2.64	52.8
54	2	3	110	75	0.29	4.46	3.47	4.73	150.0
55	2	6	135	90	.	4.03	3.19	3.95	114.3
56	2	7	155	95	0.33	4.91	3.83	4.87	165.9
57	2	8	118	85	0.25	5.20	4.04	5.50	127.5
58	2	9	130	85	0.29	4.59	3.39	5.06	155.3
59	2	10	120	80	0.15	5.00	4.07	5.17	188.0
60	2	12	115	75	0.25	5.58	4.79	5.45	162.9
61	2	15	130	80	0.21	3.41	2.04	3.34	78.5
62	2	17	110	80	0.30	4.51	3.74	4.48	128.9
63	2	18	110	80	0.32	5.39	4.29	5.34	190.5
64	2	21	110	70	0.35	4.55	3.41	4.66	123.0
65	2	26	135	90	0.30	3.80	2.59	4.10	99.6
66	2	27	108	80	0.31	4.75	3.69	4.24	184.6
67	2	28	140	95	0.44	5.97	4.87	5.91	189.0
68	2	29	140	90	0.34	4.76	3.83	5.02	170.0
69	2	30	125	90	0.32	3.81	2.94	4.02	154.0
70	2	31	118	80	0.23	4.68	3.83	4.52	181.7
71	2	34	130	90	0.14	4.69	3.85	4.69	161.2
72	2	36	115	75	0.34	5.50	4.66	5.61	170.0
73	2	38	125	90	0.38	4.84	4.19	4.88	193.4
74	2	41	115	75	0.32	5.81	4.47	5.97	149.5
75	2	42	140	90	0.26	5.01	3.95	4.71	175.8
76	2	45	120	90	0.32	4.05	2.84	5.10	123.1
77	2	48	130	80	0.29	3.12	2.44	3.74	133.0
78	2	49	135	85	0.28	4.90	3.82	4.88	131.9
79	2	50	110	80	0.29	5.00	3.63	5.17	170.0
80	2	54	120	80	0.23	5.10	3.90	5.31	180.5
81	2	55	130	90	0.27	5.10	3.85	5.10	164.0
82	2	56	130	90	0.26	4.34	3.25	4.18	243.0
83	2	57	110	70	0.20	3.30	2.62	3.63	112.5
84	2	58	135	90	0.37	5.91	4.79	6.13	216.9
85	2	59	110	80	0.23	4.79	3.51	4.59	127.0
86	2	60	120	80	0.27	3.69	3.10	3.73	153.5
87	2	62	105	75	0.36	6.74	4.40	6.96	172.9
88	2	63	120	80	0.33	4.15	3.18	4.44	146.5
89	2	64	110	75	0.26	4.68	3.41	4.70	158.3
90	2	68	140	100	0.27	5.14	3.78	5.21	130.5
91	2	71	160	100	0.34	5.13	3.11	5.28	146.5
92	2	81	120	80	0.31	5.40	5.00	6.00	191.0
93	2	82	140	100	0.36	5.28	4.54	5.30	90.8
94	2	86	130	80	0.25	3.69	2.56	3.53	102.6
95	2	90	130	85	0.26	4.95	3.77	5.01	138.9
96	2	91	105	80	0.28	5.76	4.65	5.79	159.4
97	2	93	125	85	0.36	5.78	4.57	4.93	104.3
98	2	95	130	80	0.28	4.21	3.33	4.59	137.7
99	2	97	130	75	0.36	5.29	3.81	5.29	152.4
100	2	98	130	85	0.30	5.98	4.29	5.68	175.8
101	2	102	135	95	0.27	3.41	2.55	3.56	105.5
102	2	107	118	85	0.27	5.49	3.85	5.67	181.7

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA   CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	TRI	CHEST	ABDOM	SUBCAP	ILIAC	THIGH	MIDAX	PCTBF	SUM7BF	BESTBF
1	1	1	11	4	4	8	.	.	.	5	.	4.5371
2	1	2	7	8	14	12	.	.	.	8	.	5.9566
3	1	3	13	4	13	13	.	.	.	9	.	6.3663
4	1	6	13	15	19	20	.	.	.	14	.	11.0108
5	1	7	14	14	19	19	.	.	.	14	.	10.9854
6	1	8	14	20	24	18	.	.	.	16	.	13.7899
7	1	9	7	7	9	7	.	.	.	6	.	4.9511
8	1	10	19	16	25	31	.	.	.	15	.	14.1546
9	1	12	10	10	20	11	.	.	.	10	.	8.4158
10	1	15	11	11	19	14	.	.	.	10	.	8.9553
11	1	17	7	11	10	14	.	.	.	8	.	6.4642
12	1	18	9	6	10	10	.	.	.	7	.	5.3779
13	1	21	11	8	14	10	.	.	.	9	.	7.2424
14	1	26	10	21	28	19	.	.	.	16	.	13.3701
15	1	27	10	11	15	17	.	.	.	10	.	8.0965
16	1	28	17	26	32	35	.	.	.	21	.	18.0455
17	1	29	17	17	21	16	.	.	.	16	.	13.3039
18	1	30	8	6	12	12	.	.	.	6	.	5.3222
19	1	31	16	13	18	18	.	.	.	13	.	11.1521
20	1	34	8	9	19	11	.	.	.	8	.	7.2882
21	1	36	5	4	11	9	.	.	.	6	.	3.5474
22	1	38	11	21	30	27	.	.	.	16	.	13.9734
23	1	41	6	5	19	12	.	.	.	7	.	5.2623
24	1	42	12	16	26	22	.	.	.	14	.	11.9832
25	1	45	7	10	12	12	.	.	.	9	.	6.3833
26	1	48	11	19	24	33	.	.	.	16	.	12.4455
27	1	49	4	11	17	13	.	.	.	9	.	6.4289
28	1	50	10	13	10	19	.	.	.	9	.	8.1258
29	1	54	5	6	7	9	.	.	.	4	.	3.7075
30	1	55	12	11	13	10	.	.	.	11	.	8.4765
31	1	56	7	7	6	10	.	.	.	6	.	4.5558
32	1	57	8	15	18	15	.	.	.	10	.	9.2466
33	1	58	16	17	22	18	.	.	.	16	.	13.1103
34	1	59	10	12	10	10	.	.	.	10	.	7.7776
35	1	60	11	16	18	29	.	.	.	12	.	10.5745
36	1	62	6	4	5	11	.	.	.	5	.	3.0786
37	1	63	11	13	23	23	.	.	.	13	.	10.1933
38	1	64	6	8	9	10	.	.	.	7	.	4.9759
39	1	68	11	13	15	14	.	.	.	11	.	9.1187
40	1	71	9	10	16	13	.	.	.	9	.	7.5588
41	1	81	8	8	16	20	.	.	.	8	.	6.5427
42	1	82	10	17	23	44	.	.	.	13	.	11.2747
43	1	86	7	8	12	18	.	.	.	9	.	5.6920
44	1	90	15	14	22	14	.	.	.	14	.	11.7185
45	1	91	9	6	15	11	.	.	.	8	.	6.0393
46	1	93	19	18	32	31	.	.	.	18	.	15.8302
47	1	95	12	11	19	19	.	.	.	11	.	9.2799
48	1	97	11	16	26	33	.	.	.	13	.	11.6551
49	1	98	9	12	18	12	.	.	.	12	.	8.5224
50	1	102	15	17	19	27	.	.	.	14	.	12.3732
51	1	107	5	3	7	9	.	.	.	4	.	2.6821
52	2	1	16	9	10	9	5	25	9	.	17.11	8.6728

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	TRI	CHEST	ABDOM	SUBCAP	ILIAC	THIGH	MIDAX	PCTBF	SUM7BF	BESTBF
53	2	2	7	7	22	12	12	8	10	.	16.00	6.6712
54	2	3	8	8	15	12	17	11	16	.	14.69	6.4101
55	2	6	13	22	31	25	23	17	22	.	24.17	15.1306
56	2	7	16	22	27	17	18	17	23	.	23.62	15.5791
57	2	8	12	25	35	14	22	12	20	.	22.19	16.4245
58	2	9	8	9	32	12	6	14	12	.	15.82	9.0242
59	2	10	16	18	19	17	20	15	18	.	21.16	13.0572
60	2	12	10	10	25	9	15	11	10	.	15.50	9.0850
61	2	15	10	13	24	11	17	22	16	.	20.82	10.0020
62	2	17	9	10	22	12	17	18	10	.	16.00	8.3594
63	2	18	14	9	24	9	18	15	14	.	17.51	9.9009
64	2	21	11	8	11	8	9	11	7	.	12.94	6.8436
65	2	26	10	15	21	10	13	15	12	.	19.00	10.3007
66	2	27	9	15	25	20	15	14	21	.	21.00	10.5133
67	2	28	14	27	32	17	21	17	30	.	24.00	17.4003
68	2	29	18	26	30	18	28	26	32	.	27.00	18.1040
69	2	30	11	12	21	13	16	13	11	.	18.60	9.5735
70	2	31	12	12	21	13	17	15	17	.	17.00	9.8990
71	2	34	11	17	26	17	17	13	16	.	19.00	12.0086
72	2	36	7	17	21	15	11	20	17	.	17.45	10.0253
73	2	38	20	32	28	19	27	24	30	.	27.25	20.6844
74	2	41	8	7	20	10	13	12	8	.	15.00	6.7272
75	2	42	14	20	27	12	24	14	17	.	22.00	14.1997
76	2	45	9	15	12	14	10	14	14	.	17.00	8.7673
77	2	48	16	32	34	28	27	30	29	.	30.00	20.1681
78	2	49	19	24	29	20	21	18	24	.	26.76	17.5775
79	2	50	11	8	18	8	7	13	8	.	15.69	7.7752
80	2	54	6	10	16	11	10	7	11	.	14.00	6.5926
81	2	55	16	12	20	12	11	10	16	.	17.00	11.0697
82	2	56	6	7	12	7	5	12	9	.	12.93	5.0273
83	2	57	13	15	17	21	16	13	25	.	22.70	10.7409
84	2	58	13	27	38	27	32	30	29	.	27.80	17.8960
85	2	59	10	10	9	7	6	7	10	.	13.60	6.9496
86	2	60	11	15	21	20	13	10	17	.	19.70	10.6270
87	2	62	14	14	20	11	15	14	13	.	17.60	11.1204
88	2	63	20	23	34	26	29	29	27	.	28.00	18.2448
89	2	64	7	7	12	8	9	8	5	.	11.40	5.3470
90	2	68	11	15	27	12	29	19	13	.	20.90	11.4373
91	2	71	8	12	23	13	16	11	13	.	17.00	8.8674
92	2	81	11	9	15	13	13	12	11	.	14.00	7.7232
93	2	82	14	26	28	27	23	14	26	.	24.00	16.4871
94	2	86	13	16	19	11	16	24	18	.	22.39	11.3634
95	2	90	13	22	23	14	23	12	18	.	21.00	14.0354
96	2	91	11	14	24	13	14	16	12	.	18.00	10.6796
97	2	93	16	22	28	20	29	17	25	.	25.00	15.7165
98	2	95	16	20	28	20	20	24	22	.	25.00	14.9998
99	2	97	13	15	23	18	21	17	23	.	23.60	11.5514
100	2	98	8	6	11	11	10	7	6	.	10.00	5.1902
101	2	102	15	22	22	24	16	24	24	.	26.00	14.5611
102	2	107	7	6	16	9	7	15	9	.	12.00	5.5307

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	HRTRATE	PCTGRD	ML_KG	METVO2	CLASS	HRO3	SYSO3	DIASO3	HRO5	SYSO5	DIASO5
1	1	1	180	14	35.0	.	4	108	.	.	102	.	.
2	1	2	180	14	35.0	.	4	114	.	.	102	.	.
3	1	3	180	16	38.5	.	3	108	.	.	102	.	.
4	1	6	180	19	43.5	.	4	90	.	.	84	.	.
5	1	7	180	15	37.0	.	4	96	.	.	84	.	.
6	1	8	180	20	45.0	.	4	108	.	.	96	.	.
7	1	9	180	18	42.0	.	4	96	.	.	78	120	80
8	1	10	180	16	38.0	.	4	102	155	60	102	135	70
9	1	12	180	23	50.0	.	5	108	160	70	102	125	60
10	1	15	170	20	45.0	.	5	84	160	65	78	140	70
11	1	17	180	19	43.5	.	4	90	132	64	90	120	72
12	1	18	180	20	45.0	.	4	102	148	56	96	148	84
13	1	21	180	23	50.0	.	5	102	130	58	96	116	70
14	1	26	180	14	35.0	.	4	78	124	60	78	118	62
15	1	27	180	23	50.0	.	5	102	142	58	96	140	72
16	1	28	180	14	35.0	.	3	114	160	56	102	156	68
17	1	29	180	15	37.0	.	3	114	136	60	108	140	66
18	1	30	180	22	48.5	.	5	114	156	68	102	136	68
19	1	31	180	20	45.0	.	4	108	156	68	102	138	66
20	1	34	180	17	40.0	.	4	96	160	60	84	140	60
21	1	36	162	18	42.0	.	4	.	.	.	.	.	.
22	1	38	180	16	38.0	.	3	84	152	75	84	132	75
23	1	41	180	17	40.0	.	4	96	138	62	84	125	70
24	1	42	180	19	43.5	.	4	90	152	62	84	144	60
25	1	45	180	18	42.0	.	4	102	170	70	102	144	76
26	1	48	120	3	19.0	.	1	66	145	85	66	130	80
27	1	49	180	16	38.5	.	4	108	115	80	102	105	70
28	1	50	180	15	37.0	.	3	96	150	90	96	130	80
29	1	54	180	15	36.5	.	4	108	.	.	102	.	.
30	1	55	180	21	47.0	.	4	.	.	.	.	.	.
31	1	56	180	16	38.5	.	4	108	.	.	96	.	.
32	1	57	180	13	34.0	.	4	84	170	70	78	145	70
33	1	58	180	18	42.0	.	4	.	.	.	.	.	.
34	1	59	180	7	21.0	.	1	114	.	.	108	.	.
35	1	60	180	18	42.0	.	4	96	150	70	96	135	70
36	1	62	180	17	40.0	.	4	108	.	.	96	.	.
37	1	63	180	14	35.0	.	3	.	.	.	98	.	.
38	1	64	180	15	37.0	.	3	108	.	.	.	.	.
39	1	68	180	20	45.0	.	4	114	156	60	104	135	65
40	1	71	180	14	35.0	.	3	108	142	78	102	128	80
41	1	81	180	20	45.0	.	4	96	152	58	96	140	70
42	1	82	180	14	35.0	.	3	108	170	60	96	140	70
43	1	86	180	14	35.0	.	4	84	.	.	72	.	.
44	1	90	180	17	40.0	.	4		.		.	.	.
45	1	91	180	15	37.0	.	3	120	.	.	108	.	.
46	1	93	180	14	35.0	.	3	96	145	80	90	138	90
47	1	95	180	17	40.0		4	108	150	100	90	125	95
48	1	97	180	16	38.5		4	96	145	72	90	138	75
49	1	98	180	18	42.0	.	3	108	144	60	102	132	72
50	1	102	180	12	30.0	.	3	90	120	70	84	142	80
51	1	107	180	22	48.5	.	5	84	147	60	84	120	60
52	2	1	167	13	33.9	32.3	4	93	145	85	90	135	80

FACULTY FITNESS RECORDS, 1986, CAT=R, 3/24/87
ALLDATA CAMPBELL DISSERTATION SET

OBS	YEAR	NUMB	HRTRATE	PCTGRD	ML_KG	METVO2	CLASS	HR03	SYS03	DIAS03	HR05	SYS05	DIAS05
53	2	2	171	7.0	23.0	26.0	3	148	200	90	118	175	90
54	2	3	181	23.0	49.0	50.0	6	113	165	75	101	125	70
55	2	6	144	12.0	31.5	29.5	3	77	180	90	79	145	90
56	2	7	183	16.0	37.5	37.8	4	105	190	85	100	170	85
57	2	8	185	22.0	47.0	44.7	5	123	155	90	112	130	90
58	2	9	173	20.0	44.5	45.0	5	109	165	80	.	140	85
59	2	10	164	18.0	41.0	38.7	5	111	150	80	105	130	80
60	2	12	178	24.0	51.9	45.7	6	110	140	65	105	130	60
61	2	15	170	18.0	41.0	34.8	5	76	170	80	77	145	80
62	2	17	181	18.0	41.0	44.1	4	107	125	80	93	120	75
63	2	18	180	19.0	43.0	40.2	5	100	130	80	93	120	70
64	2	21	150	28.0	58.5	57.5	6	77	145	70	68	130	70
65	2	26	140	13.0	33.9	30.9	4	95	160	95	93	160	95
66	2	27	171	19.0	43.0	42.0	5	111	158	75	102	135	75
67	2	28	177	16.0	37.5	35.2	3	120	175	90	110	160	80
68	2	29	172	14.0	34.5	32.4	3	123	170	85	118	145	90
69	2	30	174	16.0	37.5	35.1	5	117	165	85	113	150	85
70	2	31	169	20.0	44.5	44.5	5	105	130	70	99	125	75
71	2	34	155	16.0	37.5	36.7	3	122	180	90	113	170	90
72	2	36	174	19.0	43.0	37.6	4	109	135	65	104	120	70
73	2	38	165	12.5	32.3	28.5	3	108	165	90	98	.	.
74	2	41	178	24.0	51.9	46.5	6	105	160	70	98	135	70
75	2	42	180	19.5	43.8	41.6	5	102	180	85	94	160	85
76	2	45	138	5.0	20.0	14.7	1	118	140	90	90	140	90
77	2	48	116	9.5	23.1	20.4	1	69	150	80	67	136	80
78	2	49	153	12.0	31.5	31.8	3	109	184	85	99	165	85
79	2	50	123	7.3	25.5	26.1	2	82	130	80	78	115	85
80	2	54	141	15.0	36.0	35.1	4	88	140	85	84	135	85
81	2	55	172	22.0	47.0	42.6	6	126	165	85	117	160	90
82	2	56	163	17.0	39.0	30.4	5	90	160	90	81	150	90
83	2	57	102	8.5	25.5	20.8	2	73	110	65	70	110	65
84	2	58	170	17.0	39.0	38.2	4	113	160	80	105	145	85
85	2	59	169	10.0	28.0	31.5	3	114	166	76	109	135	80
86	2	60	158	16.0	37.5	36.2	5	96	180	90	85	155	90
87	2	62	165	15.0	36.0	33.1	4	102	145	80	97	130	80
88	2	63	174	16.5	38.2	35.4	4	116	150	85	110	130	90
89	2	64	160	22.0	47.0	47.7	6	86	180	80	91	150	75
90	2	66	177	19.0	43.0	39.3	5	113	170	100	103	148	90
91	2	71	189	16.0	37.5	34.1	4	120	185	85	120	180	90
92	2	81	178	30.0	61.8	58.0	6	96	145	75	96	135	75
93	2	82	186	14.0	34.5	33.9	3	127	180	85	119	170	90
94	2	86	140	11.0	29.5	29.3	3	72	140	80	65	135	75
95	2	90	146	12.0	31.5	29.5	3	96	150	80	91	130	85
96	2	91	183	16.0	37.5	37.1	4	122	115	70	119	115	70
97	2	93	182	14.0	34.5	31.9	3	115	170	80	84	145	85
98	2	95	162	17.0	39.0	32.6	5	103	170	80	91	145	85
99	2	97	155	11.0	29.5	29.3	3	104	180	90	99	155	90
100	2	98	172	27.0	56.9	56.5	6	94	175	80	90	155	90
101	2	102	166	10.0	28.0	29.1	3	124	185	100	98	150	90
102	2	107	186	32.0	51.4	51.4	6	110	150	78	.	125	78

APPENDIX B

INFORMED CONSENT

Oklahoma State University

School of Health, Physical Education and Leisure Services

STILLWATER, OKLAHOMA 74078
COLVIN PHYSICAL EDUCATION CENTER
(405) 624-5493

INFORMED CONSENT FOR FITNESS TESTING

SUBJECT'S NAME ______________________ DATE ______________

The battery of tests that you are about to undergo is to aid in the evaluation of your current physical fitness status. The results of the tests will be explained and interpreted to you and additionally will be added to the information previously gathered in the faculty fitness study. 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. Test procedures are similar to those that have been used in this research previously; therefore, you should be familar with the procedure which will be used.

The evaluation will include a resting and exercise electrocardiogram and blood pressure, weight analysis, dietary and stress inventory, respiratory capacities and function, a treadmill exercise tolerance test to determine maximal oxygen intake capacity, and selected blood variables analyzed from venous blood.

Before you undergo testing, Dr. A.B. Harrison will review your medical history and examine resting physiological data to determine whether clearance should be given for the test. Contraindications to exercise testing would include electrocardiogram abnormalities, abnormal heart rate responses, elevated systolic or diastolic blood pressure, or medical information that may indicate that a physician's approval is required.

During exercise testing, Dr. Harrison and other trained personnel will monitor your blood pressure, heart rate and electrocardiogram. Expired air will also be collected via a mask or two way valve so that an actual determination can be made of your maximal oxygen intake. These measurements will provide important information regarding the state of your heart and your cardiovascular fitness. There exists the possibility of certain undesirable changes occuring during the exercise test. They include abnormal blood pressure, pulse rate and electrocardiographic response and in very rare instances heart attack or fatality. Every effort will be made to minimize any hazard by increasing the work effort slowly and by continuous observation and monitoring during testing. Emergency equipment is readily available to deal with any unusual situation which may arise.

All tests except the treadmill walk and blood test are resting tests and involve no unusual risk or discomfort. The treadmill test involves walking at a comfortable rate but workload does increase as the test progresses. A 12-lead ECG is monitored during the treadmill walk and the test is terminated upons signs of cardiac distress. Collection of blood may involve some temporary discomfort.

CONSENT BY SUBJECT

The information which is obtained will be treated as privileged and confidential and will not be released or revealed to any non-medical person without your express written consent.

My signature signifies that I have read the foregoing, understand the procedure as it has been explained by Dr. Harrison or his assistants and agree to participate in the testing. I am aware of any risks which might be involved with my taking the test and understand that test results will be used for research purposes as well as to provide me with a fitness assessment. I also understand that I may withdraw from and discontinue this test at any time during its performance.

CENTENNIAL DECADE 1980 • 1990

Date ______________________ Subject ______________________

Investigator ________________ Witness ______________________

APPENDIX C

DATA COLLECTION FORMS

HEALTH AND FITNESS CENTER
Oklahoma State University

The following information is needed for our records and in assessing your current health and fitness status. By providing as much of this information as possible in advance, time will be saved during the evaluation. All information provided will be held in strict confidence.

NAME ______________________ DATE ______________________

ADDRESS: Street ____________ City ____________ State ______ ZIP______

HOME PHONE ____________ EMPLOYER ______________________

OCCUPATION ____________ BUSINESS ADDRESS ______________ PHONE ______

AGE LAST BIRTHDAY ______ BIRTH YEAR _____ Does your job require physical activity? _____

Do you currently smoke? _____ If so, what? ____________ number/day ______
If not, have you ever smoked?____ If yes, what? __________ no/yrs______ yrs. quit____

Do you ever drink alcoholic beverages? _____ If yes, approx. no.: less than 1/day _____
1-2 per day ______ 3 or more per day ______

Do you currently participate in any form of exercise on a regular basis?_______
Indicate no. of times/weekly of participation: walking _____ jogging _____ swim _____
golf _____ basketball _____ handball/racquetball _____ tennis _____ other (name)______
If you walk, job or swim, please indicate distance and time covered each session and approximate pace ______________________

What is your estimate of your current medical condition? ex.___ good___ fair___ poor___
What is your estimate of your current physical fitness? ex.___ good___ fair___ poor___

Circle the number of blood relatives (parents, grandparents, brothers, sisters, that have been diagnosed as having some form of heart disease:
Under 60 years of age: 1 2 3 4 5 6 7 8 9 Over 60 years of age: 1 2 3 4 5 6 7 8 9

Have you ever been told that you have any form of heart disease? _____
Have you ever been told that you have diabetes? _____
Do you have blood relatives with diabetes? _____ If so, how many? _____

Do you consider yourself to be overweight? _____ If so, approx. how many lbs.? _____
Do you have any medical conditions (other than heart disease or diabetes) that might affect your exercise performance? _____ If so, please list ______________

Who is your family physician? ______________ City ____________
Address, if known ______________ date last medical exam __________
Would you like your stress test records sent to this physician? _____
If you would prefer to have your records sent to another physician, please list name and address ______________________

Are you currently taking any kind of medication? _____
If yes, is it non-prescription? _____ If so, name ______________
If yes, is it prescription? _____ If yes, give name if possible ______________

Have you ever been told that you had high cholesterol or high triglyceride levels in the blood? Cholesterol: yes___ no___ Triglyceride: yes___ no___

If you know your cholesterol and/or triglyceride levels, please list

Cholesterol _________ Triglyceride _________

Date____________ mo./day/yr.

SUMMARY SHEET

Member No.______ 1-11

□F (fac. pay)
□C (comm. pay)
□R (research)
□S (special)
□A (retest)

01 □ 0 ≥ 60
□ P PS
□ H 50+
□ C cs
□ M mthn

□male
□female

Name______________ ______________ (first) (last)

Home Address______________ (zip code)

02 City____________ State______ H Phone___/___-____ W Phone___/___-____

Level of Supervision □ TLEX □HSWF □ SEMP □BCLB □MNGR □HVLB □OFWK

Profession____________ Birthyear______ Age____

03 Ht_____ Wt______ BSA_____ Physician____________ City__________ Date Last Med____

Contraindications______________

04 Medication______________ Family History______________ □AS □CS □PS Risko______

05 Smoking □SM □NS □Q Years Quit______ Years Smoked______ □CI □CG □PI Number/Day______

Activity______________ type Days/Wk______ Hrs/Session______ Min/Session______

Pts/Wk______ Months on Pattern______

Alcohol (yes/no)______ □less than 1 drink/day □1-2/day □3+/day

11 Schneider index______ Resting Pulse: Lying______ Standing______

Blood Pressure: Sitting______ Lying______ Standing______ ICE______

12 RESP: O_2 intake______ Min Vol Vent______/m^2 Vent EQ______ TVC______ FVC______ FEV_1______

FVC/vc______ vital cap______ % norm______ MBC______ % norm______ %MVV______

TV______ BPM______

13 EKG: Comments______________ P-R______ Pulse______ Amp P______ Amp R______

Amp T______ work time______ rest time______ rest/work______ QIHS______ QRS______

EP______ TP______ EP/HR______ EP/TP______ ST depression______ Arrythmia______

14 ANT: Predicted weight (Benke Meas. Used)______ Res ±______ TRI______ Chest______ Abdom______

Subscap______ Iliac______ Bicep______ Rt. wrist______ % B.F. nomogram______ S.G.______

4s______ I. Wt. Res ±______ under water______

15 TREAD: Heart Rate______ METS______ Speed______ % Grade______ O_2L______ O_2 ml/kg/min______

Class______ Comments______________

16 SFRT: Grip (strong)______ weak______ LEG strong______ weak______ flex______

Push______ Pull______ SRT______ VJRT______ O_2 Sat______

20 POST: 3 min. HR____ BP____ EP____ TP____ EP/HR____ EP/TP____ EKG______________ QIHS______

21 5 min. HR____ BP____ EP____ TP____ EP/HR____ EP/TP____ EKG______________ QIHS______

22 Chol-Tri Total______ HDL______ LDL______ TRI______

Treadmill Results

NAME ______________________ AGE ________ SEX ________ DATE ____________

Resting: Heart Rate Blood Pressure Cat. ______________

Supine ______________ _____/_____

Standing ______________ _____/_____

3.4 mph

Grade	METS	/ O2	Heart Rate	BP	EKG Comments
0	3.4	11.2			
2	4.2	14.5			
3	4.7	16.5			
4	5.1	18.0			
5	5.7	20.0			
6	6.1	21.5			
7	6.6	23.0			
8	7.1	24.5			
9	7.5	26.5			
10	8.0	28.0			
11	8.5	29.5			
12	9.0	31.5			
13	9.4	33.9			
14	9.9	34.5			
15	10.3	36.0			
16	10.8	37.5			
17	11.2	39.0			
18	11.7	41.0			
19	12.2	43.0			
20	12.7	44.5			21-32 cont. on back

Recovery: HR BP

3 min. ____________ ________/________

5 min. ____________ ________/________

8 min. ____________ ________/________

Reasons for Stopping: Anxiety ☐ Dyspnea ☐ Nausea ☐ Dizziness ☐ Chest Pain ☐
Leg Weakness ☐ Claudication ☐ Gen. Fatigue ☐
Hypotension ☐ EKG Changes ☐ Hypertension ☐
Other ______________________________________

Grade	METS / 02		Heart Rate	BP	EKG Comments
21	13.2	46.0			
22	13.6	47.0			
23	14.0	49.0			
24	14.9	51.9			
25	15.3	53.6			
26	15.8	55.7			
27	16.3	56.9			
28	16.7	58.5			
29	17.2	60.2			
30	17.7	61.8			
31	18.13	63.5			
32	18.6	65.1			

Cooper's Fitness Classification: Men

Category	Measure 0^2ml/kg/min	Age 13-19	20-29	30-39	40-49	50-59	60+
I. Very Poor		< 35.0	< 33.0	< 31.5	< 30.2	< 26.1	< 20.5
II. Poor		35.0-38.3	33.0-36.4	31.5-35.4	30.2-33.5	26.1-30.9	20.5-26.0
III. Fair		38.4-45.1	36.5-42.4	35.5-40.9	33.6-38.9	31.0-35.7	26.1-32.2
IV. Good		45.2-50.9	42.5-46.4	41.0-44.9	39.0-43.7	35.8-40.9	32.2-36.4
V. Excellent		51.0-55.9	46.5-52.4	45.0-49.4	43.8-48.0	41.0-45.3	36.5-44.2
VI. Superior		> 56.0	> 52.5	> 49.5	> 48.1	> 45.4	> 44.3

Coopers Fitness Classification: Women

Category	Measure 0^2ml/kg/min	Age 13-19	20-29	30-39	40-49	50-59	60+
I. Very Poor		< 25.0	< 23.6	< 22.8	< 21.0	< 20.2	< 17.5
II. Poor		25.0-30.9	23.6-28.9	22.8-26.9	21.0-26.4	20.2-22.7	17.5-20.3
III. Fair		31.0-34.9	29.0-32.9	27.0-31.4	24.5-28.9	22.8-26.9	20.2-24.4
IV. Good		35.0-38.9	33.0-36.9	31.5-35.6	29.0-32.8	27.0-31.4	24.5-30.2
V. Excellent		39.0-41.9	37.0-40.9	35.7-40.0	32.9-36.9	31.5-35.7	30.3-31.4
VI. Superior		> 42.0	> 41.0	> 40.1	> 37.0	> 35.8	> 31.5

VITA 2

Kathryn D. Campbell

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECT OF AGE AND ACTIVITY ON MAXIMAL OXYGEN CONSUMPTION AND SELECTED PHYSIOLOGICAL VARIABLES IN ADULT MALES

Major Field: Higher Education

Minor Field: Health, Physical Education and Recreation

Biographical:

Personal Data: Born in Albuquerque, New Mexico, April 21, 1949, the daughter of W. A. and Mary Dunaway. One child, Jarrel Lee, born September 2, 1970.

Education: Attended elementary and junior high school in Alamogordo, New Mexico; graduated from Las Cruces High School, Las Cruces, New Mexico in 1966; received the Bachelor of Science in Education degree from New Mexico State University, Las Cruces, in 1972; received the Master of Science in Health, Physical Education, and Recreation degree from Oklahoma State University, Stillwater, Oklahoma, in 1977; completed 21 hours toward a Ph.D. in Exercise Science degree at Arizona State University, Tempe, Arizona, in 1984; completed requirements for the Doctor of Education degree in Higher Education at Oklahoma State University, Stillwater, Oklahoma, in May, 1987.

Professional Experience: Competed as a member of the women's intercollegiate field hockey, volleyball, softball and golf teams while attending New Mexico State University. Employed from 1973 to 1975 with Tucumcari Public Schools, Tucumcari, New Mexico; served as girls physical education teacher and coach; served as graduate teaching assistant and research assistant in the School of Health, Physical Education and Leisure Services at Oklahoma State University from 1975-77, 1984-85 and 1986-87. Employed by Western New Mexico University, Silver City, New Mexico from 1977 to 1979; served as women's basketball and volleyball coach and men's tennis coach. Employed by Oklahoma State University School of HPELS as lecturer and student teacher supervisor, 1985-86.

Professional Organizations: Member of the American Alliance for Health, Physical Education, Recreation and Dance; American College of Sports Medicine; Central States Chapter of ACSM; Oklahoma Association for Health, Physical Education, Recreation and Dance; New Mexico Association for Health, Physical Education, Recreation and Dance; Phi Epsilon Kappa.