THE EFFECT OF PARTICIPATION IN AN AEROBIC TRAINING PROGRAM FOR SELECTED MEN OVER AGE 25

By

GERALD DOUGLAS HUDDER

Bachelor of Arts
William Jewell College
Liberty, Missouri
1954

Master of Science
West Virginia University
Morgantown, West Virginia
1959

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of the Oklahoma State University
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Thesis Approved:

Roy B. Harrison
Thesis Adviser

Aelbin P. Warner

Harry K. Brobst

John G. Bayless

Gene L. Post

D. Durham
Dean of the Graduate College

769865

PREFACE

Few people question the beneficial effects of regular physical activity. However, one problem often confronting those who wish to become and to remain physically fit is the selection of a physical fitness program upon which they can rely. A current program that has become popular with many groups is entitled "Aerobics." Originally, this program was used for training purposes by the United States Air Force. The purpose of this aerobic activity study was to evaluate its effectiveness in securing and maintaining good levels of cardiovascular fitness for male middle-aged subjects.

The writer wishes to thank all those who encouraged him during the development and completion of this study. Gratitude is acknowledged to Drs. Robert S. Brown, Gene Post, and Harry K. Brobst. A special thanks is extended to Dr. A. P. Warner, advisory committee chairman, for his guidance and concern. Appreciation is expressed to Dr. John G. Bayless for his personal encouragement. To Dr. Aix B. Harrison for his "second mile" support, the writer acknowledges his indebtedness and voices his appreciation.

To my wife and willing "helpmate" Jean, for her unwavering source of encouragement, for her patience and for her sacrifices, I give my deepest thanks and gratitude. To my daughters, Judy and Jenny, for their stimulating support I acknowledge my appreciation.

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CHAPTER I

BACKGROUND OF THE STUDY

Hypokinetic disease is a term coined recently by Hans Kraus and Wilhelm Raab. It means, literally, disease associated with lack of (hypo) motion (kinetic). More specifically it refers to disease caused by lack of physical activity. Kraus and Raab assert that the variety of pathological conditions collectively designated as "hypokinetic" diseases can be attributed in a major degree to the prevailing lack of exercise.

"It is imperative that drastic steps be taken to stop and prevent further physical and concomitant emotional and moral disintegration in an alarmingly softening atmosphere of 'take-it-easy-ism,' which may not forever be able to resist the increasing pressure of other, more dynamic and aggressive Isms."[1]

They also proclaim that experience has shown that it is survival of the fittest, not the fattest! Likewise, it is true that lack of exercise significantly contributes to degenerative changes in the heart muscle and possibly the arterial system as well.

Kraus and Raab warn that many physically active people may have coronary heart disease and that this suggests that there are other contributory elements, presumably dietary and emotional patterns, which

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[1]Hans Kraus, M. D. and Wilhelm Raab, M. D., Hypokinetic Disease (Springfield, Illinois, 1961), p. 173.

must be considered as one attempts to investigate and establish a relationship between physical activity and coronary disease.

As a consultant to the President on Physical Fitness in 1964, Stan Musial made the following observation: ... "Although few people today question the beneficial effects of regular physical activity, we still have a lot to learn about what certain activities contribute to physical fitness. There also is a great need for better methods of evaluating the effectiveness of specific physical fitness programs and for better means of measuring the physical proficiency of individuals."[2]

Jean Mayer, a senior member of the faculty of the department of nutrition at the Harvard School of Public Health, has long been regarded as an authority on nutrition and weight control. In an article entitled "The Best Diet is Exercise," he made the following statement: "Some of the statistical studies point to an indirect role of inactivity in the development of cardiac conditions, because of the association of inactivity and excessive weight. In view of the fact that heart disease is not only the great killer in the United States (over one-third of the deaths) but also is the main cause of disability among middle-aged persons, the topic is obviously one of major national concern."[3]

From the early days of the "age of man" until the present time, man's health and physical fitness were inseparable components of his welfare and survival. There is very little question that health and physical fitness are important, but there is not always agreement as to

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[2]Edwin A. Fleishman, The Structure and Measurement of Physical Fitness (Englewood Cliffs, N. J., 1964), p. v.

[3]Jean Mayer, "The Best Diet is Exercise," Reprinted in Science and Theory of Health (Dubuque, Iowa, 1966), p. 185.

the specific elements which compose these two commodities. Medical men and physical educators do not always agree as to the role of physical activity in maintaining health and fitness.

In their book, Physical Education, a Problem-Solving Approach to Health and Fitness, Perry B. Johnson et al. state that health and fitness are really a continuum. "Each person has existed, is existing, and will continue to exist, at any given moment, at some rather specific point along what might be called a 'health and fitness continuum'."[4] This so designated continuum of health and fitness ranges from death to a person's maximum health. "The maximum point that one can attain and his actual position at a given moment are each determined by many contributing factors, some of which are hereditary and others environmental."[5]

Because fitness or physical fitness is such a broad category the type of fitness that this writer chose to investigate was that of cardiovascular endurance required for prolonged exertion of the whole body. This is commonly referred to as "stamina."

At this point, a definition of terms may clarify the intent of the writer as he employs certain words. Aerobic activity is light or moderate work during which a person can take in enough oxygen to meet the demands of his body. This is referred to as steady state work. The heart rate during aerobic activity usually remains below 180 beats per minute.

Anaerobic activity denotes strenuous work that taxes the body

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[4]Perry B. Johnson et al., Physical Education, a Problem-Solving Approach to Health and Fitness (New York, 1966), p. 10.

[5]Ibid, p. 10.

beyond its ability to take in an adequate amount of oxygen and consequently forces the body into oxygen debt. This activity causes the heart rate to exceed 180 beats per minute. Oxygen debt (a term often used as a synonym for anaerobic activity) is used to express a deficit in oxygen intake during strenuous activity that must be repaid during a recovery period following that activity. It is measured by the excess oxygen that is consumed during a recovery period (over the normal resting oxygen intake).

Cardiovascular refers to the heart and blood vessels. Cardiorespiratory refers to the heart and lungs. Cardiovascular and cardiorespiratory are often used interchangably.

In any study dealing with cardiovascular endurance one must recognize that the field is so broad that it must be narrowed to a specific type of study or work. Most of the experimental studies on the effect of exercise or activity on the cardiovascular system are concerned with either pulse rate response or blood pressure response to that exercise or activity. Brown and Kenyon, co-editors of Classical Studies on Physical Activity, support this assertion as they record these words: "Historically, research on the effect of exercise on pulse rate and blood pressure goes back to the early 1900's. Among the pioneer researchers in this field were medical doctors; this reflects the emphasis placed on physical fitness at that time. The work of C. Ward Crampton, G. L. Meylan, W. Stone, and T. B. Barringer are examples of these early studies."[6]

In the 1930's and 1940's physiologists and physical educators

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[6]Roscoe C. Brown, Jr., and Gerald S. Kenyon, Classical Studies on Physical Activity (Englewood Cliffs, N. J., 1968), pp. 101-02.

studied cardiovascular exercise responses using more refined statistical techniques. The papers of Tuttle, McCurdy and Larson, and of Metheny and Brouha represent some of the work done during these two decades.

W. W. Tuttle was a physiologist who was concerned with pulse rate as it was affected by exercise. He developed the concept of a standard pulse ratio to compare different individuals' levels of cardiovascular fitness. Using a step test for the standard exercise, he applied this and then recorded the total pulse rate for two minutes after the standard exercise. This was then divided by the normal resting pulse rate for one minute in order to obtain the pulse ratio. In this work the standard pulse ratio adopted was 2.5. This empirical value was adopted by Tuttle because "experience has shown that this ratio 2.5 may be obtained by the majority of individuals by moderate amounts of exercise."[7]

McCurdy and Larson were among the first men to attempt to use modern measurement theory in constructing an exercise tolerance test.[8] Theirs was a very complete paper and provided a good introduction to the techniques of test construction.

In studies conducted in the Harvard Fatigue Laboratory by Metheny and Brouha, male students from Harvard and female students from Wellesley College performed moderate and strenuous exercises on the treadmill. Their physiological responses were then measured. In this classical study the authors concluded that the differences in response to exercise between men and women were similar to the differences found between

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[7] W. W. Tuttle, "The Use of the Pulse Ratio Test for Rating Physical Efficiency," <u>The Research Quarterly</u>, II (1931), p. 7.

[8] J. H. McCurdy and L. A. Larson, "Measurement of Organic Efficiency for Prediction of Physical Condition," <u>The Research Quarterly Supplement</u>, VI (1935), pp. 11-41.

trained and untrained men.[9] They suggested that the physiological adaptation of women to moderate and strenuous exercise is not as efficient as the adaptations of men for the same exercise.

L. Brouha worked with many others in the early 1940's and is perhaps the best known of the authors presented in the above studies. He was instrumental in the development of the Harvard Step Test.[10] This was perhaps one of the most widely used of all the cardiovascular fitness tests in the 1940's and 1950's. It has some factors of limitation, however. It is dangerous to use without the approval of a physician. It is not as precise a test of aerobic fitness as some other tests and for these reasons this writer did not choose to employ it. Montoye noted that although the Harvard Step Test cannot be used to predict performance, it is a good measure of cardiovascular fitness.[11]

Recently, cardiologists have become interested in studying the effects of exercise on the heart as one method of understanding the basic physiology of the heart and vascular system. Of more practical value are the surveys reported on the relationship between regular exercise and coronary heart disease.

> "The possibility that physical activity continued at a moderate level through middle age might be protective against the development of coronary heart disease has been studied seriously for only a decade. Most of the effort up to the

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[9] E. L. Metheny et al., "Some Physiologic Responses of Women and Men to Moderate and Strenuous Exercise: A Comparative Study," American Journal of Physiology, CXXXVI (1942), pp. 318-26.

[10] L. Brouha, A. Graybiel, and C. W. Heath, "The Step Test, A Simple Method of Measuring the Physical Fitness for Hard Muscular Work in Adult Man," Revue de Canadian Biologie, II (1943), pp. 86-91.

[11] H. J. Montoye, "The 'Harvard Step Test' and Work Capacity," Revue de Canadian Biologie, XI (1953), pp. 491-99.

present time has been put into trying to establish that coronary heart disease does in actual fact occur less frequently among physically active men than among their sedentary contemporaries ... Under ideal circumstances one would like to see a physical fitness program started in middle-aged males with properly matched controls in order to see if such a program reduced the coronary heart disease attack rate but the magnitude of this task is so large that it is not likely to be carried out. In the meantime one must view the hypothesis that exercise is a protective measure against coronary heart disease in middle-aged men with caution and admit that there is only presumptive evidence for this concept."[12] Thus stated Harold L. Taylor.

In assuming this position, Taylor argues with the precision of the early studies and he believes that while the data generally tend to show lower death rates resulting from coronary heart disease among the active population, there are possible selective factors and other sources of bias that might have affected these results. He desires more precision in the future studies on these types before definitive conclusions can be reached. The writer believes that since this was written there have been such studies and that they show or tend to suggest that, indeed, cardiovascular fitness has been strengthened by activity and that coronary heart disease has been found to be lessened in those who participate in active programs that cause the whole body to work and that demand high oxygen intake.

Morris examined health records and death certificates of 31,000 men employed by the London Transport System. He noted that about twice as many fatal attacks occurred to the bus drivers as occurred to the conductors. The difference was attributed to the fact that the buses were double-decked and while the drivers had almost no opportunity for

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[12] Harold L. Taylor, "Coronary Heart Disease in Physically Active and Sedentary Populations," Journal of Sports Medicine and Physical Fitness, II (1962), p. 73.

physical exertion, the conductors climbed, many times each day, the stairs to the upper deck.[13] Morris also noted that the weight of the drivers increased whereas the weight of the conductors remained relatively stable.

Dr. Paul Dudley White, noted heart specialist and the personal physician of the late President Dwight D. Eisenhower, said: "There has been much discussion in the days gone by about the possible role of inactivity in the production of disease and the beneficial influence of exercise, physical and mental, in the prevention of disease, but much more research is needed before we can speak with authority in one way or another on these important points."[14]

Today amazing progress has been made in fighting many of the contagious and even chronic illnesses. Medical facilities of all kinds have increased in their efficiency along with the training the doctors are receiving. What gave impetus to the state of physical health that we are now experiencing nation-wide? If anything good can come from war it appears that the current thrust for physical fitness came from the early days of World War II. One of the greatest outcomes of World War II for the health of the nation was the information that a great proportion of American men were not physically fit to carry effectively even the peace-time requirements of a vigorous nation.

In a 1942 publication from the United States Office of Education one finds this quotation: "It is common knowledge among physical educa-

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[13] J. N. Morris, J. D. Heady, and A. B. Raffle, "Physique of London Busmen: Epidemiology of Uniforms," Lancet, CCLXXI (1956), p. 569.

[14] Hans Kraus, M. D. and Wilhelm Raab, M. D., Hypokinetic Disease (Springfield, Illinois, 1961), p. v.

tion instructors in high schools and colleges that large numbers of their male students are weak, have poor coordination, cannot climb a rope, carry a burden equal to their own weights, or vault out of a trench the height of their chests. The poor physical condition of the majority of the American young people is a serious handicap in training soldiers, sailors and airmen and interferes with the maximum industrial and agricultural production."[15]

John F. Kennedy stated that in America there is an increasingly large number of young Americans who are getting soft. This softness can cause or help cause the vitality of the nation to be destroyed.

> "For the physical vigor of our citizens is one of America's most precious resources. If we waste and neglect this resource ... we will be unable to realize our full potential as a nation ... All of us must consider our own responsibilities for the physical vigor of our children and the young men and women of our community. We do not want them to become a generation of spectators. Rather we want each of them to be a participant in the vigorous life."[16]

The Russians are also to be thanked for our increased awareness of the need for fitness. Interest in the fitness of our nation is apparent during war-time and the period immediately prior to the Olympic contests. In response to the keen competitive state between the United States and Russia, we, as a nation, have become more conscious of physical fitness.

One Russian author making a comparison between the U. S. A. and the U. S. S. R. insinuates that the Russian system of education produces

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[15]U.S. Office of Education, Federal Security Agency, Physical Fitness Through Physical Education for the Victory Corps, Pamphlet No. 2, Washington, D. C., 1942, p. 47.

[16]John F. Kennedy, "The Soft American," Background Readings for Physical Education, editors Ann Patterson and Edmond C. Hallberg, (New York, 1967), p. 395.

better physical specimens who perform better on American-devised fitness tests than do the American youth. "In comparison with the U. S. A., the U. S. S. R. has a much higher level of physical preparation of children of school age."[17]

To any challenge the Americans receive from Russia it appears that the nation is ready to accept and to engage in a rigorous contest. The late President Kennedy said:

> " ... If we are to retain this freedom for ourselves and for generations yet to come, then we must be willing to work for those physical qualities upon which the courage and intelligence and skill of man so largely depend. In the past, on many occasions, I have stressed the importance of vigorous physical activity for our children. We must illustrate by deed and example, as well as by words, the importance of physical vitality and health. We must live our lives in such a way that our children, and their children after them, will form a natural and lasting commitment to the vigorous life. The government cannot compel us to act, but freedom demands it. A nation is merely the sum of all its citizens, and its strength, energy, and resourcefulness can be no greater than theirs."[18]

Bowerman and Harris included the following statement in their recent book, Jogging: "The Metropolitan Life Insurance Company reports that in 1966, diseases of the heart and arteries accounted for more than half of the deaths in the U.S. ..."[19] "Unquestionably many factors are involved in causing heart attacks. Lack of physical exercise is only one. But medical research indicates it may be among the most impor-

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[17]G. I. Kooshkin, "The New School Program in Physical Education in the U. S. A.," Theory and Practice of Physical Culture, VI (1963), pp. 63-4.

[18]The President's Council on Physical Fitness, Adult Physical Fitness, A Program for Men and Women, Washington, D.C., 1963, p. 1.

[19]William J. Bowerman and W. E. Harris, M. D., Jogging, A Physical Fitness Program for All Ages (New York, 1967), p. 13.

tant."[20]

Bowerman and Harris also asserted that the most active men not only had a lower incidence of attacks but that their chances of survival were considerably greater. They stated that "recent medical data suggests that exercise after 30 may be more important than activity performed earlier in life."[21]

They believe that jogging is one of the best forms of exercise for health insurance. They also suggest that each participant work by plan. The reason that they give for working with a plan is that "working by plan helps to insure regularity, moderation, and variety."[22] They stress the point that regularity is essential for any benefits. "There are no lasting benefits to health when you exercise for a short time and then stop."[23]

These men also believe that when one is beginning, he should consider that he is training to develop a habit of permanent moderate exercise. They urge that a record be kept of each day's activity. "Train, don't strain," is the motto they repeatedly prescribe. It is interesting, too, to note the different names applied to jogging. Perhaps the most unusual is the "Socrates Shuffle."

Recently there has been an increased interest in the whole area of physical fitness. The schools, Y. M. C. A., and sports clubs have had "Run for Your Life," "Swim for Your Life," and other programs of fit-

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[20]Ibid., p. 14.

[21]Ibid., p. 15.

[22]Ibid., p. 23.

[23]Ibid., p. 24.

ness. The hundred-mile running club and the five-hundred mile clubs were outgrowths of these programs. "Walk for Your Life" and other "catchy" titles have encouraged many persons to participate in vigorous activity. Other fitness programs have also been tried successfully.

One of these programs was the 5BX Plan that was devised as a training plan for the Royal Canadian Air Force.[24] It has had many users outside the Air Force because of the ease with which it could be administered. It is a general fitness program that includes Five Basic Exercises. Obviously, it is named the 5BX for that reason. A person can participate in this program in his own home at his own rate of progress in only eleven minutes per day. The 5BX Plan was so successful that a similar program for women was developed. It was titled the "XBX Plan for Physical Fitness."[25]

The President's Council on Physical Fitness has initiated several programs for fitness. These fitness programs originated during President Dwight D. Eisenhower's tenure of office. President Eisenhower urged all Americans to be fit: "National policies will be no more than words if our people are not healthy in body, as well as of mind, putting dynamism and leadership into the carrying out of these major decisions. Our young people must be physically as well as mentally and spiritually prepared for American citizenship."[26]

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[24] 5BX Plan, RCAF Pamphlet 30-1, 2nd edition, AFP 50-5-1, The Royal Canadian Air Force, Ottawa, Canada, 1962.

[25] XBX Plan, RCAF Pamphlet 30-2, AFP 50-5-2, The Royal Canadian Air Force, Ottawa, Canada, 1962.

[26] Dwight D. Eisenhower, quoted in How to Keep Fit and Like It, Arthur H. Steinhaus (Chicago, 1957), front cover.

Three programs were offered the American public. One series was entitled Youth Physical Fitness[27] and it is often referred to as the "Blue Book Series." Its primary purpose was to interest the elementary school personnel in a fifteen-minute program of vigorous activity for the elementary school children. The other two were entitled Vim (A Complete Exercise Plan for Girls 12 to 18)[28] and Vigor (A Complete Exercise Plan for Boys 12 to 18).[29] Also made available was a publication for adults, Adult Physical Fitness.[30] These plans resembled the 6BX and the 5BX programs in the manner in which they could be adapted to an individual's own program and schedule and without any special equipment. The exercises in the adult program were of three general types: warm-up exercises, conditioning exercises, and circulatory activities. In the activities designed to aid circulation, running and running-in-place were recommended as well as walking.

Mention must be made of Dr. Bruno Balke who has been widely accepted as one of the foremost leaders in the field of performance physiology and space medicine. While working for the Civil Aeromedical Research Institute, Dr. Balke established a fifteen-minute run as a field test for mass testing and by its high correlation with his maximum

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[27]The President's Council on Youth Fitness, Youth Physical Fitness, Suggested Elements of a School-Centered Program, Washington, D.C., 1961, pp. 111.

[28]The President's Council on Physical Fitness, Vim, (A Complete Exercise Plan for Girls 12 to 18), Washington, D.C., 1964, pp. 24.

[29]The President's Council on Physical Fitness, Vigor, (A Complete Exercise Plan for Boys 12 to 18), Washington, D.C., 1964, pp. 24.

[30]The President's Council on Physical Fitness, Adult Physical Fitness, A Program for Men and Women, Washington, D.C., 1963, pp. 64.

oxygen consumption treadmill test (a laboratory test)[31] proved its validity. Dr. Balke believes that " ... physical fitness depends on the individual's biodynamic potential which is composed of his functional and his metabolic potential. The best test of physical fitness would be man's ability to survive under extra-ordinary biological demands."[32]

The current physical fitness program that has been widely acclaimed and used in both military and civilian circles is a program titled "Aerobics," by Lt. Colonel Kenneth H. Cooper. Cooper is also a medical doctor. His program was recorded in book form and is currently published by Bantam Books. A new version detailing specific requirements for an exercise program has become available. These books are entitled Aerobics[33] and The New Aerobics.[34]

Aerobics literally means "with oxygen." Dr. Cooper uses the term to denote activities or exercises that create a need for increased oxygen intake for a long period of time. Endurance type exercises are activities that tax the body's capacity to inhale oxygen and to deliver it to the cells in which it is combined with fuel foods for the production of energy. Cooper has not hesitated to recommend running as the most effective exercise in promoting and maintaining cardiovascular

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[31]Bruno Balke, M. D., "A Simple Field Test for the Assessment of Physical Fitness," Federal Aviation Agency Civil Aeromedical Research Institute, Report 63-6, Washington, D.C., 1963, pp. 8.

[32]Bruno Balke, M. D., "The Effect of Physical Exercise on the Metabolic Potential, A Crucial Measure of Physical Fitness," Exercise and Fitness (The Athletic Institute, Chicago, 1960), pp. 73-81.

[33]Kenneth H. Cooper, M. D., Aerobics (New York, 1968), pp. 182.

[34]Kenneth H. Cooper, M. D., The New Aerobics (New York, 1970), pp. 191.

fitness.

Cooper's "Aerobics" exercise program has vast appeal to many educators and laymen. It employs a unique method of allowing "points" for various physical activities. His program is relatively simple to start and it has the most scientific program of exercise of any of the fitness programs. It is aimed primarily at cardiovascular or endurance (stamina) type fitness. The major goal is maximal health for the individual.

The "Aerobics" program is built upon a scientifically tested point-count system that any layman can understand. Dr. Cooper has an entry test to enable placement of the participant in a suitable program. There is no specifically required exercise or activity, but the participant must exercise a minimum of four days per week. Dr. Cooper does not wish this to be a fad, but rather he would like it to be a new way of living for the participant. Cooper has no diets or calisthentics included in the program. He does suggest, however, that it is easier for an overweight man to lose weight by diet than by exercise.

In this program each participant regardless of age is expected to earn a minimum of 30 points per week. "Any variation from the 30-point week will produce more or less training effect, depending on whether the variation is more or less than 30 points' worth. In other words, 30 points per week will maintain the training effect. More than 30 will increase it. Less than 30, and you start losing it."[35] It does not matter how the points are acquired. That they are acquired is the important thing!

The training effect mentioned here is not a figment of Cooper's

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[35]Kenneth H. Cooper, M. D., Aerobics (New York, 1968), p. 50.

imagination. It is a scientifically proven fact. One of the effects of training on the cardiovascular system is the increased maximum amount of attainable oxygen which directly effects the amount of time an individual may work before becoming fatigued. Other benefits of training are a stronger heart beat, reduced heart rate, reduced breathing rate, and increased muscular strength and tonus.

"One important end result of the increased muscular strength and general endurance provided by exercise is an increase in the body's capacity for carrying on normal daily activities, a pushing back of fatigue limits. Valid research indicates that a fit person uses less energy for any given movement or effort than a flabby or weak person."[36]

A typical 30-point week for a beginner to the program might resemble the following schedule:

DAY	ACTIVITY	POINTS
Monday	Run-walk one mile in 10 minutes; brisk walk to and from work one mile each way (less than 20 min.)	3 2
Tuesday	Walk to and from work; jog one mile in 9½ min.	2 4
Wednesday	Swim 300 yards in 8 min.; walk to and from work	1½ 2
Thursday	Walk to and from work, one mile in 20 min.; run one mile in 9 min.; play handball 20 min.	2 4 3
Friday	Walk to and from work; run one mile in 8.75 min.	2 4
Saturday	Cycling 3 miles in 10 min.	3
	Total	32½ pts.

[36]The President's Council on Physical Fitness, Adult Physical Fitness, A Program for Men and Women, Washington, D.C., 1963, p. 6.

The need for aerobic fitness has never been greater. Man has made machines to do his heavy work. Hence he no longer needs great strength in his skeletal muscles. Yet man must continue to circulate his blood to breathe. If he does very little physical work that requires him to strengthen his cardiovascular system, he is surely increasing his chances for early death. Therefore, this writer wishes to be included with those who vigorously promote aerobic fitness.

Problem

The primary purpose of this study was to determine if a group of middle-aged male subjects could through a consistent 16-week program of aerobic activities of their own choosing in which they earned a minimum of 30 points per week on Dr. Kenneth Cooper's Aerobics Point System, maintain or improve their cardiovascular fitness to a level that would place them in a good or an excellent category. The criterion for assessing the cardiovascular fitness was the performance on the Balke Treadmill Test.

Sub-problems

(1) To compare the results of the exercise program between smokers and non-smokers.

(2) To compare the results of those who gained their points by running and jogging with those who gained their points primarily by swimming and playing handball.

(3) To compare the results of the Balke Treadmill Test for predicting O_2 intake with the 12-minute field test suggested by Dr. Cooper. The Pearson Product Moment Corrleation was used to determine this

result.

(4) To predict by linear regression the performance of subjects on the field test by their performance on the treadmill test.

(5) To compare each subject's weight and anthropometric measurements at the start and end of the experiment to check for significant change by use of the "t" ratio.

(6) To compare the results of the subjects who had a high cardiovascular fitness with those who were low in cardiovascular fitness by use of the "t" ratio.

Limitations

(1) A random sample of subjects was not feasible for this study.

(2) The writer could not control the subjects' personal factors such as their eating, sleeping, and other health habits.

Delimitations

(1) The size of the sample was 41.

(2) The size of the control group was 7.

(3) The subjects were males who were between 25 and 30 years of age.

(4) All of the subjects were associated with the university.

Assumptions

(1) Points were recorded honestly by the subjects.

(2) The Balke Treadmill Test is a valid predictor of O_2 uptake.

CHAPTER II

REVIEW OF LITERATURE

Treadmill Studies

The question may be raised as to why one would employ the treadmill in studies relating to heart rate, respiratory quotient, and work capacity. Some of the following reasons have been asserted to be valid ones for using the treadmill for testing.

1. Walking is a task which does not have to be learned.
2. Large muscle groups are required.
3. The work load is natural for each subject.
4. The accuracy of measurement is more nearly possible because of the use of controlled speeds and angles of the plane.

Taylor suggests that the duration and the intensity of a submaximal test should not exceed the limits of the poorest subject[1]. He also suggests that the maximal test should require all subjects to reach a comparable state of exhaustion. All of the tests should eliminate factors of skill and motivation as much as possible.

Erickson et al. reported a systematic study of treadmill walking at 16 different combinations of speeds and angles that ranged from 2.5

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[1] C. Taylor, "Studies in Exercise Physiology," American Journal of Physiology, CXXXV (1941), pp. 27-42.

miles per hour to four miles per hour and from 0^{o} to 10^{o} elevation[2]. He and his colleagues did this in an attempt to standardize the treadmill as a device for studies on controlled work output. They found that the treadmill was a desirable testing instrument for the following reasons:

1. There was little training effect.
2. Intrinsic variations were small which implied that replication of studies would be possible.
3. Small variations in speed or grade produced accurately measurable differences which could be applied to fitness testing.

In a study of energy cost comparison of the bicycle ergometer, the stool step, and the treadmill, Paul arrived at the following conclusion: "The energy cost per unit of time for the men on the treadmill was roughly three times that required on the bicycle ergometer and one and one-half times that required on the stool step . . . From the results of this experiment energy cost prediction (within confidence limits) can be made from one ergometric device to another in terms of time and energy costs."[3]

Astrand and Ryhming proposed that the test should employ the large muscle groups and relatively high work loads. Time had to be given the body to adapt to the demands of the exercise, they felt, and the work

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[2] L. Erickson et al., "The Energy Cost of Horizontal and Grade Walking on the Motor Driven Treadmill," American Journal of Physiology, CXLV (Jan., 1946), pp. 391-401.

[3] Tom L. Paul, "A Comparison of the Energy Costs of Exercises on the Bicycle Ergometer, Treadmill, and the Stool Step," (unpub. doctoral thesis, Florida State University, 1965), p. 68.

loads should not be exceedingly progressive[4].

Billings et al. found that the problem with fixed work loads is the fact that the load that may be a submaximal work load for an average or above average subject may be maximal for the subject who has a poor fitness level[5]. The study of R. C. Darling supported the findings of Billings et al.[6]

In examining various factors that might have an effect upon treadmill performance, Durnin and Namyslowski concluded that:

1. Test participation on different days had no effect on the results.
2. No measurable effects occurred because of changes in external temperature and barometric pressure.
3. The time of day was not significant on the metabolic cost of activity.
4. Emotional conditions, i.e., mild apprehension had little effect on the gross metabolism[7].

Balke and Ware chose to change the work load each minute very

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[4] P. O. Astrand and Irma Ryhming, "Nomogram for Predicting Oxygen Uptake from Submaximal Oxygen Uptake," Journal of Applied Physiology, VII (1954), pp. 218-21.

[5] C. E. Billings et al., "Measurement of Human Capcity for Aerobic Muscular Work," Journal of Applied Physiology, CXV (1960), p. 1001.

[6] R. C. Darling, "Physiology of Exercise and Fatigue," Therapeutic Exercise, ed. Sidney Licht (2nd ed., New Haven, 1961), pp. 304.

[7] J. V. G. A. Durnin and L. Namyslowski, "Individual Variation in the Energy Expenditure of Standardized Activities," Journal of Physiology, XXLIII (1958), pp. 573-77.

slightly (1%) to assure the body time to adapt to the new level[8]. When adequate physiological adjustments accompanied the increased work load, they continued until the heart rate reached 180 beats per minute. After 180 beats per minute, the work was not accompanied by adequate adjustment. Because of this, a terminal point of 180 beats per minute, a set time duration or set work load, was the point adjudged by Balke and Ware to represent a valid test of circulo-respiratory capacity. Many studies support their findings. Notable among them are those of Faria and Nagle and Bedecki.

Faria concluded that the results of his study support the position that increasing work demands on the heart results in increased tolerance for exercise. He stated that unless the stress placed on the heart is great enough to elevate the rate to approximately 145 beats per minute or more "such activity is likely to result in no significant gain in physical working capacity."[9]

Nagle and Bedecki sought to determine if the relationship of the 180 heart rate per minute to signs of physiological incompetence was peculiar to the stress used by Balke or was demonstrable under various exercise stress conditions. The results of their study indicated a correlation of +.85 between heart rate times and all-out run times for their 44 subjects. They concluded that the 180 beats per minute heart rate serves as a valid cut-off point in the measuring of aerobic work

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[8] B. Balke and C. W. Ware, "An Experimental Study of Physical Fitness of Air Force Personnel," U. S. Armed Forces Medical Journal, X (1959), pp. 675-688.

[9] Irvin Edwin Faria, "Cardiovascular Responses to Exercise as Influenced by Training of Various Intensities" (unpub. Ed.D. thesis, Stanford University, 1968), pp. 92.

capacity in man[10]. Physiological inadequacy which occurred at the 180 beats per minute heart rate was indicated by an acute decrease in the ratio of O_2 consumed to the work accomplished, an excessive volume of ventilation, and a tendency for O_2 consumption to level off, possibly indicating a near maximum effort.

The earliest treadmill study reviewed by this writer was that of Dill, Edwards, and Talbott[11]. The purpose of their study was to investigate the respiratory quotient of the subjects. They used a 20-minute treadmill test run at a speed of 9.3 kilometers per hour. This aerobic test recorded an observed decline in the respiratory quotient of the subjects as work continued. The treadmill remained horizontal for the duration of this test.

In another early study on treadmill performance, Robinson reported that the maximal pulse rate means for a group of boys whose mean age was 14.1 years was between 190 and 195 beats per minute after a five-minute run[12]. This does not refute the previously cited study of Balke and Ware in which a criterion of 180 beats per minute was recorded as being aerobic.

Let us examine the studies of Balke and Ware. They are the forerunners in the treadmill studies of "physical fitness" or "physical performance capacity." They named this "work capacity" and they defined

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[10] F. J. Nagle and T. G. Bedecki, "Use of the 180 Heart Rate Response as a Measure of Circulatory Capacity," The Research Quarterly, XXXIV (1963), pp. 361-69.

[11] D. B. Dill, H. T. Edwards, and J. H. Talbot, "Studies in Muscular Activities," Journal of Physiology, LXIX (1930), pp. 263-91.

[12] Sid Robinson, "Experimental Studies in Physical Fitness in Relation to Age," Arbeitsphysiologie, X (1939), pp. 252-321.

it as ... "the highest level of metabolic load which can be compensated for adequately by optimal coordination of the functional reserves."[13]

They required each subject to perform work on a treadmill. The belt was level (horizontal 0% incline) and the speed was set at 3.3 miles per hour. They then increased the subject's work load by elevating the angle of the treadmill by 1% each minute while the speed of the belt was maintained constantly at 3.3 miles per hour. The test was terminated when the subject's heart rate reached 180 beats per minute. Although maximal work capacity may extend beyond this point, Balke and Ware chose the 180 beats per minute of the heart as the criterion. They say that ... "there are sufficient physiological indications to validate this criterion as a useful measure of the aerobic crest load."[14]

In this study by Balke and Ware, the subjects were given a training session to help assure that they would be relaxed enough to give a normal reading during the actual test. A resting pulse rate and blood pressure were taken before and after the actual test. During the test the subject's heart or pulse rate and blood pressure were taken the second half of each minute. The use of blood pressure as a criterion for individual differentiation of work capacity was found to be of little value. In later work by Balke he omitted the blood pressure measures recorded during such tests. However, Balke and Ware found that "high diastolic pressure (100 $_{mm}$Hg and above) usually designate low levels of work capacity ..."[15]

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[13]B. Balke and C. W. Ware, "An Experimental Study of 'Physical Fitness' of Air Force Personnel," U. S. Armed Forces Medical Journal, XIX (1959), p. 675.

[14]Ibid., p. 676.

[15]Ibid., p. 679.

Balke and Ware concluded that factors such as age, weight, personal habits, and activity levels had some effect on the work capacity of their subjects. They did not conclude that oxygen consumption is a reliable measure of work capacity because of the overlap of individual differences.

Contrary to popular assumption, Balke and Ware did not find a progressive decrease in work capacity to be an inevitable process wholly correlated with age. The living style and habits had a more notable effect upon the work capacity of the individual than did his age. Balke and Ware did find that the sedentary or "intermittently active" individuals' work capacity did decrease with age. " ... Results for the group with regular physical activity demonstrated that a high level of capacity for aerobic work can be maintained as one grows older."[16]

In separating the subjects into three different weight categories, overweight, normal weight, and underweight, the investigators found that the overweight individual (on the average) had a lower work capacity than the normal or the underweight subjects.

The smokers and non-smokers were very similar in their results up to the age of 30. After the age of 30, the smokers displayed less functional reserves than those who were non-smokers.

In this Balke-Ware test, the findings revealed that only 18% of the subjects could be rated as being in the "good" work capacity category and 42% were in the poor category. The remaining 40% were only fair.

Taylor, Buskirk, and Henschel designed a test to determine the maximal O_2 intake independent of motivation and skill. In this test

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[16] Ibid., p. 683.

there were various treadmill performance requirements. In the first visit all the subjects performed the treadmill version of the Harvard Step Test. The results of this were used to predict the grade which would elicit the maximal oxygen intake. Upon the occasion of the second visit, each subject was given an individual test. He was asked to walk on the treadmill during the warm-up or second trial at a speed of 3.5 miles per hour at a grade of 7%. After this, each subject proceeded to run seven miles per hour at the pre-established grade. Repetition of this procedure was necessary until two grades were found that resulted in oxygen intake levels that met the established criterion[17].

The following test is one that was used by J. B. Daugherty in a study with male subjects ranging in age from 20 to 25 years[18]. On a horizontal treadmill, the subjects performed for six minutes at each of the following speeds, 2.3 miles per hour, 3.5, 4.6, and 6.9 miles per hour. The purpose and findings of Daugherty's study were related to the respiratory quotients of the subjects at the various speeds.

Workman and Armstrong developed an equation to predict 0_2 consumption and subjects walking on the treadmill. The prediction was derived by combining the height and the weight of the subject with the speed and grade of the treadmill[19].

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[17]H. L. Taylor, E. Buskirk and A. Henschel, "Maximal 0_2 Intake as an Objective Measure of Cardio-Respiratory Performance," Journal of Applied Physiology, VIII (1955), pp. 73-80.

[18]J. B. Daugherty, "An Analysis of Physical and Physiological Characteristics of Endurance Performance in Young Men" (unpub. Doctoral dissertation, New York University, 1950), pp. 126.

[19]J. M. Workman and B. W. Armstrong, "A Nomogram for Predicting Treadmill-Walking 0_2 Consumption," Journal of Applied Physiology, XIX (1964), pp. 150-51.

A comparison of the maximal 0_2 intakes elicited by four maximal tests often used in work capacity studies was made by J. L. Newton[20]. These were:

1. Cureton's "All-Out" Treadmill Test
2. Balke Treadmill Test
3. A three-to-five minute treadmill run to exhaustion
4. A bicycle ride to exhaustion

A conclusion of this study was that all test results were comparable for the fit subjects but not for the less fit ones.

One treadmill test developed by Slonim, Gillespie, and Harold measured the peak 0_2 uptake of 50 naval aviation cadets[21]. In this test, each subject walked at 3.5 miles per hour at a grade of 10% for six minutes. This was designated as a warm-up. After the warm-up, each subject rested for 30 minutes. The real test then began with the treadmill speed constant at 3.5 miles per hour and the incline at a 20% grade. The subjects walked at this rate and incline for six minutes or until they failed to remain on the treadmill. On the initial visit, all subjects were given this test. For the second trial, the grade was raised to 24 per cent. The next day the grade was raised to 26 per cent and the following day it was raised to 28 per cent. No subject required more than five elevations to define his peak value. If a subject failed to complete a test, the treadmill grade was lowered one per cent until a test was found which the subject could complete.

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[20]J. L. Newton, "The Assessment of Maximal 0_2 Intake," Journal of Sports Medicine and Physical Fitness, III (1963), pp. 164-69.

[21]N. B. Slonim, D. G. Gillespie, and W. H. Harold, "Peak Oxygen Uptake of Healthy Young Men as Determined by a Treadmill Method," Journal of Applied Physiology, X (1957), pp. 401-04.

In another treadmill study, D. B. Dill found that the oxygen costs for athletes and non-athletes were similar at lower rates and grades, but there was a variance between the cost of trained and untrained subjects at a higher rate[22].

Comparing maximum 0_2 uptake values, Glassford, Baycroft, Sedgwick, and MacNab found that direct treadmill tests employing greater muscle mass yielded higher maximal 0_2 uptake values than did the direct bicycle ergometer tests. The indirect test investigated by these men was the Astrand-Ryhming nomogram. They found that the indirect test had a significantly higher mean, but that it was as highly correlated as were the three direct tests. "The Astrand-Ryhming nomogram appears to be as good a predictor of physical fitness as defined by the Johnson-Brouha-Darling tests as are the three direct tests of maximal 0_2 uptake."[23]

Howard et al. report that participation of their subjects in hockey, swimming, and basketball promoted a significant increase in performance time on the treadmill and a significantly lower heart rate as a result of the basketball training sessions. The wrestlers and volleyball participants failed to demonstrate any significant change in their performance on the treadmill after training the same amount of time as the hockey players, the swimmers, and the basketball players[24].

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[22] D. B. Dill, "Oxygen Used in Horizontal and Grade Walking and Running on the Treadmill," Journal of Applied Physiology, XX (1965), pp. 19-22.

[23] R. G. Glassford et al., "Comparison of Maximal Oxygen Uptake Values Determined by Predicted and Actual Methods," Journal of Applied Physiology, XX (1965), p. 512.

[24] M. L. Howard et al., "Effect of Participation in Various Athletic Activities Upon Treadmill Performance," (micro-card UO 65 289, University of Alberta, 1964), pp. 190.

Learning has little effect on O_2 consumption at a given speed and grade on the treadmill according to R. J. Shephard. He also found that "the aerobic power of non-athletic subjects is such that when the treadmill slope is varied and the speed held constant, the speed selected is usually better suited to walking than to running. At the lowest speed (3 m.p.h.) the gross O_2 cost was almost linearly related to treadmill slope."[25]

"During treadmill studies, smokers had a decrease in respiratory minute volume and a lower O_2 consumption at equivalent heart rates than non-smokers," report Cooper, Gey, and Bottenberg[26].

They arrived at this conclusion after testing two groups of subjects whose working conditions, after-duty hours, food, and conditioning programs were known to be the same. Only in their smoking and non-smoking habits did they differ appreciably.

Cooper, Gey, and Bottenberg reported that "any amount of cigarette smoking not only affected endurance performance, but also limited the response to training."[27] Performance of the smokers on a twelve-minute run was found to be inversely related to the number of cigarettes smoked.

Kenneth Cooper reports a correlation between field and treadmill testing. He found that the accuracy of the estimate is directly related

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[25] R. J. Shephard, "A Nomogram to Calculate the O_2 Cost of Running at Slow Speeds," Journal of Sports Medicine and Physical Fitness, IX (1969), p. 13.

[26] K. H. Cooper, G. O. Gey, and R. A. Bottenberg, "Effects of Smoking on Endurance Performance," Journal of American Medical Association, CCIII (1968), p. 123.

[27] Ibid., p. 125.

to the motivation of the subjects. If cost and time expenditures were not factors, the laboratory method would be better for finding maximal oxygen consumption. Because, however, the field test uses a well-known type of exercise, costs nothing to perform, and allows the testing of large groups of subjects simultaneously, it appears to have advantages over the laboratory tests.

"Because of the high correlation with maximal oxygen consumption, it can be assumed that the 12-minute field performance tests is an objective measure of physical fitness reflecting the cardiovascular status of an individual."[28]

Cardiovascular Fitness

Cureton recognizes the limitations of the use of heart rate as a measure of cardiovascular fitness, but he insists that heart rate is the most reliable of physiological variables that reflect the internal efficiency of the bodily process in response to exercise or work[29].

"The Astrand-Ryhming maximal 0_2 intake test appears to differentiate between individuals who are in approximately the same state of training," says Hyde[30].

As early as 1932 Cotton reported that there is a wide range of heart rates for different classes of men. For normal young men, he

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[28]Kenneth H. Cooper, M. D., "A Means of Assessing Maximal 0_2 Intake," Journal of American Medical Association, CCIII (1968), p. 135.

[29]T. K. Cureton, Physical Fitness, Appraisal and Guidance (St. Louis, 1947), pp. 144.

[30]Rodney C. Hyde, "The Astrand-Ryhming Nomogram as a Predictor of Aerobic Capacity for Secondary School Students" (unpub. thesis, University of Alberta, 1965), p. 87.

listed 66 beats per minute. This was suggested for those who had no athletic history. For those of average athletic ability, he suggested 63 beats per minute. For Olympic athletes he recorded 50 beats per minute and for champion swimmers he reported 47[31].

Henry considered the resting heart rate important because he felt that it possibly reflected the physiological benefits that result from training[32].

Fraser and Chapman found that the heart rates of subjects walking on a treadmill at three miles per hour at a 5% grade reached a plateau very quickly[33].

In studying the heart rates of subjects from five to forty years of age, Bengtsson observed that heart rate increased linearly with exercise intensity. Simultaneously, 0_2 consumption also increased linearly with exercise intensity[34].

Astrand supported this and found similar linear relationships for subjects from age four to thirty-three. He stated that the slope of the heart rate-0_2 intake curve is determined by the subject's aerobic capacity and he later noted that it is impossible to judge a person's physical condition from the slope and the mean of a curve showing heart rate

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[31]F. S. Cotton, "The Relationship of Athletic Status to the Pulse Rate in Men and Women," Journal of Physiology, LXXVI (1932), pp. 39-51.

[32]F. M. Henry, "The Influence of Athletic Training on the Resting Cardiovascular System," The Research Quarterly, XXV (1954), pp. 38-41.

[33]R. S. Fraser and C. B. Chapman, "Studies on the Effect of Exercise on Cardiovascular Function," Circulation, IX (1954), pp. 193-97.

[34]E. Bengtsson, "The Working Capacity in Normal Children Evaluated by Submaximal Exercise Compared With Adults," Acta Medica Scandinavia, XLIV (1954), pp. 91-109.

if the aerobic capacity is not taken into consideration.[35]

"It would seem reasonable," states M. L. Howell, "that if heart rate is used to assess a person's level of fitness for exercise, then the heart rate during exercise should be considered the most important criterion.[36]

Taylor in early studies agreed that exercise heart rate is a better indicator of fitness than recovery heart rate.[37]

Nagle and Bedecki stated that as heart rate increases becomes a more valid measure of circulo-respiratory capacity.[38]

Extraneous factors that can substantially alter an individual's heart rate must be considered. Some of these are room temperature, excitement level of the subject, etc. Dill found that heart rate is extremely sensitive to changes in external temperature and humidity, even with moderate work loads.[39]

Kozar noted that anticipation of an exercise can account for as

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[35] P. O. Astrand, "Human Physical Fitness with Special Reference to Age and Sex," Physiological Reviews, XXXVI (1956), pp. 307-35.

[36] M. L. Howell et al., "Effect of Participation in Various Athletic Activities Upon Treadmill Performance," (a study, University of Alberta, 1964), p. 151.

[37] C. Taylor, "Some Properties of Maximal and Submaximal Exercise with Reference to Physiological Variation and the Measurement of Exercise Tolerance," American Journal of Physiology, CXLII (1944), pp. 200-12.

[38] J. Nagle and T. G. Bedecki, "The Use of the Exercise Heart Rate Response as a Measure of Circulo-respiratory Capacity" (unpub. lecture, University of Florida, 1962).

[39] D. B. Dill, "The Economy of Muscular Exercise," Physiological Reviews, XVI (1936), pp. 263-91.

much as 28-58 per cent of an individual's resting heart rate.[40]

Durnin and Namyslowski reported a lowering of the heart rates of the subjects who exercised while those in the control group did not show a lowered rate.[41]

Using the 5BX Fitness Program, Cooper reported that after five weeks of training his subjects' heart rates were reduced by as high as nine beats per minute with the lowest reduction being that of two beats per minute.[42]

"Perhaps one of the most important uses of cardiovascular tests in which pulse rate and blood pressure are measured is as an educational device," reported Johnson and Nelson.[43] In presenting a brief summary of research findings concerning cardiovascular fitness tests, they included a twelve-minute run-walk test. They reported that with any test of cardiovascular fitness great care should be taken in the measurement of pulse rate and blood pressure. They, too, warn that the tester must allow for emotional factors, time of day, exercise, changes in body positions, altitude, and humidity as well as the subject's current health

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[40] A. J. Kozar, "A Study of Telemetered Heart Rate During Sports Participation of Young Adult Men" (unpub. Doctoral dissertation, University of Michigan, 1961), pp. 127.

[41] J. V. G. A. Durnin and L. Namyslowski, "Individual Variation in the Energy Expenditure of Standardized Activities," Journal of Physiology, XCLIII (1958), pp. 573-77.

[42] L. A. Cooper, "A Comparison of the Effects of Short Intensive and Prolonged Intensive Exercise Programs on Treadmill Performance and Certain Cardiorespiratory Functions" (Master's Thesis, University of Alberta, 1963), pp. 91.

[43] Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis, Minnesota, 1959), p. 299.

status. Any or all of these factors in various combinations may influence cardiovascular measurement.[44]

In his classical study, Astrand records that "during submaximal work with a fixed intensity in uncomplicated forms of exercise a fairly constant, possibly a somewhat improved mechanical efficiency will be observed ... The reduction of pulse rate that is seen during training is thus probably mainly dependent on an increase in the stroke volume of the heart."[45]

Jokl, in his book, Heart and Sport, reported that "on the whole, trained athletes have lower resting pulse rates than untrained individuals."[46] The slow heart rate of athletes is but one of many projections of a principle of cardiovascular economy.

"The fact that in highly trained athletes, the cardiac rate may be as low as 50 per cent of normal average invites conclusions regarding the long-term effects of such bradycardia upon the myocardium. The effect of training revealed by these cardiac rates at rest may be considered the expression of a biological law which determines the economizing effect of training upon the blood circulation."[47]

Mitchell, Sproule, and Chapman concluded from their study of maximal O_2 intake tests that "the relative importance of cardiac capacity and

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[44]Ibid.

[45]P. O. Astrand, "Human Physical Fitness with Special Reference to Sex and Age," International Research in Sport and Physical Education, editors E. Joke and E. Simon (Springfield, Illinois, 1964), p. 541.

[46]Ernst Jokl, Heart and Sport (Springfield, Illinois, 1964), p. 49.

[47]Ibid.

increase in AV oxygen difference must be determined. It is probable that in the normal individual the ability to increase cardiac output is the more important of the two factors."[48]

"In any event the full meaning of maximal O_2 intake is in terms not merely of the ability of the heart mechanically to propel blood, but also of the ability of the tissues to extract O_2 from blood perfusing them."[49] This study supports the idea that fitness of the cardiovascular system is not merely "heart" centered.

Andersen and Hermansen attempted to evaluate the whole range of variability concerning aerobic work capacity. They compared successful young Norwegian athletes with subjects whose occupations were sedentary and who had no athletic background. "It was clearly found that maximal heart rate is related to fitness to the extent that fit subjects have lower maximal heart rates."[50] They found this to be true at all metabolic levels.

In a similar study, Andersen and Hermansen found that "the heart rate oxygen uptake relationship was the same for sedentary-living men, regardless of age, but maximal heart rate was lower in older men."[51] They also noted that "the effect of training upon maximal heart rate in

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[48] J. H. Mitchell, B. J. Sproule, and C. B. Chapman, "The Physiological Meaning of the Maximal O_2 Intake Test," Journal of Clinical Investigation, XXXVII (1958), p. 546.

[49] Ibid., p. 545.

[50] Lars Hermansen and K. Lange Andersen, "Aerobic Work Capacity in Young Norwegian Men and Women," Journal of Applied Physiology, XX (1965), p. 430.

[51] K. Lange Andersen and Lars Hermansen, "Aerobic Work Capacity in Middle-aged Norwegian Men," Journal of Applied Physiology, XX (1965), p. 432.

the middle-aged man is uncertain. In this connection it should be realized that the term maximal heart rate may be misleading ..."[52] The possibility exists that even during the heaviest work load the heart is not maximally activated. They further state that "the limitation for the maximal oxygen uptake may lie in the periphery, for instance in the dimension of the vascular bed of the muscles which thus limits the blood flow to the muscles."[53]

If this be true, then the limiting factor for maximal O_2 uptake may not be the performance capacity of the cardiac muscle, but rather the muscles themselves. This is why it is necessary to have a training program employing the large muscles.

Effect of Training

One issue that must be addressed in experimental studies in physiology is that of the effect of training. Numerous studies have been conducted and the writer wishes to review some of them.

In "Effect of Athletic Training on Exercise Cardiac Output," one reads this: "The data presented here suggest that after a period of athletic training the ventilation, heart rate and cardiac output responses for a given external work load decrease ..."[54] This study emphasized that the effects of training can be studied only by consecutive measurement with each subject acting as his own control.

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[52]Ibid., p. 436.

[53]Ibid., p. 436.

[54]G. M. Andrew, C. A. Guzman, and M. R. Becklack, "Effect of Athletic Training on Exercise Cardiac Output," Journal of Applied Physiology, XXI (1966), p. 603.

Faulkner states that "apparently modern training programs are not training the aerobic capacity of athletes any better than did the training programs of the 1930;s .... That many runners appear to have attained their maximum aerobic capacity by the time they reach maturity requires a serious reevaluation of current training practices."[55] Faulkner asserts that there is a very different type of training program needed to maintain the aerobic capacity than the program that places its emphasis on the traditional over-distance running.

Douglas and Becklake found that "after training, subjects performed any given work load with less increase in heart rate, cardiac output and minute ventilation; i. e., there was less stress on circulation and respiration than before training. Thus, a greater maximal work capacity was possible after training even though no increase in maximal circulatory capacity was demonstrated."[56]

"It has long been known that habitual vigorous physical activity gradually produces a slowing of the heartbeat at rest as well as a lowering of its peak acceleration during exercise and a faster deceleration in the post-exercise phase ..."[57] reports Raab.

"The ultimate neurophysiological mechanisms underlying the characteristic antiadrenergic preponderance in well-trained individuals are not yet clearly understood. Nevertheless, it may be safely assumed that

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[55]J. A. Faulkner, "New Perspectives in Training for Maximum Performance," Journal of American Medical Association, CCV (1968), p. 121.

[56]F. G. V. Douglas and M. R. Becklake, "Effect of Seasonal Training on Maximal Cardiac Output," Journal of Applied Physiology, XXV (1968), p. 602.

[57]Wilhelm Raab, M. D., "Training, Physical Inactivity and the Cardiac Dynamic Cycle," Journal of Sports Medicine, IV (1966), p. 42.

the deterioration of antidrenergic counterregulation which results from lack of physical exercise constitutes together with coronary atherosclerosis one of the most potent causative elements in today's uncontrolled premature cardiac mass mortality in prosperous soft-living matrons."[58]

Williams reports that the effects of training are fairly rapid initially, "but as the relationship between improvement and the time factor is shown to be logarithmic, an increasingly longer period of time is needed to produce a steadily decreasing margin of improvement. This explains why it is that a moderately high level of performance can be attained after only a few weeks' training, whereas the highest performances are only achieved after a long period."[59]

Sharkey and Holleman support the position that during intense activity training there is more improvement than a lower levels of activity. Exercise of sufficient difficulty to elicit training heart rates of 180 beats per minute was significantly more rewarding than exercises that elicited only 120 to 150 beats per minute. Using the Balke test as a pre- and post-test, Sharkey and Helleman found that the group which trained at 180 beats per minute remained on the treadmill longer (18 minutes in the post test) and had a greater degree of variance between the pre and post tests (3.75 minutes more than of the other two groups).[60]

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[58]Ibid., p. 44.

[59]J. G. P. Williams, Medical Aspects of Sport and Physical Fitness (New York, 1965), p. 14.

[60]B. J. Sharkey and J. P. Holleman, "Cardiorespiratory Adaptations to Training at Specified Intensities," The Research Quarterly, XXXVIII (1967), pp. 698-704.

Jackson, Sharkey, and Johnson concluded in their study that the benefits from training two or three times per week may have been as beneficial as the five-day-per-week training programs.[61]

In a study dealing with college men, Baker discovered that skipping rope may be a valuable substitute for jogging. He found that by rope-skipping ten minutes per day for five days each week these subjects showed no significant difference at the end of a six-week program than did their counter group who trained thirty minutes per day by jogging five days per week. He recommended that anyone might choose rope-skipping because it is less time consuming than jogging and it can be done in an average-sized room without any difficulty.[62]

The conclusion of Bird and Alexander from their study of the effects of individually geared exercise programs is that "significant gains in physical fitness of adult men (reflected by treadmill performance time, metabolic efficiency and terminal 0_2 intake) can be achieved by *ad libitum* participation in a moderate physical activity program."[63] In their 23-week program all subjects increased in treadmill performance time and metabolic efficiency. Paddleball was the sport most often used by the subjects of this study. Of the total training time, 47% involved participation in paddleball, 19% in 5BX programs, and the other 34% was

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[61] J. A. Jackson, B. J. Sharkey, and L. P. Johnson, "Cardiorespiratory Adaptations to Training at Specified Frequencies," *The Research Quarterly*, XXXVIII (1967), pp. 698-704.

[62] J. A. Baker, "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Men," *The Research Quarterly*, XXXIX (1968), pp. 240-43.

[63] Patrick J. Bird and John F. Alexander, "Effects of an Individually Geared Exercise Program on Physical Fitness of Adult Men," *The Research Quarterly*, XXXIX (1968), p. 863.

divided among various other physical activities.

Weber and Knowlton found that a program of strenuous activity for a period of eight weeks improved circulo-respiratory fitness but that a skill-oriented tennis class appeared to have none of the advantages of a physical fitness class. Dr. Kenneth Cooper's point count evaluation concurs with this judgement as he, too, awards little value for tennis or golf for cardiovascular improvement.[65]

One of the studies by Cureton gives a specific reason for hard exercise by middle-aged men: "The deterioration of capillaries and of circulation in general, we see as the principal trend for middle-agers to resist. Hard exercise seems to be the only way to make this resistance. We have shown that practically all of the motor fitness characteristics deteriorate after 26 years of age as an average."[66] He continues by saying that, in general, the sports or casual games like volleyball, golf, bowling, quoits, shuffleboard, etc., do not make the changes needed for adequate physical fitness. Swimming is an activity that Cureton equates with running for the improvement of the cardiovascular system.[67]

Harrison reported in a study of swimmers that after a period of four months of daily swimming the subjects showed considerable improvement in cardiovascular fitness and endurance. Harrison's study showed

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[64]Herbert Weber and Ronald Knowlton, "A Comparitive Study of Physique and Performance Measures Resulting from a Short Term Physical Fitness Course", The Research Quarterly, Vol. 39 #4, Dec. 1968 pp. 1107-1114.

[65]Kenneth H. Cooper, Aerobics (New York, 1968), p. 182.

[66]T. K. Cureton, "Anatomical, Physiological and Psychological Changes Induced by Exercise Programs in Adults," Exercise and Fitness, a collection of papers presented at the Colloquium on Exercise and Fitness, Athletic Institute, 1960, p. 173.

[67]Ibid., p. 174.

that by regular (at least three times per week) swimming of at least a half-mile a substantial improvement could occur.[68]

Subjects engaged in a four-week training program that did not stress cardiovascular fitness showed a small gain in cardiovascular fitness when tested by Alexander, Martin, and Metz.[69]

Johnson et al. state that the importance of the circulo-respiratory system in health and fitness cannot be over emphasized. "The benefits to be derived from a functionally efficient cardio-respiratory system are threefold: improved work capacity, increased efficiency in daily living, and prevention or dealy in the onset of certain chronic degenerative circulatory diseases."[70]

They press the point by saying that "there is considerable evidence, and such evidence continues to accumulate, that lack of adequate physical activity is a causative factor in the development of chronic, degenerative diseases of the heart and circulatory system.[71] ... Therefore, it appears that if a person is concerned about doing those things he can do in order to decrease the probability of suffering from degenerative changes he must logically include in his prevention program some regular activity that will lead to optimal circulo-respiratory fit-

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[68] A. B. Harrison, "Swim for Fitness," The Physical Educator, XXII (1965), pp. 129-30.

[69] J. F. Alexander, S. L. Martin, and Kenneth Metz, "Effects of a Four-Week Training Program on Certain Physical Fitness Components of Conditioned Male University Students," The Research Quarterly, XXXIX (1968), pp. 16-24.

[70] Perry B. Johnson et al., Physical Education, A Problem Solving Approach to Health and Fitness (New York, 1966), p. 100.

[71] Ibid., p. 101.

ness."[72]

These same authors also state this: "There is little doubt that regular and at least moderate exercise will reduce the resting heart rate; and up to a point the more vigorous the regular exercise the greater the reduction."[73] This means that the heart rests more often and there is evidence that the total work is decreased and that both the coronary reserve and the efficiency are increased.

Updyke and Johnson concluded that overload is absolutely necessary and they presented evidence that training programs in which heart rates are less than 120 beats per minute are of little value. They state that 180 beats are superior to 150 beats for circulo-respiratory training. These men also noted that at least three exercise sessions per week were necessary.[74]

Virtually all of the physical activities of daily living involve the development of an oxygen debt reported Knuttgen. The cardiovascular system is not prepared to make immediate delivery of 0_2 when a person starts any activity. This under-supply of 0_2 during the initial stages of work causes the greater 0_2 consumption after the completion of exercose. This is the time at which the 0_2 debt is repaid. Knuttgen gives the following definition of oxygen debt: "the total amount of 0_2 taken

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[72]Ibid., p. 109.

[73]Ibid., p. 290.

[74]W. F. Updyke and P. B. Johnson, Principles of Modern Physical Education, Health, and Recreation (New York, 1970), pp. 721.

up during recovery in excess of the basal or resting requirement."[75]

Cooper devised and promulgated a physical fitness program based upon aerobics. What is aerobics? It "refers to a variety of exercises that stimulate heart, blood and lung activity for a time period sufficiently long to produce beneficial changes in the body."[76] Cooper refers to these changes as the training effects. In essence, it is the capacity of the cardiovascular system to deliver more O_2 to all parts of the body. He states that the main reason for the popularity of aerobics is that it provides a kind of life insurance. "In little more than a year, aerobics has grown from near obscurity to worldwide scope."[77]

In his recently revised Aerobics program, Dr. Cooper has calculated new norms to aid the middle-aged and older population. The new program has four age categories: under 30, 30-39, 40-49, and 50 and over. He now includes safety tips, fitness-testing rules, and revised progressive point count charts.

In The New Aerobics, Cooper states that running is unquestionably the most productive exercise in terms of aerobic benefits, but he cautions that the unconditioned person must walk before he runs. "One of the results of reaching the proper point goal and staying there is a reduced heart rate ... There is no medical evidence that a person has a fixed number of heartbeats per lifetime. Yet a slower rate is

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[75] H. G. Knuttgen, "Symposium on Oxygen Debt," Physiological Aspects of Sports and Physical Fitness (Chicago, 1968), p. 9.

[76] Kenneth H. Cooper, M. D., The New Aerobics (New York, 1970), p. 15.

[77] Ibid., p. 14.

definitely less work for the heart."[78]

Added support of an aerobics fitness program is reported by Guild, a physician who lists five requisites that can be used as guidelines for choosing activities:

1. It must be an activity that is safe for the subject and will produce improved fitness.

2. It should be a year-round activity that can be performed at any time of the day or evening.

3. It must allow for easy scheduling and it must be scheduled in advance or else the time for the activity may not be available.

4. It should be an activity that is not expensive.

5. It should be enjoyable. It must be fun, not work!

Guild also recommends that the person who is trying to become physically fit keep his goal and program to hemself. If he "backslides" hsi friends may make unkind remarks that will further hamper his progress and if he quits, any kind of an interlude will make the resumption of the program much harder.[79]

Brouha, whose findings support those of Cooper, reported that the heart becomes more efficient with training. While beating less frequently, the heart provides more power as the stroke volume and cardiac output are increased. "For a standard amount of work the heart rate becomes slower as training progresses."[80] He concludes that it is not

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[78]Kenneth H. Cooper, M. D., "Key to Fitness at Any Age -- The New Aerobics," The Reader's Digest, XCVI (March, 1970, p. 220.

[79]Warren R. Guild, M. D., "Fitness for Adults," Journal of Sports Medicine, III (1963), pp. 101-04.

[80]Lucien Brouha, M. D., "Physiology of Training Including Age and Sex Differences," Anthology of Contemporary Readings, An Introduction to Physical Education, editors Howard S. Slusher and A. S. Lockhart (Dubuque, Iowa, 1966), p. 163.

exceptional for the resting pulse rate of the subject in training to be reduced by 10 to 20 beats per minute. "This greater efficiency of the heart enables a larger blood flow to reach the muscles, insuring an increased supply of fuel and O_2, and permitting the individual to reach higher levels of performance."[81]

White expressed agreement with those who suggest that exercise has positive effects on health, but he stressed that no binding rules could be made as to the amount or intensity of the exercise as each person requires an individual appraisal. It now appears that Cooper's field test may be an adequate appraisal for the majority of individuals.[82]

In a discussion of training, Brouha reports that endurance may be measured but that it is not fully understood. "Whether the greater muscular efficiency obtained by training is due primarily to chemical factors in the muscle, to an improved blood circulation, to a more efficient action of nervous impulses or other causes is still debatable."[83]

Davis, Logan, and McKinney report that it appears obvious that more research is needed to determine the mechanisms which bring about endurance as a result of training. "The fact remains, nevertheless, that muscular activity produces marked changes in the efficiency of the

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[81] Ibid., p. 109.

[82] Paul D. White, M. D., "The Role of Exercise in the Aging," Journal of American Medical Association, CLXV (1957), pp. 70-71.

[83] Lucien Brouha, M. D., "Training," Science and Medicine of Exercise and Sports, ed. W. R. Johnson (New York, 1960), p. 405.

organism known as endurance."[84]

In the study of Knehr, Dill, and Neufeld it was reported that after training subjects in exhausting work, "the capacity for aerobic energy transformation had been increased."[85] After a training period of six months the resting pulse rate decreased for all subjects an average of five beats per minute.

These findings support others that suggest that the more spectacular gains are observed after the early or initial training period. "The rate of improvement depends on the individual's initial state and on how rigorous a regime he follows. Any regime systematically followed will have its most striking results following a few weeks of training; after the first rapid gains, hard diligent work is required if a continued improvement is to be secured."[86]

With reference to the value of running for the development of cardiovascular fitness, Golding and Bos are in agreement with Cooper. They, too, believe that it is the best activity for this purpose. They contend, too, that distance swimming is excellent, but it may be more difficult to exercise in this manner because of the necessity of one's having a pool available. They report that the need for oxygen is not that of lacking environmental oxygen because there is more available

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[84]E. C. Davis, G. A. Logan, and W. C. McKinney, Biophysical Values of Muscular Activity (Dubuque, Iowa, 1965), p. 59.

[85]C. A. Knehr, D. B. Dill, and William Neufeld, "Training and Its Effects on Man at Rest and at Work," Classical Studies on Physical Activity, editors R. C. Brown, Jr., and G. S. Kenyon (Englewood Cliffs, N. J., 1968), p. 200.

[86]Ibid., pp. 194-95.

than one can use. Rather the factor that limits the performance of one is his ability to extract the 0_2 of the environment and to transmit it to the cells needing it. "The purpose of the endurance exercise is to encourage the blood to pick up more 0_2 and transport it more efficiently to the muscle cells."[87]

Hebbelinck reported that ... "the most widely used ergometric techniques are found in the area of cardiorespiratory endurance, sometimes ranged under the heading of 'stamina,' cardio-vascular endurance; 'absolute or general endurance,' measurable by more or less prolonged exertions ..."[88] He also stated that the capacity to perform steady state aerobic work could be increased by training.

This study suggested that the most used evaluative criteria for the functional capacity of the body under muscular stress are "oxygen intake, heart rate, oxygen-pulse, blood lactate concentration, cardiac output, stroke volume, pulmonary ventilation, ventilation coefficient and heart volume."[89] Of all of these criteria the one that appears to be the most valid is the oxygen intake.

Hebbelinck concluded that "physical training evaluation of athletes should include two types of ergometric tests, exploring both the aerobic and the anaerobic capacities."[90]

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[87] L. A. Golding and R. R. Bos, Scientific Foundations of Physical Fitness Programs (Minneapolis, 1967), p. 54.

[88] M. Hebbelinck, "Ergometry in Physical Training Research," The Journal of Sports Medicine and Physical Fitness, IX (June, 1969), p. 72.

[89] Ibid., p. 73.

[90] Ibid., p. 77.

Saltin and Astrand reiterated the fact that "the maximal O_2 uptake is a measurement of the maximal motor power by aerobic processes. The aerobic work power, then, is a dominant factor for a good performance in endurance events."[91]

In the study just quoted it was found that subjects who trained by running performed better on the treadmill than on the bicycle ergometer but that the subjects who trained by programs other than running performed better on the bicycle ergometer.

In "Personal Health and Fitness," Cureton states that "the main personal goal is more life for one's years" and this writer adds possibly greater longevity as well. This goal should be reached by physical training that develops and maintains endurance and organic fitness. In general, the positive objectives of learning to do well such activities as walking, running, skating, skiing, and dancing give insurance for circulatory-respiratory fitness to develop. Cureton continues ... "such a programme leads to 'self-insurance' ... Trends in the research studies indicate that man's hope of warding off sudden death is squarely centered in the personal fitness programme."[92]

Summary

In summary, the literature generally supports the premise that there is a need for research in aerobics fitness programs.

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[91]Bengt Saltin and Per-olof Astrand, "Maximal O_2 Uptake in Athletes," Journal of Applied Physiology, XXIII (1967), p. 355.

[92]T. K. Cureton, "Personal Health and Fitness," Physical Education Journal (Austrailia), No. 13, June-July, 1958 (reprint by W. & J. Barr, 105 Brunswick Street, Fitzroy, N. 6., p. 3).

Massie et al. in A Critical Review of the Aerobics Points System" called for a revision of Cooper's point count system. "A revision of Cooper's tables along the lines proposed will obviously take some time. However, the precise quantitation of training is sufficiently important, and the basic concept of Cooper's book is sufficiently useful that this time will be well spent."[93]

Cooper's 12-minute field test has been used in numerous studies and has been proved to be a highly reliable indicator of cardiorespiratory fitness. In using this twelve minute run-walk test with adolescent boys, Doolittle and Bigbee found that the distance an individual covered by running and/or walking in twelve minutes was a highly reliable and valid indicator of his cardio-respiratory fitness and it was found to be more valid than the 600-yard run-walk test. The test-retest coefficient was .94 and the validity coefficient was .90 when maximum 0_2 intake was used as the criterion.[94]

Ribisl and Kachadorian support the need for a longer run than the 600-yard run-walk test. The two-mile run time was their criterion for valid measurement of aerobic capacity. They reported that there was a high degree of relationship between the maximal 0_2 intake and the two-mile run time. "On the basis of these results, the two-mile run should be viewed as a valid measure of aerobic capacity."[95]

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[93] John Massie et al., "A Critical Review of the 'Aerobics' Points System," Medicine and Science in Sports, II (Spring, 1970), pp. 1-6.

[94] T. L. Doolittle and Rollin Bigbee, "The Twelve-Minute Run-Walk: A Test of Cardiorespiratory Fitness of Adolescent Boys," The Research Quarterly, XXXIX (1968), pp. 491-95.

[95] Paul M. Ribisl and William A. Kachadorian, "Maximal 0_2 Intake Prediction in Young and Middle-Aged Males," Journal of Sports Medicine, IX (1969), p. 20.

The advantage of the two-mile run in the prediction of aerobic capacity according to them is "that this distance is long enough to require that the individual supply the greater proportion of the energy through aerobic rather than anaerobic processes, and short enough to allow a maximal effort before motivation becomes a limiting factor in the performance."[96]

Newton, in an assessment of maximal O_2 intake, found that the Balke test or the standard treadmill run gave the highest O_2 consumption for those tested. "The Balke test and the treadmill run incorporate more realistic work rates than the Cureton test and allow sufficient time for the individual to reach his maximum VO_2,"[97] according to Newton. He also stated that in the Balke test the need for preliminary testing was kept at a minimum.

Cooper suggested a 16-weeks' training program to elevate one's aerobic fitness to the "good" level.[98] The writer has found no study that would disprove the assertion that a 16-week program of aerobic training would be adequate.

Cooper's latest book, The New Aerobics, includes some adjustments of his earlier point count system. This writer predicts that this book will be an even greater success than its predecessor because it includes a revised point count system, a chapter on indoor exercise equipment, and a chapter for women.

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[96] Ibid., p. 21.

[97] Jerry L. Newton, "The Assessment of Maximal O_2 Intake," Journal of Sports Medicine, III (1963), p. 168.

[98] Kenneth H. Cooper, M. D., Aerobics (New York, 1968), p. 6.

Cooper describes "Aerobics" in one sentence in his newer book: "Aerobics is a system of exercise designed to improve your overall health, but particularly the condition of the heart, lungs, and blood vessels." As he said, "this doesn't tell all, of course, but it does sum it up."[99]

These are the readings that have contributed to the writer's understanding of the problem and his selection of tests and procedure. He affirms the value of fitness training, and joins Cooper in this exclamation: "What is the ultimate goal of all our studies? I'm not an anarchist, but I'd like to start an aerobic revolution."[100]

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[99]Kenneth H. Cooper, M. D., The New Aerobics (New York, 1970), p. 169.

[100]Kenneth H. Cooper, M. D., Aerobics (New York, 1968), p. 160.

CHAPTER III

METHOD AND PROCEDURE

The procedures followed in this investigation were chosen after an extensive search and review of the related literature. After a personal meeting with Dr. Kenneth Cooper this writer chose to use the "Aerobic Training Program" and point count to find if participation in such a program could significantly effect the aerobic fitness levels of selected subjects. To be more specific, this writer chose to employ a recognized test of cardiovascular fitness, the Balke Treadmill Test, as well as the 12-minute field test for the pre-test in this study. Only the Balke Treadmill Test was administered for the post-test.

Selection of the Subjects

Forty-one male subjects were enlisted by the writer to participate in this physiological investigation. All of the subjects were volunteers and of the forty-one subjects who began the training program thirty-four completed the experiment. The subjects were solicited by direct appeal, by advertisements placed in the university newspaper, and by a letter placed in each faculty locker in the physical education complex. Most of the volunteers learned about the program by reading the letters they found in their lockers. Others volunteered because a friend was already participating and told them about it.

The subjects ranged in age from 25 years to 51 years. The physiological characteristics of the subjects ranged widely and this information is recorded in detail in Chapter IV. The subjects varied in weight, level of fitness, anthropometric measures, and height as well as in age.

Apparatus and Equipment

The two most essential pieces of equipment for this study were the Physiograph and the Quinton motorized treadmill. Other necessary tools were the spygmomanometer, stethoscope, scales, stop watch, Lange skinfold fat calipers, Lufkin anthropometric tape, and the Wang calculator which was invaluable for the calculation of the data. Photographs of most of this apparatus appear in the Appendix.

Testing Procedure

Each subject was asked to have a physical examination to assure the writer that each participant was physically able to enter the program.

The actual test procedure was as follows: Upon approval by a physician, the subject was asked to run-and-or walk a measured course for 12 minutes to determine the distance he might cover in that period. This was used to determine the fitness level of the subject and from these results he was placed in an appropriate exercise program.

Within a week after completion of the 12-minute field test, the subjects were asked to report to the physiology laboratory for more precise measures. Upon arrival at the laboratory each subject was weighed (sans shoes) and his weight in pounds and his height in inches were recorded in his personal record folder. Also recorded at this time were the girth measurements of the wrist, ankle, gastrocnemius, or calf and the forearm. The fat measurements of the midaxillary at xiphoid skinfold and the triceps skinfold were checked with the Lange skinfold fat calipers and these measurements were entered in each subject's record folder.

Each subject was then asked to sit quietly for a few minutes. After this rest period, the blood pressure of each subject was taken and recorded. Following the recording of the blood pressure, the subject's skin was then prepared for placement of electrodes.

The skin was thoroughly cleaned with soap and water and then scrubbed lightly with a cloth. In some instances it was necessary to shave the subject in order to assure the bond between the electrode and the subject's skin. Rubbing alcohol was used to assure that all surface contaminants had been removed. The surface electrodes were then placed on the subject's lower rib cage, one on the left front approximately four inches below the left nipple and one on the right front approximately four inches below the right nipple. The electrode that was used as a ground was placed on the sternum approximately in the middle of the vertical axis.

The surface electrodes were called self-adhering because of the double-sided adhesive washers that were used to hold the electrodes in place. They were filled with electrode paste which is a conductive element designed to assure the electrical contact between the electrode disc and the body surface.

The Physiograph was checked for its paper supply to guarantee that the test could be recorded without interruption. The ink wells were filled and the automatic paper speed control was set. The marking pen was examined to ascertain that the flow was sufficient to record the complete test, yet not excessive.

After this preliminary procedure, the subject's lead wires from the electrodes were attached directly to the Hi-Gain preamplifier. From the Hi-Gain preamplifier two couplings were needed to transfer the electrical impulses to the recording amplifiers. One coupling was made to the impedance pneumograph which was already coupled to the recording amplifier on another channel. The impulses from the amplifier caused the recording pens to vibrate thus leaving the tracings of the rhythmical patterns on the recording paper.

Each subject remained seated until a resting heart rate and respiratory rate were monitored. After these rates were recorded, the subject prepared to step on the treadmill. Having been shown earlier how to mount and dismount the treadmill in order to prevent accidents and to allay fears that could adversely affect performance, the subject then readied himself on the side of the treadmill for the entry test. He was reminded not to grasp the handrails unless they were needed in an emergency or for a balance problem.

The treadmill test was an uphill walk at a constant speed of 3.5 miles per hour. The slope or grade at which the test was begun was level, 0%. It was increased one percent each minute until the subject's heart rate (which was being monitored the last 15 seconds of each minute on the Physiograph) reached 180 beats per minute. At this point, the subject was asked to step from the treadmill and to sit down. A recovery heart rate measurement was taken the last 15 seconds of each minute for a five minute recovery period. At the end of this period, the subject's blood pressure was again recorded. A few of the subjects did not remain the treadmill until their heart rates reached 180 beats per minute, because they became exhausted and felt that they must stop for they could move no further.

After this entry test, each subject developed his own individual aerobic exercise program. The only request was that he follow Dr. Kenneth Cooper's plan and gain at least 30 points by at least four days of participation within any weekly period. Copies of the Aerobics Point System were made and distributed to the participants of the training program.

The experimental group was divided into two subgroups after the initial Balke treadmill test. Subgroup 1, included all subjects who remained on the treadmill for 18 minutes or longer. This subgroup is referred to or labeled as the "High Fitness Group." Subgroup 2 comprised all the other subjects in the experimental group. These subjects remained on the treadmill less than 18 minutes on the pre-test. They are labeled as the Average Fitness Group.

The purpose for this sub-division of the experimental group was to facilitate the investigation to ascertain if subjects who were already in a high level of cardiovascular fitness would maintain that fitness through participation in the aerobic training program. The control group had no subject who would be placed in the high fitness level therefore the control group was not divided. The numerical composition of each of the four groups after this subdivision was as follows:

1. Group I N = 27 Total Experiment Group
2. Subgroup I N = 6 High Fitness Group
3. Subgroup II N = 21 Average Fitness Group
4. Group II N = 7 Control Group

The writer did not strenuously encourage any subject to continue if he appeared to lose interest in completing the program. Each subject was asked to record and to submit to the investigator either on a weekly or a bi-weekly basis a point count report. The subjects were not supervised as they followed their daily exercise programs and the writer assumed that the point count records that were reported were accurate.

The activities that were reported by the subjects included running, jogging, paddleball, handball, walking, swimming, and various combinations of these activities.

Seven of the subjects were unable to complete the 16-weeks program and did not take the post-test. Four subjects who did not follow the exercise program as intended joined three volunteers who entered the program as control subjects making a total of seven in the control group. Twenty-seven volunteers completed the program in the experimental training program group.

At the end of the 16-week period, these subjects were recalled for the post exercise program test. The post-test followed the same pattern as the entry test.

The program for the analysis of covariance was run at the Oklahoma State University Computer Center. The computer was an IBM 360 Model 50. The program used was titled: BMDO4V - Analysis of Covariance - Multiple Covariates - Revised October, 1968 - Health Sciences Computing Facility U.C.L.A.

The writer calculated each subjects ideal body weight by using the Behnke Formula and compared the predicted ideal weight with the actual weight of each subject at the end of the 16 week training period to see if the post-test weight were closer to the predicted weight than the pre-test weight. The Behnke Formula is recorded in its entirety in Appendix G.

Treatment of Data

The writer entered the scores of the individual participants in a table entitled "Raw Score Table." From this table the writer converted the scores into group scores and other measures to be used in formulas. The formulas used were needed to test the hypotheses that were presented in Chapter I. The statistical treatments that were selected were those of the correlation, the linear regression, the "t" test, and the analysis of covariance.

A Pearson Product Moment correlation was used to determine the relationship of the subjects' test runs of 12 minutes with their treadmill times.

The linear regression was calculated to predict a "distance" on the 12-minute run test from a given time on the treadmill test. This was done to see if a subject's performance on one of these tests could be used as an accurate predictor of his performance on the other.

The "t" test was the statistical technique that was utilized to check the significance of the change between the pre-test and the post-test means for the control and experimental groups. The level of .05 was designated as that of significance. The "t" test was used to check the hypothesis that there was no significant difference between the mean scores of the subjects in the control group and the subjects in the experimental group on pre-test treadmill times, heart rates and weights.

The analysis of covariance was the statistical treatment used to compare the various group's scores as they related to each other in the post-test adjusted mean resting heart rates, weights and treadmill times. If the variances were significant in the pre-test, the analysis of covariance facilitated equalization of the means.

CHAPTER IV

RESULTS

The purpose of the investigation reported in this paper was to ascertain whether an aerobics training program of sixteen weeks duration significantly affected the cardiovascular fitness of subjects. The results of the study are herein recorded. A recognition of those subjects in possession of high fitness levels at the initiation of the program facilitated a comparison of fitness levels and the maintenance thereof when said subjects also engaged in the training program.

The entry test in which all of the subjects (except one control) participated was the Cooper 12-Minute Run Test. Table I, yields the information regarding the initial performance means in miles of both the experimental and control groups.

TABLE I

INITIAL RESULTS OF COOPER'S 12-MINUTE RUN TEST

	Experimental Group	Control
N =	27	7
Range =	1.1 to 2.0 miles	.8 to 1.4 miles
Mean =	1.38 miles	1.1 miles
Standard Deviation =	.21	.22

Using the fitness categories designated by Cooper in relationship to performance, the investigator found that the mean performance of the experimental subjects placed them in the "fair" category. Observing the mean of the control group's performance, he concluded that these subjects were in the "poor" category. Perceiving that a possible significant difference existed initially between the experimental and controls subjects, the writer recognized the need to administer an analysis of covariance upon the data obtained from the pre and post-tests of weight, heart rate, and treadmill performance. The fitness categories as defined by Cooper are identified in Table II.

TABLE II

COOPER'S FITNESS CATEGORIES BASED ON 12-MINUTE RUN PERFORMANCE[1]

Fitness Category	Distance Covered	Oxygen Consumption
I Very Poor	Less than 1.0 mile	28.0 (Ml/Kg/Min)
II Poor	1.0 to 1.24 miles	28.1 to 34 "
III Fair	1.25 to 1.49 miles	34.1 to 42 "
IV Good	1.50 to 1.74 miles	42.1 to 52 "
V Excellent	1.75 miles or more	52.1 (Ml/Kg/Min)

The mean weights of both the experimental and control groups for the pre-tests and post-tests, their standard deviations, the optimum predicted weights and their standard deviations are recorded in Table III. The post-test mean weights of both the experimental and control weights

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[1]Kenneth Cooper, Aerobics (New York, 1968), p. 36.

were nearer their optimum predicted mean weights than were their pre-test weights. Although the post-test mean weight of the control group was reduced by two pounds, the post-test mean weight of the experimental group was reduced by nine pounds.

The pre-test mean weight for the experimental group was 186.4, for the control group it was 176.1. The post-test mean weight for the experimental group was 176.7. This mean post-test weight was still 6.5 pounds over the optimum predicted weight. The control group post-test mean weight was 174 and this mean weight was 13 pounds heavier than the predicted optimum weight.

A "t" test was used to test for significance of difference between the pre-test mean weight of these groups. The "t" ratio (1.23) was not large enough to be significant at the .05 level.

TABLE III

WEIGHT OF SUBJECTS IN POUNDS

Test Means and Standard Deviations	Experimental Group N = 27	Control N = 7
Pre-test Mean	186.4	176.1
Standard Deviation	27.77	14.95
Optimum Predicted Mean	170.2	161.0
Standard Deviations	21.27	9.63
Post-Test Mean	176.7	174.0
Standard Deviation	22.74	16.15

TABLE IV

SUMMARY OF RESTING HEART RATES AND RESTING BLOOD PRESSURE

Test Means and Standard Deviations	Experimental Group	Control
Resting Heart Rate Pre-test Mean	75.5	89.1
Standard Deviation	15.19	10.84
Resting Heart Rate Post-test Mean	71.8	91.4
Standard Deviation	8.62	18.94
Resting Blood Pressure Pre-test Mean	130/86	134/86
Standard Deviation	9.85/9.9	9.51/3.55
Resting Blood Pressure Post-test Mean	129/83	131/89
Standard Deviation	10.61/7.79	8.97/5.03

Experimental N = 27
Control N = 7

The heart rate or pulse rate in man is a variable factor, but Williams stated that the average was nearly 78 beats per minute. He also stated that the blood pressure was recorded in its maxima and minima, the normal value often being of the order of 120/80.[2]

Mellerowicz stated that the number of heart beats per minute at rest could be decreased to approximately 50% of the initial figure. He further stated that highly-trained persons may have heart rates of 30-40 beats per minute.[3]

The mean resting heart rate for the experimental group's pre-test

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[2] J. G. P. Williams, Medical Aspects of Sport and Physical Fitness (New York, 1965), pp. 13-4.

[3] H. Mellerowicz, "The Effects of Training on O_2 Consumption of the Health and Its Importance for Prevention of Coronary Insufficiency", Health and Fitness in the Modern World (The Athletic Institute, Chicago, 1961), p. 84.

was 75.5 beats per minute, compared with 89.1 for the control group for the same test. A "t" ratio of (4.79) between these two means was significant beyond the .01 level.

The blood pressure measure has not been as consistent a predictor of cardiovascular fitness, but it, too, is usually lowered by aerobic training. In Table IV, one finds that the resting blood pressure mean of the experimental group was lowered slightly whereas that of the control group rose very slightly. The slight variance could have resulted for many reasons. Measurement error is possible to this extent.

The pre-test resting blood pressure mean of the control group, (134/86) was close to that of the experimental group (130/86). The post-test blood pressure means were again not varied enough to suspect a significant difference. On the post-test the control group mean was (131/89) while the experimental group mean was (129/83). Because of this closeness between means of the control and the experimental and the closeness between means of the control and the experimental and the closeness between the means of the pre-test-post-tests the writer chose not to pursue any further the blood pressure data.

The treadmill test, according to Cooper, is the most accurate and objective test yet devised for measuring a man's cardiovascular fitness. The Balke Treadmill Test has as its main criterion the heart rate. When the subject's heart reaches 180 beats per minute the test is completed.[4]

The Balke Treadmill Test scores of the experimental and control groups are shown in Table V. These times were the length of minutes the subjects remained on the treadmill before their heart rates reached

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[4]Kenneth Cooper, M. D., Aerobics (New York, 1968), p. 32.

TABLE V

BALKE TREADMILL PERFORMANCE TIMES

MINUTES TO REACH 180 PULSE RATE

Test Means and Standard Deviations	Experimental Group	Control
Pre-test Mean	15.5	12.7
Standard Deviation	3.07	3.24
Post-test Mean	19.5	13.4
Standard Deviation	2.39	2.55

180 beats per minute. The pre-test mean time for the experimental group on the treadmill was 15.5 minutes. For the control pre-test time the mean was 12.7 minutes. The "t" ratio (2.06) for the differences between the groups pre-test treadmill times was significant at the .05 level. The experimental mean post-test time was 19.5 minutes on the treadmill. The control increased their time to 13.4 minutes on the post-test. The increase of the experimental group mean on the treadmill test from the pre-test to the post-test was four minutes. This performance raised its subjects to the "good" category. The control group increased its mean time on the treadmill from the pre- to the post-test by less than one minute, but this was sufficient to raise them from the "very poor" to the "poor" category.

Observing Table VI, one can find the predicted amount of O_2 consumed if he knows the duration of the test group upon the treadmill. This is in agreement with Mellerowicz's study.[5]

[5] H. Mellerowicz, "The Effects of Training on O_2 Consumption of the Heart and Its Importance for Prevention of Coronary Insufficiency", Health and Fitness in the Modern World (The Athletic Institute, Chicago, 1961), p. 91.

For the experimental group whose post-test mean on the treadmill was 19.5, the predicted consumption of 0_2 was 41-45 millimeters per kilogram of body weight per minute. The mean predicted 0_2 consumption of the control group was 10 millimeters per kilogram per minute less. Projecting this information onto Cooper's Fitness Categories, Table II, one finds that the experimental group should have run between 1.50 and 1.74 miles on the post-test 12-minute run. Using this table, one may assume that the control group should have run between 1.0 to 1.24 miles. It appears that these tests are fairly accurate in their appraisal of aerobic fitness.

The table below, Table VI, identifies the classification of the fitness of subjects according to the amount of 0_2 consumed within a given period of time on the treadmill. Understanding this table will help the reader interpret the results recorded in Table V.

TABLE VI

SCORING THE BALKE TEST

Duration of Test (in minutes)	Oxygen Consumption (ml/kg/min)	Classification
12-below	30 and under	Very poor
13 and 14	31-35	Poor
15 and 16	36-37	Fair
17	38-40	Average
18 and 19	41-45	Good
20 and 21	46-50	Very good
22 and 23	51-55	Excellent
24 and over	56 and above	Superior

[6]Kenneth Cooper, M. D., Aerobics (New York, 1968), p. 32.

O_2 consumption is usually expressed in millilieters per kilogram of total body weight per minute. Maximum O_2 consumption, says Cooper, tells how much O_2 a subject is consuming during any activity, and it cancels out differences resulting from variations in body weight. It is the millimeters figure that Cooper has translated into his aerobic point count system.[7]

In correlating the data from the Balke Treadmill Test and Cooper's 12-Minute Run Test, the writer found that the correlation coefficient for the experimental group of 27 subjects was +.75 and for the control group of seven subjects was +.26. The +.75 correlation is reasonably high, however, it should be noted that this would not apply to the general population but rather to a group of individuals who were average or above in their cardiovascular fitness and well motivated for the 12-minute run. Self-motivation appears to be a decisive factor in the correlation of these two tests, for, as Cooper says, the 12-Minute Run is an all-out test that requires the subject to exert himself.[8] The subjects who volunteered to become a part of the experimental group were willing to do their best and were probably more highly motivated.

A linear regression formula was employed to predict the performance scores of the experimental subjects on the 12-Minute Run Test by their performance scores on the treadmill test. The correlation figure for the control group was too low to attempt to predict performance scores. Figure 1 depicts the linear regression. The regression formula which can be used to predict a 12-minute run distance is $\tilde{Y} = .6205 + (.049)(\tilde{X})$

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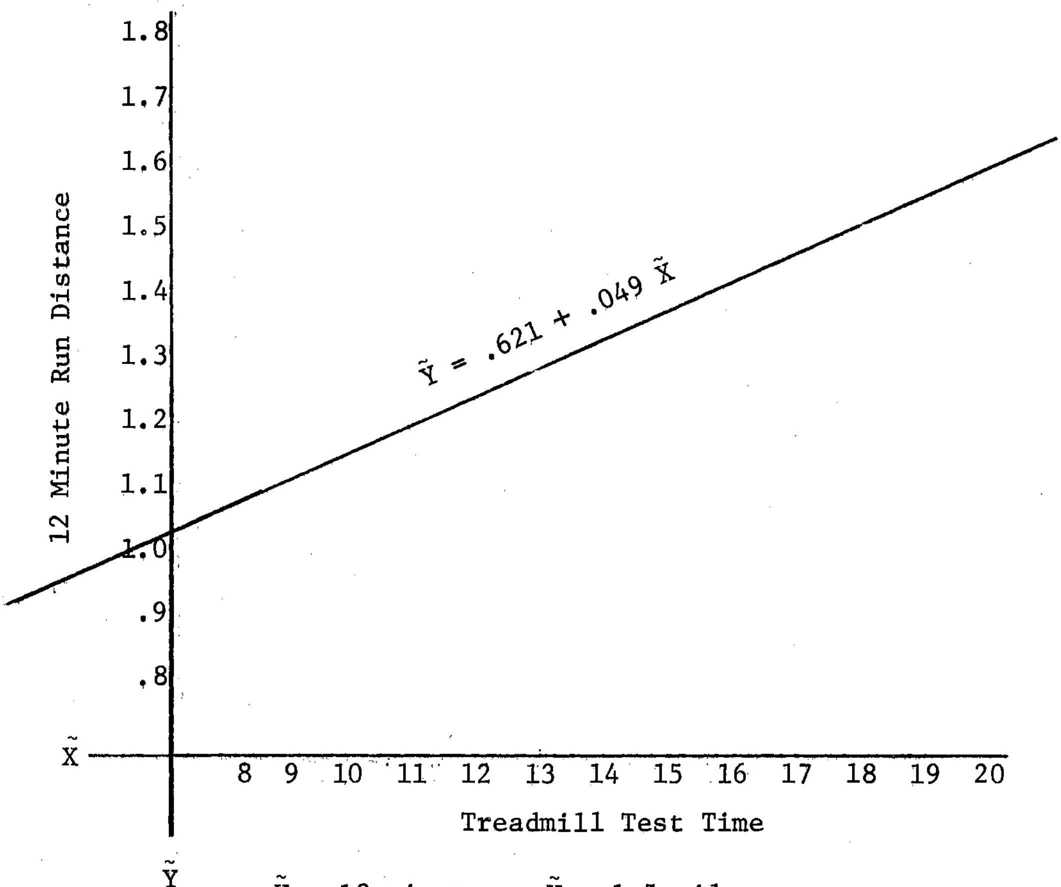
[7]Ibid., p. 30.

[8]Ibid., p. 35.

$\tilde{Y}$ = Score to be predicted - 12 Minute Run Distance. $\tilde{X}$ = Score used as predictor - Treadmill time. This linear regression equation can be applied only to individuals who are average or above in their cardiovascular fitness and highly motivated.



$\tilde{X}$ = 18 minutes; $\tilde{Y}$ = 1.5 miles
$\tilde{X}$ = 13 minutes; $\tilde{Y}$ = 1.26 miles

Figure 1. Linear Regression Prediction for Balke Treadmill Test Score and 12-Minute Run Scores

The results of the "t" test applied to the heart rate, weight, and treadmill means for both the pre-tests and post-tests of the experimental group are shown in Table VII. The results of the "t" application to the control data are posted in Table VIII.

TABLE VII

SUMMARY OF PRE-TEST-POST-TEST EXPERIMENTAL DATA
ON DWYER'S "t" TEST FOR PAIRED MEASURES†

Critical "t" = 2.056 > .05

Tests	Mean Difference	SD	df	t
Resting Heart Rate Beats Per Minute	3.7	6.7	26	2.796*
Weight in Pounds	5.93	7.45	26	4.056**
Treadmill Time in Minutes	3.93	2.59	26	7.719***

*"t" significant beyond the .05 level.

**"t" significant beyond the .01 level.

***"t" significant beyond the .01 level.

†The formula for Dwyer's "t" test appears in the Appendix.

TABLE VIII

SUMMARY OF PRE-TEST-POST-TEST CONTROL DATA
ON DWYER'S "t" TEST FOR PAIRED MEASURES

Critical "t" = 2.447 > .05

Tests	Mean Difference	SD	df	t
Resting Heart Rate Beats Per Minute	2.2	10.33	6	.8848
Weight in Pounds	2.14	2.23	6	1.981
Treadmill Time in Minutes	.714	1.03	6	1.698

By using Dwyer's "t" test for significance between means of paired measures, the writer concluded that the experimental group made significant improvement in each of the tested criteria from the pre-test to the post-test. The lowered heart rate was significant at the .05 level. The weight and treadmill measures were significant beyond the .01 level.

The final statistical treatment of this study was an analysis of covariance applied to the post-tests of the weight, heart rate, and treadmill performance means for the experimental and control groups, and the experimental subgroups.

Popham reports that "the analysis of covariance allows the researcher to study the performance of several groups which are unequal with regard to an important variable as though they were equal in this respect. Sometimes the possible confounding variables will be identified in advance of the data collection. In other cases the researcher discovers such confounding variables only after the data have been gathered. Both situations can be appropriately handled through the use of the analysis of covariance model."[9]

He warns the researcher not to be too sure when dealing with intact groups because the possibility of an unknown confounding variable's existence is always a reality.

The apparent differences in the post-test mean weights for both the experimental and control groups were not significant. In Table IX the "F" value for each of the treatments was too small to reject the null hypothesis. The adjusted mean weight for the experimental group

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[9]W. J. Popham, Educational Statistics Use and Interpretation (New York, 1967), p. 223.

TABLE IX

ANALYSIS OF COVARIANCE FOR WEIGHTS OF EXPERIMENTAL AND CONTROL SUBJECTS

Treatment Group	N	df	Pre-test Mean Pounds	Post-test Mean Pounds	Adjusted Mean Pounds	F
Total Experimental	27	26	186.3704	180.4444	178.7129	.732
Control	7	6	176.1429	174.0000	180.6783	
High Fitness Exp.	6	5	167.1667	166.3330	170.7492	.041
Control	7	6	176.1429	174.0000	170.2149	
Average Fitness Exp.	21	20	191.8571	184.4762	181.1603	1.320
Control	7	6	176.1429	174.0000	183.9476	
High Fitness Exp.	6	5	167.1667	166.3333	181.9667	.536
Average Fitness Exp.	21	20	191.8571	184.4762	180.0095	

None of the "F" values in Table IX were large enough to be significant at the .05 level.

was approximately two pounds lower than the post-test mean and eight pounds lower than the pre-test mean. The adjusted mean weight for the control group was approximately six pounds higher than the post-test mean and four pounds heavier than the pre-test mean. The analysis of covariance was computed at the Oklahoma State University Computer Center and a copy of the A.O.C.V. Table from the IBM printout is in the Appendix.

In Table X one can see that the total experimental group mean for heart rate was significantly different from the control for heart rate was significantly different from the control group mean heart rate. An "F" value of 2.47 was needed for the .05 level and the computed "F" value was (3.182). The adjusted mean resting heart rate of the different treatment groups ranged from 67.9 B/P/M for the high fitness experimental group to 82.32 B/P/M for the control group.

The "F" values in Table XI reveal significant differences between the post-test means of the experimental and control groups in all but one of the analyses for the treadmill tests for experimental and control groups. The mean of the total experimental group and the control group mean was significantly different beyond the .01 level.

The high fitness experimental group mean treadmill time was significantly different from the control group mean beyond the .05 level and although it was not as highly significant as the difference between the total experimental group and the control group, it was adequate to be significant at the .05 level.

The average fitness experimental group mean treadmill time was significantly different from the mean of the control group. The "F" was large enough to be significant beyond the .01 level.

The analysis of covariance indicated no significant difference

TABLE X

ANALYSIS OF COVARIANCE FOR RESTING HEART RATES OF EXPERIMENTAL AND CONTROL SUBJECTS

Treatment Group	N	df	Pre-test Mean B/P/M	Post-test Mean B/P/M	Adjusted Mean B/P/M	F
Total Experimental	27	26	75.4815	71.7778	74.384	3.182*
Control	7	6	89.1429	91.4286	81.374	
High Fitness Exp.	6	5	68.6667	63.6667	75.8924	.323
Control	7	6	89.1429	91.4286	80.9493	
Average Fitness Exp.	21	20	77.5714	74.0952	77.1293	1.759
Control	7	6	89.1429	91.4286	82.3263	
High Fitness Exp.	6	5	68.1667	63.6667	67.9044	2.444
Average Fitness Exp.	21	20	77.5714	74.0952	72.8844	

*"F" significant > .05

Means are recorded in beats per minute.

between the means of the high fitness and the average fitness groups on their treadmill time gains from the pre-test to the post-test scores. These latter two treatment groups did not vary as much as it appeared that they might from surveying the large pre-test-post-test increase. The reader can observe this in Table XI. It would be expected, however, that the high fitness level mean would not rise as greatly as would the mean of the average fitness experimental group. The adjusted means were nearly identical for these two treatment groups.

The vast improvement of the experimental group in terms of mean increase on their post-test treadmill performance over that of the control group proved to be significant beyond the .05 level. This significance was found for the total experimental group as well as for both of the sub-groups.

TABLE XI

ANALYSIS OF COVARIANCE OF BALKE TREADMILL TEST VALUES FOR EXPERIMENTAL AND CONTROL SUBJECTS

Treatment Group	N	df	Pre-test Mean Minutes	Post-test Mean Minutes	Adjusted Mean Minutes	F
Total Experimental	27	21	15.5185	19.5185	19.2236	*28.724
Control	7	6	12.7143	13.4286	14.5659	
High Fitness Exp.	6	5	19.8333	21.3333	18.8170	** 6.384
Control	7	6	12.7143	13.4286	15.5855	
Average Fitness Exp.	21	20	14.2857	19.0000	18.7574	***26.234
Control	7	6	13.4286	13.4286	14.1563	
High Fitness Exp.	6	5	19.8333	21.3333	19.3400	.024
Average Fitness Exp.	21	20	14.2857	19.0000	19.5695	

*"F" significant > .01.

**"F" significant > .05.

***"F" significant > .01.

Means represent length of time in minutes on treadmill.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to determine if a group of middle-aged men could through a consistent, 16-week program of aerobic activities of their own choosing in which they earned a minimum of 30 points on Cooper's Aerobics Point System, maintain or improve their cardiovascular fitness to a level that would place them in a good or an excellent category. The criterion for good fitness was the minimum performance of 18 minutes on the Balke Treadmill Test.

This problem was surrounded by various sub-problems which made the study even more interesting. Some of the anticipated sub-problems did not materialize as the writer could not predict the exact intact distribution for this study. For this reason, some of the sub-problems listed in Chapter I were not investigated.

The experimental subjects who volunteered were nearly all non-smokers. Only two of the experimental volunteers smoked regularly, so the investigator excluded this aspect of the study.

One other sub-problem had to be omitted because of the lack of distribution in the subjects' choices of activity. Almost unanimously, the subjects chose paddleball as their primary source of training exercise activity.

A correlation and a linear regression prediction were calculated for the subjects' performances on the Cooper 12-Minute Run Test and the Balke Treadmill Test.

The subjects' pre-test and post-test weights were recorded and an optimum weight was predicted for each subject by computation of the Behnke Formula.

A comparison of the experimental pre-test mean and post-test mean for weight, resting heart rate, and treadmill performance was checked for significant difference by use of the "t" test. The same procedure was followed for the control group.

The statistical treatment of the data had to be altered from the treatment proposed in Chapter I. After collection of the data, the investigator realized that the differences in the pre-test mean of the control group and the experimental group would have to be equalized for the comparison of results of the post-test means to have any significance. Instead of the "t" test for significance, an analysis of covariance was employed to accomplish this needed adjustment.

To compare the mean scores of those subjects who possessed a high level of cardiovascular fitness at the start of the training program with those who had normal or average fitness, the writer used the analysis of covariance to equalize the differences in the pre-test mean scores.

The review of literature included materials from three main areas. These areas were treadmill studies, cardiovascular fitness, and effects of training. The literature generally supported the premise that there was a need for further research in aerobics fitness programs.

The procedures that were followed in attempting to determine the effects of the training program upon the subjects were outlined and discussed in Chapter III. The statistical treatment of the data was also reported in Chapter III.

In Chapter IV all of the results of the study were recorded in tables or figures and were discussed as they related to the data for each group and to the total population of the study.

Conclusions

From the data collected in this investigation, the following conclusions have been drawn.

1. An aerobic training program of 16 weeks duration in which the subjects earned 30 points per week on Cooper's Aerobic Point System was sufficient to increase or maintain the subjects fitness at the good level.

2. There was a +.75 correlation between the treadmill times and the 12-minute run distance for the experimental group and a +.26 correlation for the control group.

3. The mean weight of the experimental group was lowered significantly (.05 level or beyond) from the mean pre-test weight. The control weight difference was not significant. The "F" value indicated that the apparent difference in the post-test mean weight between the control and the experimental groups was not statistically significant.

4. The mean resting heart rate of the experimental group on the post-test was significantly lower (.05 level) than the pre-test rate. The control group mean did not change significantly during this time.

5. The experimental mean resting heart rate on the post-test was significantly different than the mean resting heart rate of the controls. The "F" was large enough to indicate significant difference at the .05 level.

6. The experimental groups' mean treadmill time on the post-test was significantly better (.01 level) when compared to the pre-test means. The control groups' mean was not significantly different from the pre-test to the post-test.

7. The experimental groups' post-test mean treadmill time was significantly (.01 level) greater than the control groups' post-test treadmill time.

Recommendations

The results of this study must be interpreted in relation to the intact population. Inferences to the general population can not be made from this study as this was a voluntary sample of university-affiliated men.

1. Enough subjects should be enlisted in order to assure that there would be an adequate number to complete the study.

2. It is further recommended that the control group be the same size as the experimental group.

3. Additional studies should include the administration of the Cooper 12-Minute Run Test to the total group, both the experimental and control groups, en masse at the initiation and conclusion of the program. This should motivate all of the subjects on this all-out test.

4. The writer recommends that the experimental subjects be assigned in equal numbers to different exercise training programs in order to compare the results and means of the groups participating in different physical activities.

5. The investigator suggests that other studies observe and report effects of Cooper's fitness program for shorter periods to ascer-

tain how quickly one may reach the good fitness level.

6. Follow-up studies should be made every year using the same subjects to indicate the lasting effects of this study.

7. Similar studies should be conducted with different age groups, varied occupations and with female as well as male subjects.

8. Smokers should be enlisted for participation in such a program to determine if they make equal or similar changes as they participate in the program.

9. The writer recommends that the records of all of the subjects who participated in the study be kept in the physiology of exercise laboratory for examination, should any subject's physician wish to do so.

BIBLIOGRAPHY

1. Alexander, J. F., S. L. Martin, and Kenneth Metz. "Effects of a Four-Week Training Program on Certain Physical Fitness Components of Conditioned Male University Students," The Research Quarterly, XXXIX (1968), pp. 16-24.

2. Andersen, K. Lange and Lars Hermansen. "Aerobic Work Capacity in Middle-Aged Norweigian Men." Journal of Applied Physiology, XX (1965), p. 432-36.

3. Andrew, G. M., C. A. Guzman, and M. R. Becklack. "Effect of Athletic Training on Exercise Cardiac Output," Journal of Applied Physiology. XXI (1966), p. 603-08.

4. Astrand, P. O., "Human Physical Fitness with Special Reference to Age and Sex," Physiological Reviews, XXXVI (1956), pp. 307-335.

5. Astrand, P. O. "Human Physical Fitness with Special Reference to Sex and Age," International Research in Sport and Physical Education. Editors, Joke and E. Simon, (Springfield, Illinois, 1964), pp. 517-559.

6. Astrand, P. O., and Irma Ryhming, "Nomogram for Predicting Oxygen Uptake from Submaximal Oxygen Uptake," Journal of Applied Physiology, VII (1954), pp. 218-21.

7. Baker, J. A. "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Men," The Research Quarterly. XXXIX (1968), pp. 240-43.

8. Balke, Bruno, M. D., "A Simple Field Test for the Assessment of Physical Fitness," Federal Aviation Agency Civil Aeromedical Research Institute, Report 63-6, Washington, D.C., 1963, p. 8.

9. Balke, Bruno, M. D., "The Effect of Physical Exercise on the Metabolic Potential, A Crucial Measure of Physical Fitness," Exercise and Fitness, (Chicago, 1960), pp. 73-81.

10. Balke, Bruno and R. T. Clark. "Cardio-Pulmonary and Metabolic Effects of Physical Training." Health and Fitness in the Modern World (Chicago: Athletic Institute, 1961), pp. 82-89.

11. Balke, B. and C. W. Ware. "An Experimental Study of 'Physical Fitness' of Air Force Personnel," U.S. Armed Forces Medical Journal, XIX June (1959), pp. 675-688.

12. Bengtsson, E. "The Working Capacity in Normal Children Evaluated by Submaximal Exercise Compared with Adults," Acta Medica Scandinavia, XLIV (1954), pp. 91-109.

13. Billings, et. al. "Measurement of Human Capacity for Aerobic Muscular Work," Journal of Applied Physiology, XV (1960), p. 1001.

14. Bird, Patrick J., and John F. Alexander. "Effects of an Individually Geared Exercise Program on Physical Fitness of Adult Men," The Research Quarterly, XXXIX (1968), pp. 857-864.

15. Bowerman, William J. and W. E. Harris, M. D. Jogging, A Physical Fitness Program for All Ages (New York, 1967), pp. 128.

16. Brouha, L., M. D. "Physiology of Training Including Age and Sex Differences," Anthology of Contemporary Readings, An Introduction to Physical Education. ed. Howard S. Slusher and A. S. Lockhart (Dubuque, Iowa, 1966), pp. 324.

17. Lucien Brouha. "Training," Science and Medicine of Exercise and Sports, ed. W. R. Johnson (New York, 1960), pp. 537.

18. Brouha, L., A. Graybiel, and C. W. Heath, "The Step Test, A Simple Method of Measuring the Physical Fitness for Hard Muscular Work in Adult Man," Revue de Canadian Biologie, II (1943), pp. 86-91.

19. Brown, Roscoe C., Jr., and Gerald S. Kenyon, Classical Studies on Physical Activity (Englewood Cliffs, Prentice-Hall, Inc., 1968), pp. 101-2.

20. Consolazio, C. F., R. E. Johnson and L. J. Pecora. Physiological Measurements of Metabolic Functions in Man (New York: McGraw-Hill Book Co., 1963), pp. 505.

21. Cooper, Kenneth, M. D. Aerobics (New York: M. Evans and Co., 1968), pp. 182.

22. Cooper, Kenneth H., M. D. "A Means of Assessing Maximal O_2 Intake," Journal of American Medical Association, CCIII, Jan. (1968), p. 135-38.

23. Cooper, Kenneth H. "Key to Fitness at Any Age -- The New Aerobics," The Readers Digest XCVI (March, 1970), pp. 214-230.

24. Cooper, Kenneth H., M. D. The New Aerobics (New York, M. Evans and Co., 1970), pp. 191.

25. Cooper, K. H., G. O. Gey, and R. A. Bottenberg. "Effects of Smoking on Endurance Performance," Journal of American Medical Association, CCIII Jan. (1968), pp. 123-26.

26. Cooper, L. A. "A Comparison of the Effects of Short Intensive and Prolonged Exercise Programs on Cardio-respiratory Functions," (unpub. Master's thesis, University of Alberta, 1963), pp. 91.

27. Cotton, F. S. "The Relationship of Athletic Status to the Pulse Rate in Men and Women," Journal of Physiology, LXXVI (1932), pp. 39-51.

28. Cureton, T. K. "Anatomical, Physiological and Psychological Changes Induced by Exercise Programs in Adults," Exercise and Fitness, a collection of papers presented at the Colloquium on Exercise and Fitness, Athletic Institute, (1960), pp. 248.

29. Cureton, T. K. "Personal Health and Fitness," Physical Education Journal, (Australia, June-July, 1953), pp. 11.

30. Cureton, T. K. Physical Fitness, Appraisal and Guidance (St. Louis, 1947), pp. 144.

31. Cureton, T. K. Physical Fitness of Champion Athletes, (Urbana, Illinois, 1951), pp. 238.

32. Darling, R. C. "Physiology of Exercise and Fatigue," Therapeutic Exercise, ed. Sidney Licht (2nd ed., New Haven, 1961), pp. 234.

33. Daugherty, J. B. "An Analysis of Physical and Physiological Characteristics of Endurance Performance in Young Men" (unpublished Doctoral dissertation, New York University, 1950), pp. 126.

34. Davis, E. C., G. A. Logan, and W. C. McKinney, Biophysical Values of Muscular Activity (Dubuque, Iowa, 1965), pp. 151.

35. Dill, D. B. "The Economy of Muscular Exercise," Physiological Reviews, XVI (1936), pp. 263-91.

36. Dill, D. B. "Oxygen Used in Horizontal and Grade Walking and Running on the Treadmill," Journal of Applied Physiology, XX (1965), pp. 19-22.

37. Dill, D. B., H. T. Edwards, and J. H. Talbot. "Studies in Muscular Activities," Journal of Physiology, LXIX (1930), pp. 263-291.

38. Douglas, F. G. V., and M. R. Becklake. "Effect of Seasonal Training on Maximal Cardiac Output," Journal of Applied Physiology, XXV (1968), p. 600-05.

39. Durnin, J. V. G. A., and L. Namyslowski. "Individual Variation in the Energy Expenditure of Standardized Activities," Journal of Physiology, CXLIII June (1958), pp. 573-77.

40. Erickson, L., et al. "The Energy Cost of Horizontal and Grade Walking on the Motor-Driven Treadmill," American Journal of Physiology, CXLV (1946), pp. 391-401.

41. Faria, Irvin Edwin. "Cardiovascular Responses to Exercise as Influenced by Training of Various Intensities" (unpub. Ed.D. thesis, Stanford University, 1968), pp. 92.

42. Faulkner, J. A. "New Perspectives in Training for Maximum Performance," Journal of American Medical Association, CCV (Sept. 9, 1968), pp. 117-21.

43. Fleishman, Edwin A. The Structure and Measure of Physical Fitness, (Englewood Cliffs, Prentice Hall Pub. Co., 1964), p. v.

44. Fraser, R. S. and C. B. Chapman. "Studies on the Effect of Exercise on Cardiovascular Function," Circulation, (Feb., 1954), pp. 193-197.

45. Glassford, R. G., et al. "Comparison of Maximal Oxygen Uptake Values Determined by Predicted and Actual Methods," Journal of Applied Physiology, XX (1965), pp. 509-513.

46. Golding, L. A. and R. R. Bos. Scientific Foundations of Physical Fitness Programs (Minneapolis, Burgess Pub. Co., 1967), pp. 85.

47. Guild, Warren R., M. D. "Fitness for Adults," Journal of Sports Medicine, III (1963), pp. 101-104.

48. Harrison, A. B., "Swim for Fitness," The Physical Educator. XXII (Oct., 1965), pp. 129-30.

49. Hebbelinck, M. "Ergometry in Physical Training Research," The Journal of Sports Medicine and Physical Fitness, (June, 1969), pp. 69-79.

50. Henry, F. M. "The Influence of Athletic Training on the Resting Cardiovascular System," The Research Quarterly, XXV (March, 1954), pp. 38-41.

51. Lars, Hermansen, and K. Lange Andersen. "Aerobic Work Capacity in Young Norwegian Men and Women," Journal of Applied Physiology, XX (1965), pp. 425-431.

52. Howell, M. L., et. al. "Effect of Participation in Various Athletic Activities Upon Treadmill Performance," (Micro-card UO 65 289, University of Alberta, 1964), pp. 190.

53. Hyde, Rodney C. "The Astrand-Ryhming Nomogram as a Predictor of Aerobic Capacity for Secondary School Students," (unpublished thesis, University of Alberta, 1965), pp. 88.

54. Jackson, Jay A., Brian J. Sharkey, and L. Pat Johnson. "Cardiorespiratory Adaptations to Training at Specified Frequencies," The Research Quarterly, XXXIX (May, 1968), pp. 295-300.

55. Johnson, Barry L., and Jack K. Nelson. Practical Measurements for Evaluation in Physical Education (Minneapolis, Minn., 1969), pp. 477.

56. Johnson, Perry B., et. al. Physical Education, A Problem Solving Approach to Health and Fitness, (New York, 1966), pp. 486.

57. Jokl, Ernst. Heart and Sport (Springfield, Illinois, 1964), pp. 117.

58. Kennedy, John F. "The Soft American," Background Readings for Physical Education, editors Ann Patterson and Edmond C. Hallberg, (New York, Hott, Rinehart, and Winston, 1967), pp. 389-395.

59. Knehr, C. A., D. B. Dill, and William Neufeld. "Training and Its Effects on Man at Rest and at Work," Classical Studies on Physical Activity. editors R. C. Brown, Jr., and G. S. Kenyon (Englewood Cliffs, Prentice-Hall, Inc., N. J., 1968), pp. 539.

60. Kooshkin, G. I. "The New School Program in Physical Education in the U.S.A.," Theory and Practice of Physical Culture, VI (1963), pp. 63-4.

61. Knuttgen, H. G. "Symposium on Oxygen Debt," Physiological Aspects of Sports and Physical Fitness, (Chicago, Illinois, The Athletic Institute, 1968), pp. 102.

62. Kozar, A. J. "A Study of Telementered Heart Rate During Sports Participation of Young Adult Men," (unpublished doctoral dissertation, University of Michigan, 1961), pp. 127.

63. Kraus, Hans, M. D., and Wilhelm Raab, M. D. Hypokinetic Disease (Springfield, Illinois, Charles E. Thomas, pub., 1961), pp. 193.

64. Mayer, Jean. "The Best Diet is Exercise", reprinted in Science and Theory of Health (Dubuque, Iowa, 1966), pp. 186-191.

65. McCurdy, J. H. and L. A. Larson. "Measurement of Organic Efficiency for Prediction of Physical Condition," The Research Quarterly Supplement, VI (1935), pp. 11-41.

66. Mellerowicz, H. "The Effects of Training on O_2 Consumption of the Heart and Its Importance for Prevention of Coronary Insufficiency," Health and Fitness in the Modern World (Chicago, Athletic Institute, 1961), pp. 90-94.

67. Metheny, E. L., et al. "Some Physiologic Responses of Women and Men to Moderate and Strenuous Exercise: A Comparative Study," American Journal of Physiology, CXXXVI (1942), pp. 318-26.

68. Mitchell, J. H., B. J. Sproule, and C. B. Chapman. "The Physiological Meaning of the Maximal O_2 Intake Test," Journal of

Clinical Investigation, XXXVII (1958), pp. 538-546.

69. Montoye, H. J. "The 'Harvard Step Test' and Work Capacity," Revüe of Canadian Biologie, XI (1953), pp. 491-99.

70. Morris, J. N., J. D. Heady, and A. B. Raffle. "Physique of London Busmen: Epidemiology of Uniforms," Lancet, CCLXXI (1956), pp. 569.

71. Nagle, F. J., and T. G. Bedecki. "The Use of the Exercise Heart Rate Response as a Measure of Circulo-respiratory Capacity," (unpub. lecture, University of Florida, 1962).

72. Nagle, F. J. and T. G. Bedecki. "Use of the 180 Heart Rate Response as a Measure of Circulatory Capacity," The Research Quarterly, XXXIV (1963), pp. 361-69.

73. Newton, J. L. "The Assessment of Maximal O_2 Intake," Journal of Sports Medicine and Physical Fitness, III (1963), pp. 164-69.

74. Paul, Tom L. "A Comparison of the Energy Costs of Exercises on the Bicycle-Ergometer, Treadmill, and the Stool Step," (unpub. doctoral thesis, Florida State University, 1965), pp. 83.

75. Popham, James W. Educational Statistics (New York, Harper and Row, Publishers, 1967), pp. 429.

76. (The) President's Council on Physical Fitness, Adult Physical Fitness, A Program for Men and Women, Washington, D. C., 1963, pp. 64.

77. (The) President's Council on Physical Fitness. Vigor, A Complete Exercise Plan for Boys 12 to 18. Washington, D. C., 1964, pp. 24.

78. (The) President's Council on Physical Fitness. Vim, A Complete Exercise Plan for Girls 12 to 18. Washington, D. C., 1964, pp. 24.

79. (The) President's Council on Physical Fitness. Youth Physical Fitness, Suggested Elements of a School-Centered Program. Washington, D. C., 1961, pp. 111.

80. Raab, Wilhelm, M. D. "Training, Physical Inactivity and the Cardiac Dynamic Cycle," Journal of Sports Medicine, IV (1966), pp. 38-47.

81. Ribisl, Paul M., and William A. Kachadorian. "Maximal O_2 Intake Prediction in Young and Middle-aged Males," Journal of Sports Medicine, IX (1969), pp. 17-22.

82. RCAF Pamphlet 30-1, 5BX Plan. 2nd edition, AFP 50-51-1, Ottawa, Canada, The Royal Canadian Air Force, 1962.

83. RCAF Pamphlet 30-2, XBX Plan. AFP 50-5-2, Ottawa, Canada, The Royal Canadian Air Force, 1962.

84. Robinson, Sid. "Experimental Studies in Physical Fitness in Relation to Age," Arbeitsphysiologie, X (1939), pp. 252-321.

85. Saltin, Bengt, and Per-olof Astrand. "Maximal O_2 Uptake in Athletes," Journal of Applied Physiology, XXIII (1967), pp. 353-358.

86. Sharkey, Brian J., and John P. Holleman. "Cardio-respiratory Adaptations to Training at Specified Intensities." The Research Quarterly, XXXVIII (1967), pp. 698-704.

87. Shephard, R. J. "A Nomogram to Calculate the O_2 Cost of Running at Slow Speeds." Journal of Sports Medicine and Physical Fitness, IX (1969), pp. 10-16.

88. Slater-Hammel, A. T. "Computational Design for Evaluating the Significance of a Difference Between Means." The Research Quarterly, XXXVI (1965), pp. 212-215.

89. Slonim, N. B., D. G. Gillespie, and W. H. Harold. "Peak Oxygen Uptake of Healthy Young Men as Determined by a Treadmill Method," Journal of Applied Physiology, X (1957), pp. 401-404.

90. Arthur H. Steinhaus. How to Keep Fit and Like It, (Chicago, 1957), pp. 72.

92. Taylor, C. "Studies in Exercise Physiology," American Journal of Physiology, CXXXV (1941), pp. 27-42.

93. Taylor, C. "Some Properties of Maximal and Submaximal Exercise with Reference to Physiological Variation and the Measurement of Exercise Tolerance," American Journal of Physiology, CXLII (1944), pp. 200-12?

94. Taylor, Harold L. "Coronary Heart Disease in Physically Active and Sedentary Populations," Journal of Sports Medicine and Physical Fitness, II (1962), pp. 73-82.

95. Taylor, H. L., E. Buskirk, and A. Henschel. "Maximal O_2 Intake as an Objective Measure of Cardio-respiratory Performance," Journal of Applied Physiology, VIII (1955), pp. 73-80.

96. Tuttle, W. W. "The Use of the Pulse Ratio Test for Rating Physical Efficiency," The Research Quarterly II (1931), pp. 5-18.

97. U.S. Office of Education, Federal Security Agency. Physical Fitness Through Physical Education for the Victory Corps, Pamphlet No. 2, Washington, D. C., 1942.

98. Updyke, Wynn F., and Perry B. Johnson. Principles of Modern Physical Education, Health and Recreation (New York, Holt, Rinehart, and Winston, 1970), pp. 721.

99. Weber, Herbert, and R. Knowtton. "A Comparative Study of Physique and Performance Measures Resulting from a Short Term Physical Fitness Course," The Research Quarterly, Vol. 39, #4 (1968), pp. 1107-1114.

100. White, Paul D., M. D. "The Role of Exercise in the Aging," Journal of the American Medical Association, CLXV (Sept. 7, 1957), pp. 70-1.

101. Williams, J. G. P. Medical Aspects of Sport and Physical Fitness (New York, 1965), pp. 192.

102. Workman, J. M., and B. W. Armstrong. "A Nomogram for Predicting Treadmill-Walking Oxygen Consumption," Journal of Applied Physiology, XIX (1964), pp. 150-51.

APPENDIX A

RAW SCORES: DISTANCE IN MILES FOR

COOPER'S 12-MINUTE RUN WALK TEST

Experimental Subjects	Miles and Tenths of Miles	Cooper's Fitness Category
1	1.1	II
2	1.3	III
3	1.3	III
4	1.4	III
5	1.4	III
6	1.4	III
7	1.3	III
8	1.3	III
9	2.0	V
10	1.2	II
11	1.4	III
12	1.6	IV
13	1.1	II
14	1.6	IV
15	1.5	IV
16	1.6	IV
17	1.5	IV
18	1.3	III
19	1.5	IV
20	1.5	IV
21	1.4	III
22	1.3	III
23	1.7	IV
24	1.2	II
25	1.1	II
26	1.3	III
27	1.1	II
Control Subject		
1	.8	I
2	1.0	II
3	1.0	II
4	N.T.*	---
5	1.3	III
6	1.3	III
7	1.4	III

*Not Taken

APPENDIX B

RAW SCORES: RESTING HEART RATES (B/P/M)

AND RESTING BLOOD PRESSURE (MM)

	Pre-Test		Post-Test	
Subject	RHR	R/B/P	RHR	R/B/P
1	84	134/90	72	132/92
2	78	122/76	78	128/68
3	78	130/72	66	128/78
4	84	127/96	78	130/88
5	72	140/88	72	128/88
6	72	126/84	72	118/82
7	60	126/88	60	148/82
8	84	116/84	84	118/84
9	78	137/82	72	132/88
10	84	122/78	72	98/66
11	90	128/87	78	124/86
12	72	140/100	60	126/82
13	78	127/88	66	132/84
14	60	125/80	60	138/88
15	72	122/78	78	118/74
16	78	128/88	60	128/88
17	72	132/84	72	126/84
18	78	150/82	84	140/80
19	63	122/88	54	126/90
20	58	118/68	66	128/70
21	78	120/80	72	122/80
22	90	138/96	90	134/92
23	63	112/80	64	128/78
24	78	142/100	74	156/96
25	72	138/78	78	122/84
26	72	146/108	72	126/86
27	90	148/110	84	145/100

Control Group

	Pre-Test		Post-Test	
Subject	RHR	R/B/P	RHR	R/B/P
1	102	118/88	120	118/90
2	84	132/88	96	130/96
3	90	132/88	78	128/82
4	78	136/88	70	130/86
5	102	132/78	108	136/96
6	72	153/88	66	150/90
7	96	134/84	102	130/84

APPENDIX C

RAW SCORES: WEIGHTS OF SUBJECTS IN POUNDS
OPTIMUM PREDICTED WEIGHT FOR SUBJECTS

Experimental Subject	Pre-Test	Post-Test	Optimum Predicted
1	224	219	163
2	169	172	168
3	205	190	185
4	217	210	191
5	209	200	199
6	160	153	142
7	208	194	191
8	153	153	146
9	160	161	169
10	175	163	152
11	163	168	150
12	159	162	142
13	206	202	166
14	154	155	167
15	196	192	192
16	192	179	175
17	155	150	139
18	194	184	160
19	204	194	186
20	180	182	176
21	155	153	141
22	205	204	206
23	158	159	150
24	214	195	191
25	171	165	161
26	268	240	219
27	174	173	169
Control Subject			
1	162	159	149
2	206	207	179
3	188	187	165
4	162	158	153
5	171	169	162
6	166	166	153
7	178	172	167

APPENDIX D

RAW SCORES: TIME OF SUBJECTS ON BALKE TREADMILL TEST (IN MINUTES)

Experimental Subject	Pre-Test	Post-Test
1	14	22
2	17	21
3	15	21
4	15	17
5	17	22
6	15	20
7	13	18
8	16	22
9	21	20
10	9	17
11	14	16
12	18	19
13	12	16
14	18	21
15	15	21
16	18	22
17	17	19
18	15	18
19	14	19
20	23	22
21	15	16
22	14	17
23	21	24
24	11	17
25	12	23
26	17	21
27	13	16
Control Subject		
1	6	8
2	16	16
3	12	13
4	16	16
5	14	13
6	14	15
7	11	13

APPENDIX E

FORM LETTER USED IN OBTAINING SUBJECTS

Active Friend:

Welcome to your new sports and recreation center, we know you are enjoying it already.

We also know that many of you are interested in having a well rounded exercise program that would be evaluated and recorded for you each week by someone who is interested in your fitness.

This program of which we speak is not a wild hit or miss program, but one that has been tested and proved satisfactory, even for the U.S. Air Force. It is a program that is self administered and that one may do at his own convenience.

We are currently in the need of subjects who would like to work this semester in such a program. We need men who are between 25 and 50 years of age.

This program will start with a series of tests in our new physiology of exercise lab and will include various anthopometric measurements as well as a treadmill test. We know that many of you will be wanting incentive to continue your present exercise program as the weather gets nicer; let us help you.

If you are interested, please call Mr. J. Hudder at Extension 6356, or call Extension 6371 and leave your name and phone number.

I am located in Room 110 PEC and if you get a chance to drop by I would like to talk with you about this research program.

Don't hesitate, call today!

Thank you,

Gerald Hudder

APPENDIX F

FORMULAS USED IN STATISTICAL COMPUTATIONS

1. "t" Ratio

When $N_1 \neq N_2$

N_1, N_2 = Numbers of subjects in respective groups

$L_1 = N_1 \Sigma X_1^2 - (\Sigma X_1)^2$

$L_2 = N_2 \Sigma X_2^2 - (\Sigma X_2)^2$

$$t^2 = \frac{(N_2 \Sigma X_1 - N_1 \Sigma X_2)^2 \ (N_1 + N_2 - Z)}{(N_2 L_1 + N_1 L_2)(N_1 + N_2)}$$

t = square root of t^2

2. t Ratio

When N_1 and N_2 are paired measures

$X = X_1 - X_2 \qquad N = N_1 = N_2$

$$t^2 = \frac{(\Sigma X^2)(N-1)}{N\Sigma X^2 - (\Sigma X)^2}$$

t = square root of t^2

3. Correlation

$$r\,x\,y = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}}$$

$\Sigma x^2 = \Sigma X^2 - (\Sigma X)(\bar{X})$

$\Sigma y^2 = \Sigma Y^2 - (\Sigma Y)(\bar{Y})$

$$\Sigma xy = \Sigma XY - (\Sigma X)(\bar{Y})$$

4. Linear Regression

$\tilde{Y}$ = Score to Be Predicted

$\tilde{X}$ = Score to Be Predictor

$$a = \bar{Y} - b\bar{X}$$

$$b = \frac{\Sigma xy}{xy^2}$$

$$\tilde{Y} = a + b\tilde{X}$$

APPENDIX G

BEHNKE FORMULA FOR CALCULATING IDEAS BODY WEIGHT

Name ______________________ Height Without Shoes ______________

Age ______________________ Weight Without Shoes ______________

Date ______________________ Predicted Weight ________________

Formula for Calculating Ideal Body Weight

The Behnke method employs simple tape measurements to calculate how much the adult body should weigh. Use a linen tape with centimeter (cm) markings on one side, or use a regular tape measure and multiply inches by 2.54 to get centimeter (cm).

Wrists - Smallest circumference.

Left ______cm
+right ______cm
______cm

Sum ÷ $\frac{\_\_\_\_\_\_}{2}$ = Average = ______

Forearms - Largest circumference.

Left ______cm
+Right ______cm
______cm

Sum ÷ $\frac{\_\_\_\_\_\_}{2}$ = Average = ______

Calves - Largest circumference.

Left ______cm
+Right ______cm
______cm

Sum ÷ $\frac{\_\_\_\_\_\_}{2}$ = Average = ______

Ankles - Smallest circumference.

Left ______cm
+Right ______cm
______cm

Sum ÷ $\frac{\_\_\_\_\_\_}{2}$ = Average = ______

Add the four averages, divide the total at 17.07 (women divide by 16.89), and square the sum

Total of Averages ÷ $\frac{\_\_\_\_\_\_}{17.07}$ = $\_\_\_\_\_\_^{2}$ =
(Women use 16.89)

Squared Sum ________

Height - Barefoot

x ht ________cm
________cm

APPENDIX G (Continued)

Multiply the squared sum by the height. Multiply that total by .0111 to get the perfect weight in kilograms. Multiply by 2.2 to convert to pounds.

Total ____________________

x ____________________ cm

____

Ideal Weight ____________________ kg

x ______2.2______

____

Ideal Weight ____________________lbs

Figure 2. Maximum Oxygen Intake as Criterion of Functional Potential

The diagonal line relates 0_2 intake per Kg of body weight (on the ordinate) to work intensity (on the abscissa, the latter depending either on the grade at a given walking speed. The arrows pointing at this line indicate the average values of maximum 0_2 intake attained by groups of men varying in degree of physical condition.

Maximum Oxygen Intake as Criterion of Functional Potential

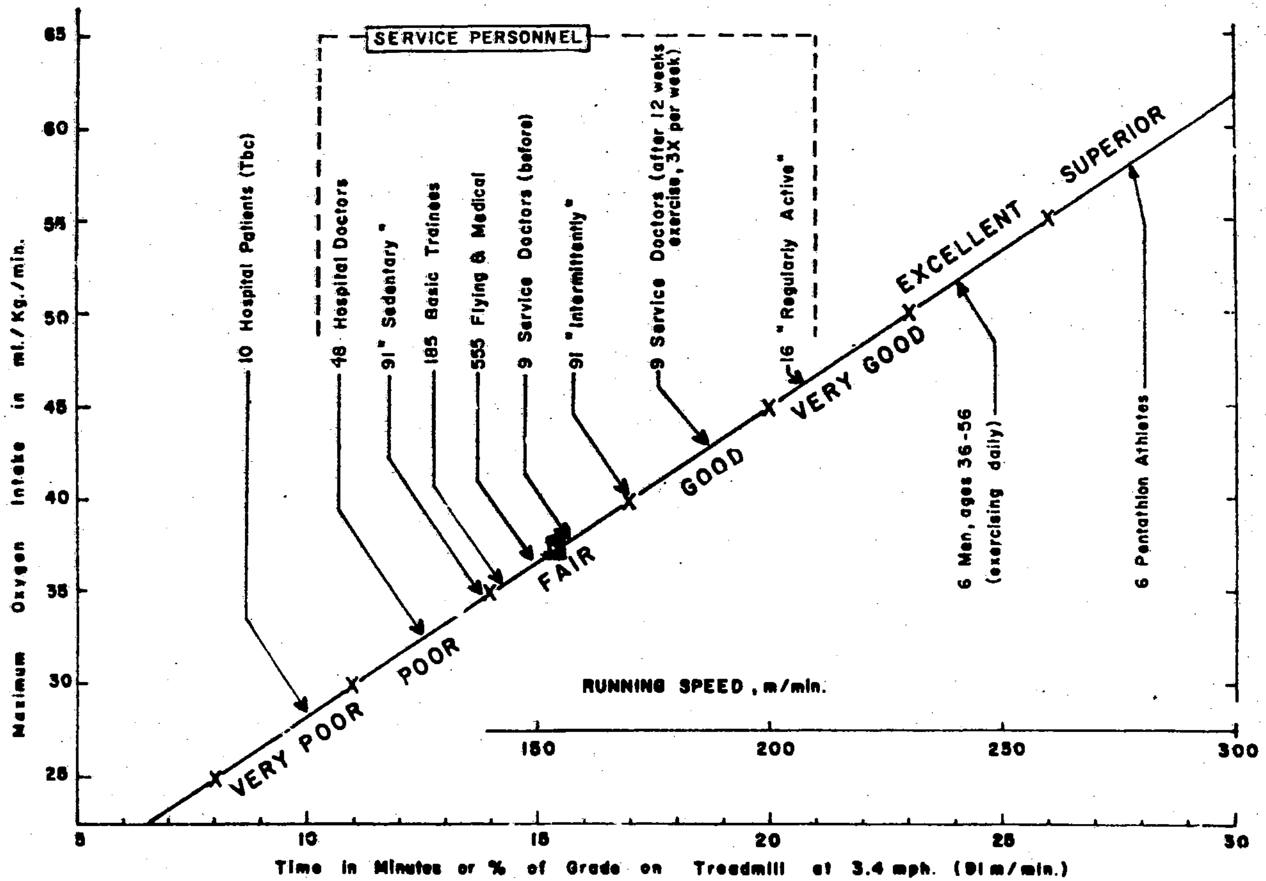
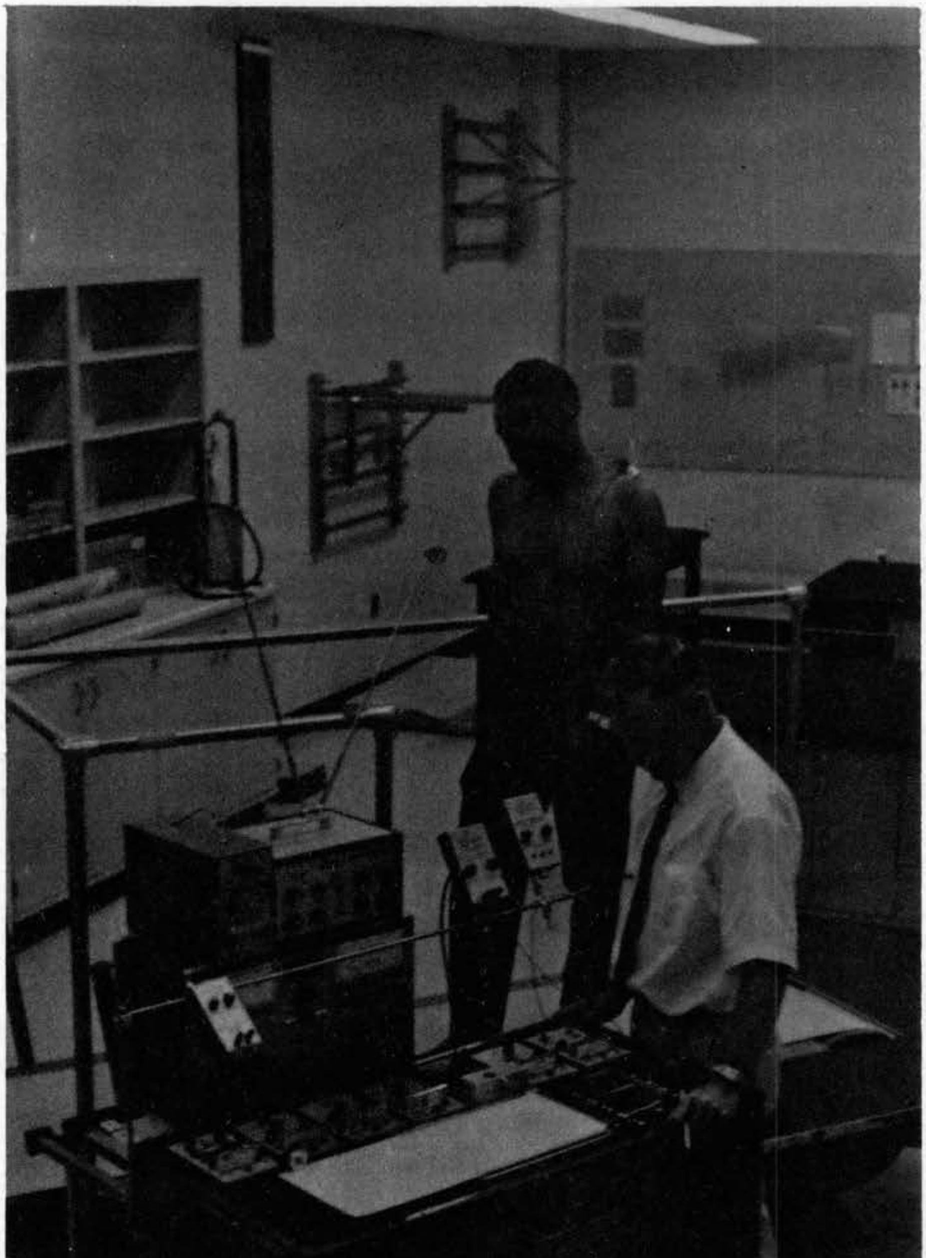


Figure 3. Heart Rate Monitored During a Treadmill Walk



VITA

Gerald Douglas Hudder

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECT OF PARTICIPATION IN AN AEROBIC TRAINING PROGRAM FOR SELECTED MEN OVER AGE 25

Major Field: Higher Education

Biographical:

Personal Data: Born in St. Louis, Missouri, March 31, 1932, the son of Vernon R. and Mildred Adams Hudder.

Education: Graduated from Normandy High School, 1950; received the Bachelor of Arts Degree from the William Jewell College, with a major in Physical Education, in June, 1954; received the Master of Science Degree from the West Virginia State University, with a major in Physical Education, in August, 1959.

Professional Experience: Entered the United States Army in 1954; discharged honorably in 1956; taught and coached basketball at Bluefield College, Bluefield, Virginia, 1956-1961; Physical Director of the Y. M. C. A., Salina, Kansas, 1961-1962; Intramural Director and Assistant Professor at Kansas Wesleyan University, Salina, Kansas, 1962-1967; graduate teaching assistant, Oklahoma State University, Stillwater, Oklahoma, 1967-1969; Associate Professor Kansas Wesleyan University 1969-1970.