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The Effect of Walking and Jogging on Selected Cardio-Respiratory Parameters of Middle-Age Men During the Initial Phase of a Training Program

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THE EFFECT OF WALKING AND JOGGING ON SELECTED CARDIO-RESPIRATORY

PARAMETERS OF MIDDLE-AGE MEN DURING THE INITIAL PHASE OF A TRAINING PROGRAM

(TITLE)

BY

MONSURU LASUN EMIOLA

THESIS

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CHAPTER I

INTRODUCTION

Man is built for movement, for physical activity. The last century and particularly, the more recent decades, have witnessed a revolution in the lives of millions of people, whereby mechanical implements have taken over tasks earlier performed by human power. The result, more leisure time and increased inactivity leading to noticeable deterioration in the ability of man to cope with and maintain a physical condition and degree of fitness that are above that required for his daily job. Inactivity has also increased the number of cardiovascular disease patients.

In modern civilization we have an enormous amount of sitting and static standing in the white collar office work, in factories, and in the social diversions which involve eating, drinking, lounging in clubs and at teas and receptions. All these are partly responsible for the increased number of cardiovascular disease patients. In many countries cardiovascular diseases are prevalent and they are responsible for the death of more persons than the next three most common causes of death combined.[1] The four leading causes of death in the

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[1] Per-Olaf Astrand and Kaare Rodahl, Textbook of Work Physiology (McGraw-Hill Book Co., 1970), p. 600.

United States for 1970 and the number of deaths per 100,000 population are as follows:[2]

Heart Disease	371.2
Cancer	154.8
Stroke	104.6
Accidents	58.0

In recent years, interest has been focused on the possible role of physical inactivity in the genesis of cardiovascular diseases. The studies of Morris and Crawford[3] pointed out that "physical activity of work is a protection against coronary (ischemic) heart disease during middle age..." In their material, the hearts of sedentary and light workers show the pathology of the hearts of heavy workers ten to fifteen years older.

Roby and Davis[4] note,

> The risk of a coronary heart attack is two to three times higher for the inactive person than that of the active, and the chance of surviving the first heart attack is also two to three times better in those who are active.

NEED FOR THE STUDY

In the examination of several thousands of middle age men, it has been found that the persons who have good circulatory fitness are

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[2]"Important Causes of Death in the United States," Encyclopedia Americana, International Edition (1970). p. 564.

[3]J. N. Morris and M. D. Crawford, "Coronary Heart Disease and Physical Activity of Work," evidence of a National Necropsy survey, British Medical Journal, 2: 1485, 1958.

[4]Frederick B. Roby and Russell P. Davis, Jogging for Fitness and Weight Control (Philadelphia: W. B. Sanders Co., 1970), p. 3.

those who have kept up their activity and eat and drink very moderately. Those who deteriorate relatively quickly seem to be muscular men who have gone sedentary. Cureton[5] believes: a) that on the average, athletes in training get much better physical fitness scores than men not in training; b) that normal men, not in training, should be able to improve their physical fitness scores by following a program of hard physical work; c) that regulated continuous running improves cardio-respiratory efficiency.

According to Cureton,[6] a man is very nearly what his activity or lack of activity makes him. He thus suggests that more time be spent studying the changes that this activity or inactivity causes rather than advocating that exercise is harmful unless wisely directed. Educators do not appreciate the often-repeated phrase, "endurance exercises will hurt your children," when no data are given to support the statement. Physical educators should not discuss the effects of exercise unless they can support the claims with scientific evidence. Cureton declares,

> We have the beginning of understanding in this area but, as an area of applied science which deserves development, we have a long way to go with the experimental work.

More and more people are believing in running as a means of gaining and maintaining physical fitness. Today, a lot of middle-age men can

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[5]Thomas K. Cureton, The Physiological Effects of Exercise Programs on Adults (Springfield: C. C. Thomas Publishers, 1969), pp. 15-16.

[6]Ibid., p. 16.

be seen jogging and running around the community. Morris and Crawford[7] believe that habitual physical activity is a general factor of cardio-vascular health in middle age. It is therefore necessary to find out what specific effects jogging and running have on the cardiovascular efficiency of these running middle age men, especially in the initial phase of their training program.

PURPOSE OF THE STUDY

The primary purpose of this investigation was to observe changes in selected cardio-respiratory measurements in middle age men following the first ten weeks of a jogging and running program. In addition, a comparison was made to determine what differences, if any, existed in the cardio-respiratory parameters between the exercising subjects and sedentary men of comparable occupation, chronological ages and body surface areas.

NULL HYPOTHESIS

There is no significant change in the cardio-respiratory efficiency of middle age men following the first ten weeks of a jogging and running program.

There is no significant differences in the cardio-respiratory parameters of the jogging subjects and sedentary men of comparable occupation, chronological ages and body surface areas following the first ten weeks of jogging.

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[7]Morris and Crawford, loc. cit., 2: 1485, 1958.

The study was completed on men voluntarily registered to take part in the "Run For Your Life" program at Eastern Illinois University and the sedentary group, selected on a voluntary basis through questionnaires. The study was limited to selected cardio-respiratory responses of the jogging subjects to the ten weeks of training and no attempt was made to study any other physiological changes that might have taken place.

The effects of certain changes in eating, drinking or smoking habits were not considered as no special controls were established.

Because the purpose of the sedentary group was to provide some basic information about sedentary middle-age men, it was decided that no re-test was needed.

DEFINITION OF TERMS

The following terms are defined for this study:

Cardio-respiratory System

The cardio-respiratory system comprises the heart, the circulatory system, and the ventilation of the lungs. The cardio-respiratory system supplies blood and oxygen to the tissues of the body.

Electrocardiograph

The electrocardiograph is an instrument for recording electrical activity of the heart muscle.

Jogging-Group J

The jogging-group J was the group of subjects who took part in the initial phase of a training program.

Oxygen Pulse

The oxygen pulse is the amount of oxygen taken out of blood per heartbeat. It is determined in this study by dividing the amount of oxygen consumed in one minute at the heart rate of 150 BPM, by the number of beats, i.e., 150.[8,9]

Oxygen Removal Rate or Rate of Oxygen Removal-ROR

Oxygen removal rate or ratio of oxygen removal-ROR is an index which gives the quantity of oxygen consumed for each liter of air breathed, expressed in O_2 ml/liter. It is a method of estimating the adequacy of pulmonary blood flow.[10]

Pulmonary Ventilation

Pulmonary ventilation refers to the periodic removal of the air in the lung alveoli.[11]

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[8] Peter V. Karpovich, Physiology of Muscular Activity (Philadelphia: W. S. Sanders Co., 1959), p. 157.

[9] Ernest Jokl, Heart and Sports (Springfield, Ill.: C. C. Thomas, 1964), p. 35.

[10] Frank Consolazio, Robert E. Johnson and Louis J. Pecora, Physiological Measurements of Metabolic Function in Man (McGraw-Hill Book Company, 1963), p. 200.

[11] Lawrence E. Morehouse and Augustus T. Miller, Physiology of Exercise (New York: The C. V. Mosby Company, 1967), p. 6.

Sedentary-Group S

The sedentary-group S is the group of men who do not participate in any regular strenuous physical activity.

t Ratio

The *t* ratio is a unit of statistical measurement used in the study to test for the significance of any gains while analyzing the pre and post-training test results.

Vital Capacity

Vital capacity is the maximum volume of air that can be expelled from the lungs following a maximum inspiration.[12]

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[12] Consolazio, Johnson and Pecora, *op. cit.*, p. 192.

CHAPTER II

REVIEW OF RELATED LITERATURE

In recent years interest has been focused on the role of physical activity in cardio-respiratory efficiency of man. Several studies have been published and many textbooks touch on cardio-respiratory responses to exercise. Many writers, however, believe that more studies are still necessary in this comparatively new field. The review of the available related literature has been divided into the following categories: (1) sources that discuss vital capacity, (2) studies on heart rate and oxygen consumption, (3) studies done on the use of sub-maximal exercise as a measure of cardio-respiratory efficiency, and (4) studies on the training of cardio-respiratory efficiency.

VITAL CAPACITY

The vital capacity is the maximum volume of gas that can be expelled from the lungs following a maximum inspiration. Baldwin et al. (1948), Pemberton and Flanagan (1956), and Pecora (1957), have all derived various formulae for predicting vital capacity taking into consideration, height, weight, age and sex. However, Kory et al.,[1]

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[1]R. C. Kory et al., "The Veterans Administration-Army Cooperative Study of Pulmonary Function," American Journal of Medicine, 30: 243-258, 1961.

reporting the results of a Veterans Administration-Army cooperative study of pulmonary function, developed a nomograph for predicting some four respiratory parameters including vital capacity, from age and height. In this study made with 468 normal males between ages 18 and 66, height demonstrated a consistently higher correlation with all the measurements of pulmonary function than did body surface area. Weight showed little or no correlation with any of the pulmonary function measurements. Age has a low negative correlation with height.

Contrary to general notion, a large vital capacity does not make a champion. However, West[2] showed that the ratio of the vital capacity to the skin surface area is greatest in athletes and least in sedentary women.

HEART RATE AND OXYGEN CONSUMPTION

One of the factors determining the rate of oxygen intake is "minute-volume" of the heart. The rate of blood flow through the body as a whole depends upon the amount of blood the heart pumps per minute. As a rule, the blood output during exercise runs practically parallel with the consumption of oxygen.[3] Cureton[4] said, that the very strong relationship between oxygen intake and endurance performance has been

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[2]H. West, "Clinical Studies on the Respiration: A Comparison of Various Standards for Normal Vital Capacity of the Lungs," Arch. Intern. Med., 25: 306, 1921.

[3]Peter V. Karpovich, op. cit., p. 132.

[4]Thomas K. Cureton, op. cit., p. 192.

known since 1925, when the works of Sargent and Hill, biophysicists, brought this into scientific focus.

Balke and Clark[5] used a prgressive series of trials, progressively increasing the slope of the treadmill one percent at 3.4 mph for each work minute until the heart rate reached 180 BPM and evaluating the oxygen intake in cc/minute/kg. On the low end of Balke's scale are hospitalized patients with chronic pulmonary diseases, and at the upper end are athletes trained for great endurance performances.

During muscular work, the amount of blood discharged from the heart with each heartbeat, is augmented and combined with an increase in the coefficient of oxygen utilization. This results in an increased delivery of oxygen to the tissues. The amount of oxygen taken out of the blood per pulse beat is called "oxygen-pulse," and is determined by dividing the amount of oxygen used during a certain period of time by the number of pulse beats during the same period. Peter Karpovich[6] found that with exercise, oxygen pulse increases rapidly and in most cases reached its maximal value of 11 to 17 cc(ml) at heart rate of 130 to 140 beats per minute. With furrther acceleration of the heart, the oxygen pulse may even tend to decrease.

Chapman and Mitchell,[7] in their study of pulse rate at submaximal level of exercise, are of the opinion that it seems likely

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[5]Bruno Balke and R. T. Clark, "Cardio-pulmonary and Metabolic Effects of Physical Training," Health and Fitness in the Modern World, 1960, pp. 82-89.

[6]Peter V. Karpovich, loc. cit., p. 157.

[7]Carleton B. Chapman and J. H. Mitchell, Scientific America, May, 1965, pp. 88-96.

that under moderate stress, the heart may increase either its pulse rate or its stroke volume, depending on the individual's physical training. They found good reason to believe that the heart of a trained athlete increases its stroke volume more rapidly than that of a sedentary person.

One presumption for an assessment of the circulatory capacity based on heart rate is that the cardiac output (Q) at a given oxygen uptake only varies within reasonable limits. Astrand and Rodahl[8] believe that if this is the case, the heart rate (HR) will inversely vary with the individual's stroke volume (SV); i.e., the larger the stroke volume, the lower the heart rate, since HR x SV = Q.

SUB-MAXIMAL EXERCISE AS A MEASURE OF CARDIO-RESPIRATORY EFFICIENCY

Various work loads have been used to test cardio-respiratory efficiency. Researchers have looked for a test that will be controlled by the fitness level of the subject itself. In some test procedures, the physical work capacity (PWC) is evaluated from data on work load, oxygen uptake, or oxygen pulse at a given heart rate, such as 180, 170, or 150 beats/minute.

Balke[9] showed by several criteria that a limitation of optimal cardiovascular and respiratory function exists when a pulse

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[8]Astrand and Rodahl, op. cit., p. 352.

[9]B. Balke, "Correlation of Static and Physical Endurance. I. A Test of Physical Performance Based on the Cardiovascular and Respiratory Responses to Gradually Increased Work," U.S.A.F. School of Aviation Medicine, Project No. 21-32-004, Report No. 1, Randolph AFB, Texas, April, 1952.

rate of 180 BPM is reached during a gradually increased work load. As a result, the Treadmill Test of Optimal Work Capacity is terminated when a pulse rate of 180 BPM is reached and at this point is referred to as the "optimal work capacity (OWC)." The optimal work capacity is achieved when the energy output and oxygen uptakes are balanced at an optimum.

According to Astrand in 1954,[10] the term "optimal" represents a high level of physical activity which is approximately 50 percent of the limitation in human work capacity. However, an adjusted version of Astrand's nomogram (1960) revealed that, on the average, the pulse rate of 154 beats per minute at an oxygen uptake, in men, represents 70 percent of the maximum.

The mean value for heart rate at a given sub-maximal oxygen uptake has been found by Astrand[11] to be the same for individual's of the same sex and state of training regardless of age (from 25 up to at least 70 years of age). This, however, does not say that there is no apparent difference both in structure and in function between older individuals of the same body size as a younger one. In fact, real performance capacity is declining with age.

The sub-maximal exercise test is a very useful test in evaluating whether or not a training program has been effective in improving the individual's circulatory capacity. It has been widely applied in

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[10] Astrand and Rodahl, op. cit., pp. 354-355.

[11] Astrand, "Aerobic Work Capacity in Men and Women with Special Reference to Age," Acta Physiol. Scand: 49 (Suppl. 169).

top athletes, in trained and untrained adults, and in children. In such cases, the individual is his own control; it is a matter of comparing the individual with himself at repeated tests over months or years. The work test should be slightly higher than the work load encountered during the subject's regular daily activities.

TRAINING EFFECTS ON CARDIO-RESPIRATORY EFFICIENCY

Few studies have been done on the effects of exercise on selected cardio-respiratory parameters. Most of the studies found positive effects of training on cardio-respiratory fitness of subjects but they agree that more studies are still necessary on cardio-respiratory response to training or exercise.

It has been observed that the heart rate during standard exercise is lowered with a training of the oxygen transporting system. The few studies published on the cardiac output during standard exercise repeated during a course of training, indicate that cardiac output is maintained at the same level. The reduction in heart rate should then mirror an increase in stroke volume.[12]

Hollmann[13] studied six previously sedentary subjects who trained four times a week, 20 to 30 minutes each time during a period of ten weeks with increased training intensity the last five weeks. The

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[12] Musshoff et al., "Stroke Volume, Arteriovenous Difference, Cardiac Output and Physical Work Capacity and Their Relationship to Heart Volume," Acta Cardiol. Brux., 14: 427, 1959.

[13] W. Hollmann, Korperliches Training als Pravention von Herz-Kreislanfkheiten (Stuttgart: Hippokrates-Verlag, 1965), p. 62.

training resulted in a 21 percent increase in maximal oxygen uptake, 13 percent increase in heart volume and resting heart rate dropped to an average of 59 BPM from 73 BPM.

Hollmann[14] also presented data from a longitudinal study showing that a regular physical training can rather effectively counteract the age-induced decrease in maximal aerobic power. Of the 56 subjects, 39 had lived a sedentary life for the last 12 to 15 years and 17 had been training on an average of twice a week. In the inactive group (mean age 59 years), the maximal oxygen uptake had declined from an average of 3.05 to 2.11 liters/minute or 31 percent. In the still physically active group (56 years of age), the decline was from 3.21 to 2.90 liters/minute or only about 10 percent. The body weight averaged 75.5 kg. in the active group and 81.5 kg. in the inactive group.

The effect of training shows itself so gradually that only after weeks may a slight evidence be observed. The maximum, however, may be reached after seven weeks of training. In one experiment on two subjects, at the end of the seventh week, the minute-volume of pulmonary ventilation decreased by 15 to 23.5 percent while absorption of oxygen increased by 0.56 to 0.85 percent. Thus the trained man breathes more economically than the untrained, therefore, for the same task, the trained subject needs less air because he can utilize a greater portion of its oxygen than can the untrained subject.[15]

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[14] W. Hollmann. loc. cit.

[15] Peter V Karpovich, op. cit., pp. 144-145.

Jackson et al.,[16] found that running on the treadmill at 7 mph for 10 minutes, 2, 3, or 5 times a week for 5 weeks, the Balke Test, showed that subjects' actual endurance score, judged by number of successfully completed training sessions, indicated that the 2, 3, or 5-day week groups all increased to approximately the 7 percent grade. With the Astrand-Ryhming nomogram, exercise pulse rates and body weights were used in predicting oxygen consumption. The pre and post-training differences in predicted O_2 consumption, placed the 2 day and 3 day groups above the 5-day group. It does seem that training two or three times a week may have been as beneficial as the 5-day program. The 5-day program seemed to be too difficult to allow for optimal adaption in non-athletes.

SUMMARY

The various studies cited have shown evidence that regular physical activity, or training, has a beneficial effect on the functioning of the heart. The opportunity to exercise must be seized now to effect health in a positive way through a systematic improvement in physical fitness by training. Older individuals may be less trainable than younger ones. It should be kept in mind, however, that some effect of training may be noticed even at a very old age. There is still a lot to find out through studies on the actual effects of exercise on the cardio-respiratory efficiency of man, both young and old.

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[16] Jay H. Jackson, Brian J. Sharkey and L. Pat Johnston, "Cardio-respiration Adaptions to Training at Specified Frequencies," Research Quarterly, 39 (May, 1968), pp. 295-300.

CHAPTER III

METHODOLOGY

The study was designed to investigate the changes that take place in selected cardio-respiratory measurements in middle age men following the first ten weeks of a jogging and running program. A comparison was also made to determine what differences, if any, existed in the cardio-respiratory parameters between the exercising subjects and sedentary men of comparable occupation, chronological age and body surface area.

SUBJECTS

Twenty-eight male volunteers made up of Eastern Illinois University faculty members and civil servants within the Charleston community, between ages 24 and 65 years were the subjects for the study. The subjects were placed into two groups as follows:

Group J-Jogging Group

This group was made up of seven men who had enrolled to participate in the initial phase of the "Run For Your Life" program at Eastern Illinois University.

<u>Group S-Sedentary Group</u>

This group was made up of twenty-one male faculty members and civil servants of Eastern Illinois University, who had volunteered through a questionnaire, to participate in the study.

EXPERIMENTAL DESIGN

The study was designed in such a way that there was an initial or pre-training testing so that the following measurements were taken before group J went into training: Weight and Height, Vital Capacity, Modified-Balke Treadmill Test of Optimal Work Capacity--to measure subjects' oxygen removal rate, oxygen pulse and time it took each subject to attain 150 BPM heart rate. This was followed by a ten-week training program by group J and a final post-training test was given to group J. Group S was tested only once and they did not take part in the training.

TREADMILL ORIENTATION

Each subject received an orientation run on the treadmill prior to the testing day, so that they could feel comfortable on the treadmill in the test situation. The procedures were explained to the subject. An A. R. Young Treadmill was used for the test.

The orientation began with the subject standing on the treadmill, holding on to the safety bar. It was explained that the treadmill would be started at a pre-set walking speed of 3.4 mph--test speed, on the level, and that the subject should walk naturally with his heels hitting

first, his back straight, and holding on to the bar. The treadmill was then started. A fan suspended in front of the subject was turned on at subject's convenience, to stimulate air flow.

When the subject was walking comfortably, he was instructed to release his grip on the bar; one hand and then the other, walking with arms swinging normally. The grade was then raised to two, four and six percent, with the speed remaining at 3.4 mph. This allowed for the subject's legs to adjust to various grades.

Procedures for inserting the mouthpiece connected to the suspended Collins Triple "J" Valve were then explained. Holding on to the safety bar with one hand, the subject inserted the mouthpiece with the other hand. He then released the bar and continued to walk naturally for two minutes. He was instructed to keep walking until the treadmill stopped completely.

Noseclips were then put on the subject and he was made to practice breathing through the mouth. The treadmill was started while subject held on to the bar. The speed was gradually increased to six miles per hour and subject was told to start jogging as he felt necessary to keep pace with the speed of the treadmill. When subject was running comfortably, he released the bar and ran normally. He then practiced inserting the mouthpiece on the run, following the same procedure as before.

The treadmill was then lowered to zero grade and slowed down to the walking speed. Subject walked for two minutes before the treadmill was finally stopped.

TESTING PROCEDURES

Preliminaries

Subjects were instructed not to eat, smoke, or drink any alcohol or beverage at least two hours prior to the test. They were also not to do any running or jogging on the day they took the test. All tests took place at the Research Laboratory of Eastern Illinois University. The room temperature and barometric pressure was recorded during each test.

Anthropometric Measurements

Each subject was weighed in his running shorts, supporter, socks and shoes on a calibrated Healthometer Scale. His weight was read to the nearest quarter-pound and converted to kilograms by dividing by 2.2 His height was also taken and read in centimeters. These, along with his age and smoking habit were recorded on a data sheet designed by Johnson.[1]

Vital Capacity Test

Vital capacity is the maximum volume of air that can be expelled from the lungs following a maximum inspiration.

The 13½-liter Collins-Motley respirometer was used. The respirometer was properly checked for balance, water level, position of the bell and ink pen (halfway down) and to make sure the canister and Sadd valves were out.

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[1]Robert E. Johnson, Francis Robbins, and Others, "A Versatile System of Measuring Oxygen Consumption in Man," Journal of Applied Physiology, 22, pp. 377-379, February, 1967.

The subject was seated comfortably, hands placed on his lap while the test was explained to him. The noseclips were put on the subject and the rubber mouthpiece inserted into his mouth. The Kymograph was turned to 160 mm/minute as subject was told to breathe deeply in and out slowly. On the third inspiration he was told to take in as much air as he could and encouraged to blow it all out up to the last possible bit. Three trials were given and the best score of the three was used for the calculation.

Modified-Balke Treadmill Test of Optimal Work Capacity[2]

Telementry. The hair around the subject's sternum and about the fifth intercostal space of his ribs was shaved V_2 and V_4 positions, respectively. A small amount of electrode jelly was rubbed vigorously on these areas with a tooth brush to remove dead skin and provide an area of irritation for electrodes attachment and contact. Excess jelly and dead skin were removed with a towel. Two patient cable electrodes were then attached at the V_2 and V_4 positions with a pea-sized drop of electrode jelly placed inside each electrode ring to help provide better contact with the skin. The patient cable was plugged into the transmitter that sent the electrocardiogram to the Lexington Physio-scope and a Sanborn Model 500 Viso-Cardiette (EKG machine) which recorded the electrocardiogram and the heart rates read with a calibrated ruler.

The Test. At a signal, the treadmill was started and the subject walked at a rate of 3.4 mph on the level. Grade was increased by

[2]Consolazio et al., op. cit., p. 371.

two percent at the end of one minute and by one percent at the end of each succeeding minute. Heart rate was recorded during the last 15-seconds of each minute of the walk until a pulse rate of 150 BPM was achieved.

Expired Air Sample. When the pulse rate of 150 BPM was achieved, the subject, who had been breathing through the mouth, since noseclips were put on prior to the start of the walk, was asked to insert the mouthpiece. The Parkinson-Cowan CD4 Meter was opened and a 30-second sample of his expired air was collected. A vacuum pump was used to draw the sample of the expired air through the plexiglass mixing chamber connected by hose to the Triple "J" valve. The sample was collected with a metalized bag designed by Johnson.[3]

The temperature of the expired air sample was read from the YSI Tele-Thermometer connected to the mixing chamber through a probe.

The air samples were analyzed with a Beckman Model E2 Oxygen Analyzer and a Beckman LB-1 Medical Gas Analyzer to determine oxygen and carbon dioxide content.

All data were recorded on a Johnson data sheet.

TRAINING

The jogging group went through a 10 week progressive walking and jogging program, 3 times a week, completing at least 2 miles

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[3]Johnson et al., loc. cit.

per workout. Speeds were graded according to each subject's progress, with heart recovery as a guide to the intensity of work.[4]

FINAL OR POST-TRAINING TESTING

The jogging subjects were given the same tests as at pre-training, i.e., Body Weight, Vital Capacity Test and the Modified-Balke Treadmill Test of Optimal Work Capacity, at the end of the 10 weeks of jogging.

Because the purpose of the sedentary group was to provide some basic descriptive information about sedentary middle age men, it was decided that no re-test was needed.

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[4] M. T. Woodall, "Run For Your Life" (Unpublished monograph: Eastern Illinois University, Charleston, Illinois, 1967), p. 15.

CHAPTER IV

ANALYSIS OF THE DATA

The investigation was designed primarily to observe changes in selected cardio-respiratory measurements in middle age men following the first ten weeks of a jogging and running program. In addition, a comparison was made to determine what differences, if any, existed in the cardio-respiratory parameters of exercising subjects and sedentary men of comparable occupation, chronological age and body surface area. Twenty-eight male Eastern Illinois University faculty members and civil servants within the Charleston community, between the ages of 24 and 65 years, chosen as described in the previous chapter, were subjects for the study. Seven walked and jogged three times a week for ten weeks. The remaining 21 men were placed in the sedentary group and they just carried on with their normal daily activities. Both groups were given the same tests at the start of the study and a post-training test was given to the subjects in the jogging group.

MEASUREMENTS

The parameters measured were Height, Body Weight, Vital Capacity, time taken to attain 150 BPM in Balke Treadmill Test, Pulmonary Ventilation, Oxygen Consumption at 150 BPM, Oxygen Removal Rate at 150 BPM, and Oxygen Pulse at 150 BPM in Balke Treadmill Test.

DATA CONVERSION

Some of the raw data were converted to standardized units for analysis. The body weight was taken in pounds and converted to kilograms by dividing by 2.2. The body surface areas were calculated from the DuBois-Meeh nomogram.[1] Vital Capacity was expressed in Liters BTPS. Oxygen Consumption, Oxygen Removal and Oxygen Pulse were corrected to STPD.

STATISTICAL TREATMENT

A t test for determining the significance of the difference between the means of small correlated samples was used in analyzing the data of group J, pre and post-training. The uncorrelated small sample means difference formula was used to determine the significance between the data of group J and group S.

To establish statistical significance, the 0.05 level of confidence was selected for the study. Clarke's[2] table was used to determine the integer denoting statistical significance.

PRESENTATION OF THE FINDINGS

A statistical comparison of the findings in each of the measured parameters is presented and discussed in the following three divisions:

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[1]D. DuBois and E. F. DuBois, "A Formula to Establish the Approximate Surface Area if Height and Weight be Known," Arch. Int. Med., 17: 863-871, 1916.

[2]David Clarke and Harrison Clarke, Research Processes in Physical Education, Recreation and Health (New Jersey: Prentice-Hall, Inc., 1970), p. 204.

(1) Group J Initial Scores vs. Final Scores; (2) Group J Initial Scores vs. Group S Scores; (3) Group J Final Scores vs. Group S Scores.

Heart Rates (All Subjects)

The mean heart rates for the two groups of subjects during the first nine minutes of the Modified Balke-Treadmill Test of Optimal Work Capacity is depicted in Figures 1 and 2. Group J had a slightly lower heart rate than group S during the initial testing. Group J showed much lower heart rates during the T_2 treadmill test than group S. As shown in Figure 2, subjects in group J walked for a longer time than group S on the treadmill before achieving the predetermined 150 BPM during the initial testing and walked another minute longer during the final testing. No tests were employed to determine the statistical significance of the differences in heart rates during the walk for either group of subjects.

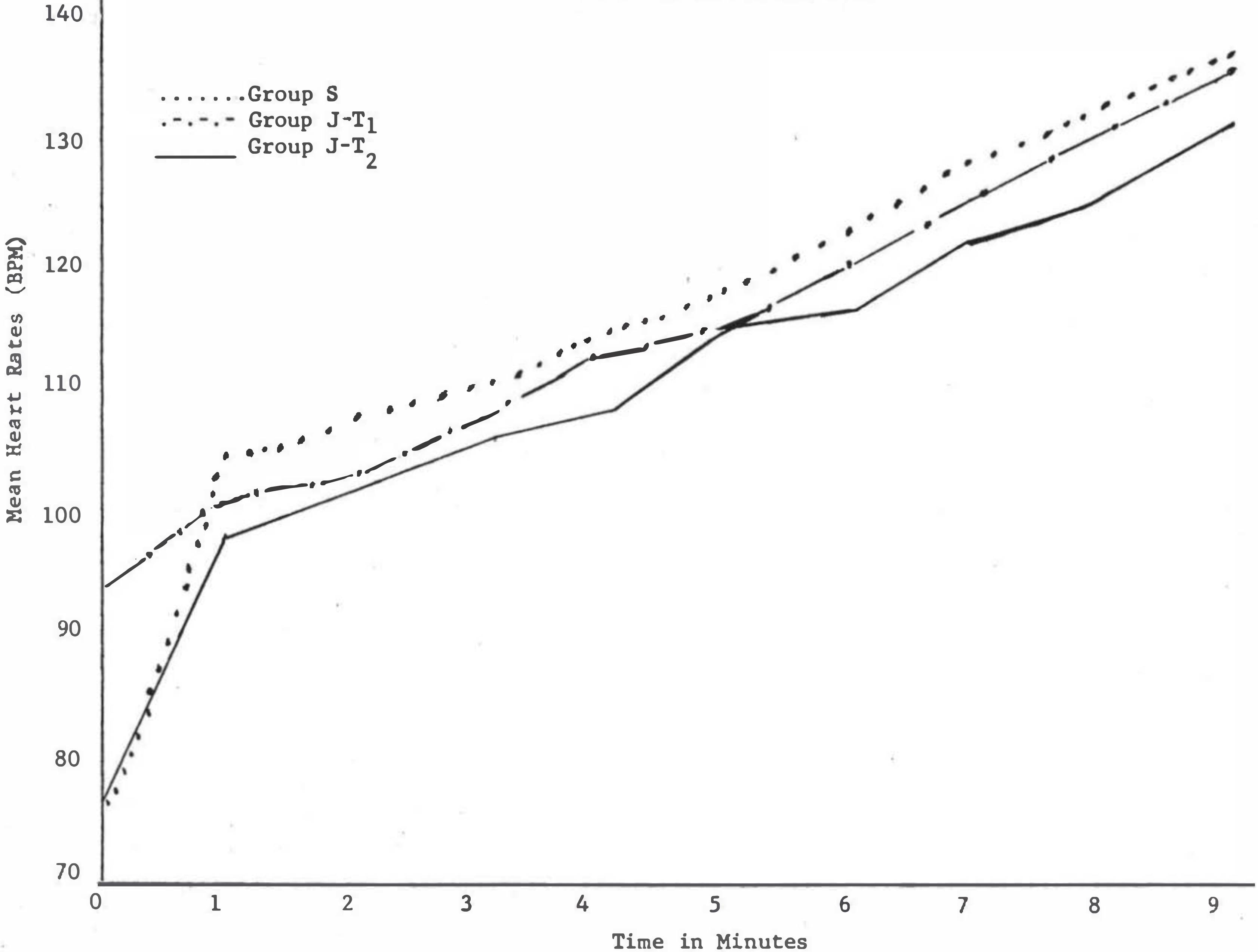
Jogging Group--Initial Scores vs. Final Scores (JT_1 vs JT_2)

Vital Capacity. The vital capacity of each subject is listed in Table 1. The mean vital capacity prior to the training program was 5.796 liters. It increased to 5.884 liters after the training program with a t value of 1.70 which was not statistically significant at the .05 level.

Pulmonary Ventilation at 150 BPM. Table 2 shows the amount of air moved by the subjects at about 150 BPM while walking on the treadmill both before and after the training period. There was an increase of 3.624 liters/minute, in the mean pulmonary ventilation of the

Figure 1

Mean Heart Rates During the First Nine Minutes
of Balke Treadmill Test



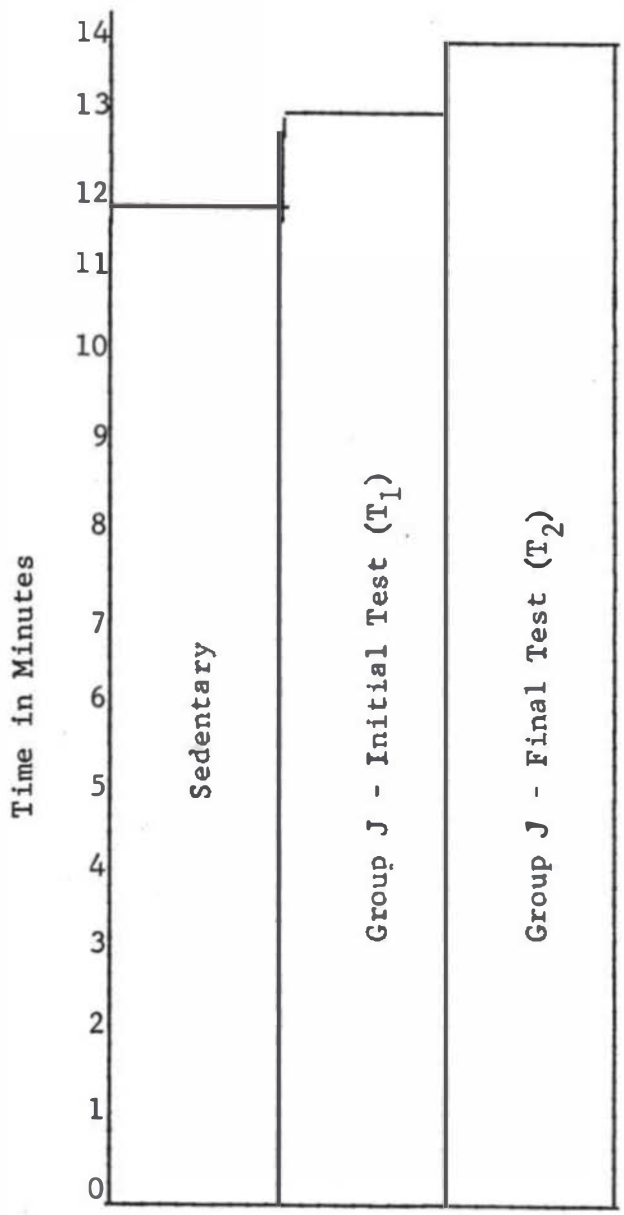


Figure 2

Mean Time Taken to Achieve 150 BPM Heart Rate

Table 1

Vital Capacity-Group J-Before and After the Training Period (JT_1 vs JT_2)

(Liters B.T.P.S.)

Subject	JT_1	JT_2
1	5.512	5.664
2	6.326	6.402
3	5.577	5.642
4	6.402	6.293
5	6.087	6.033
6	5.620	5.881
7	5.045	5.273
Mean	5.796	5.884
S.D.	0.456	0.366
t Ratio	1.70**	

**Not significant at the .05 level.

Table 2

Pulmonary Ventilation at 150 BPM-Group J
T_1 vs T_2
(Liters/Minute S.T.P.D.)

Subject	JT_1	JT_2
1	51.44	47.81
2	55.30	67.72
3	55.97	53.30
4	63.69	73.70
5	49.18	54.20
6	97.83	100.88
7	66.69	67.79
Mean	62.87	66.49
S.D.	15.40	16.53
t Ratio		1.58**

**Not significant at the .05 level.

subjects during the post training test, over the mean score during the pre-training test. The difference between the means with a *t* score of 1.58 was, however, not significant at the .05 level.

Oxygen Removal Rate at 150 BPM. There was a decrease in the mean oxygen removal rate from 40.77 ml/liter during the pre-training test, to 38.83 ml/liter during the post-training test. With a *t* score of 1.62, the difference between the means was not significant at the .05 level. (Table 3)

Oxygen Consumption at 150 BPM. The amount of oxygen consumed by each subject is listed in Table 4. There was a very slight increase of 0.58 ml/kg/min in the mean oxygen consumed during the T_2 over that of T_1. The difference was not significant at the .05 level of confidence.

Oxygen Pulse at 150 BPM. Table 5 shows the oxygen pulse of group J during the pre-training and post-training tests. There was a mean increase of 0.006 ml/kg/beat in the oxygen pulse during the post-training test. But the *t* score of 1.06 showed no significance at the .05 level.

Body Surface Area. As shown in Table 6, there was a decrease of 0.02 square meters in the body surface area of the jogging group at the end of the training period. This change was, however, not significant at the .05 level.

Sedentary Group Scores vs. Jogging Group Initial Scores (S vs. JT_1).

Vital Capacity. Table 7 shows the vital capacity of the sedentary group and that of the jogging group before training. The

Table 3

Oxygen Removal Rate at 150 BPM-Group J
T_1 vs T_2
(ml/L S.T.P.D.)

Subject	JT_1	JT_2
1	42.77	38.90
2	39.24	33.67
3	48.24	50.28
4	47.73	43.83
5	46.56	42.44
6	21.98	21.81
7	38.84	40.86
Mean	40.77	38.83
S.D.	8.46	8.36
t Ratio	1.62**	

**Not significant at the .05 level.

Table 4

Oxygen Consumption at 150 BPM-Group J
T_1 vs T_2

(ml/kg/min S.T.P.D.)

Subject	JT_1	JT_2
1	24.44	20.35
2	28.67	29.84
3	34.22	34.27
4	30.46	32.86
5	22.50	22.59
6	21.54	24.10
7	27.79	29.78
Mean	27.09	27.68
S.D.	4.21	4.95
$\underline{t}$ Ratio	0.68**	

**Not significant at the .05 level.

Table 5

Oxygen Pulse at 150 BPM-Group J
T_1 vs T_2
(ml/kg/beat S.T.P.D.)

Subject	JT_1	JT_2
1	0.158	0.136
2	0.191	0.199
3	0.219	0.221
4	0.203	0.219
5	0.149	0.151
6	0.135	0.155
7	0.179	0.192
Mean	0.176	0.182
S.D.	0.028	0.032
t Ratio	1.06**	

**Not significant at the .05 level.

Table 6

Body Surface Area-Group J
T_1 vs T_2

(Square Meters)

Subject	JT_1		JT_2
1	2.08		2.10
2	1.94		1.94
3	2.04		2.03
4	2.22		2.20
5	2.32		2.32
6	2.30		2.20
7	1.98		1.98
Mean	2.13		2.11
S.D.	0.14		0.13
_t_ Ratio		1.06**	

**Not significant at the .05 level.

Table 7

Vital Capacity-Group S Scores vs Group J
Initial Test Scores (S vs JT_1)

(Liters B.T.P.D.)

Subject	S	JT_1
1	6.141	5.512
2	5.577	6.326
3	6.076	5.577
4	4.752	6.402
5	4.991	6.087
6	4.666	5.620
7	5.772	5.045
8	6.510	-----
9	4.015	-----
10	5.490	-----
11	5.447	-----
12	6.185	-----
13	5.100	-----
14	5.859	-----
15	5.208	-----
16	5.707	-----
17	4.731	-----
18	5.664	-----
19	4.557	-----
20	4.774	-----
21	5.968	-----
Mean	5.390	5.796
S.D.	0.634	0.456
t Ratio	1.51**	

**Not significant at the .05 level

means showed that subjects in group J had a slightly higher vital capacity than group S subjects. But the mean difference with a *t* score of 1.51 was not statistically significant at the .05 level of confidence.

Pulmonary Ventilation. The pulmonary ventilation for subjects in group S and group J initial tests are listed in Table 8. The means showed that group J subjects moved 8.36 liters/minute of air more than group S subjects at heart rates of 150 BPM. But this difference was not statistically significant at the .05 level.

Oxygen Removal Rate. The means of the oxygen removal rate at 150 BPM showed that group J subjects had a little less oxygen removal rate during the initial test than group S subjects. The mean difference with a *t* score of 0.59 was insignificant at the .05 level. (Table 9)

Oxygen Consumption. The amount of oxygen consumed at a heart rate of 150 BPM by group S subjects and those in group J at T_1 are listed in Table 10. The means showed that the subjects in group S, even though they had done less work, consumed 0.79 ml/kg/min more that group J at T_1. This difference, with a *t* of 0.43 was, however, not significant at the .05 level.

Oxygen Pulse. The means of the oxygen pulse showed that group S subjects consumed 0.184 ml/kg/beat as opposed to 0.176 ml/kg/beat consumed by group J subjects at T_1 with a heart rate of 150 BPM. The mean difference was not significant at the .05 level. (See Table 11)

Table 8

Pulmonary Ventilation at 150 BPM-Group S Scores vs Group J Intital Test Scores (S vs JT_1)

(liters/minute S.T.P.D.)

Subject	S	JT_1
1	47.09	51.44
2	53.27	55.30
3	47.77	55.97
4	64.39	63.69
5	46.71	49.18
6	66.91	97.83
7	65.99	66.69
8	64.48	-----
9	50.83	-----
10	49.21	-----
11	52.37	-----
12	47.77	-----
13	54.27	-----
14	41.59	-----
15	45.59	-----
16	80.19	-----
17	-----	-----
18	57.83	-----
19	46.66	-----
20	41.81	-----
21	65.52	-----
Mean	54.51	62.87
S.D.	9.996	15.402
t Ratio	1.57**	

**Not significant at the .05 level.

Table 9

Oxygen Removal Rate at 150 BPM-Group S Scores vs Group J Initial Test Scores (S vs JT_1)

(ml/ L S.T.P.D.)

Subject	S	JT_1
1	45.02	42.77
2	52.56	39.24
3	54.01	48.24
4	46.13	47.73
5	39.18	46.56
6	37.51	21.98
7	40.01	38.84
8	40.48	-----
9	42.89	-----
10	40.03	-----
11	34.75	-----
12	45.43	-----
13	34.64	-----
14	51.70	-----
15	40.58	-----
16	41.03	-----
17	-----	-----
18	39.43	-----
19	42.43	-----
20	47.12	-----
21	34.95	-----
Mean	42.49	40.77
S.D.	5.543	8.459
t Ratio	0.59**	

**Not significant at the .05 level.

Table 10

Oxygen Consumption at 150 BPM-Group S Scores vs Group J Initial Test Scores (S vs JT_1)

(ml/kg/min. S.T.P.D.)

Subject	S	JT_1
1	20.61	24.44
2	33.29	28.67
3	30.51	34.22
4	33.59	30.46
5	22.27	22.50
6	27.20	21.54
7	30.77	27.79
8	29.42	-----
9	32.43	-----
10	25.57	-----
11	21.44	-----
12	31.20	-----
13	22.26	-----
14	26.28	-----
15	27.36	-----
16	33.90	-----
17	-----	-----
18	27.30	-----
19	27.06	-----
20	26.59	-----
21	28.63	-----
Mean	27.88	27.09
S.D.	3.980	4.210
t Ratio	0.43**	

**Not significant at the .05 level.

Table 11

Oxygen Pulse at 150 BPM-Group S Scores vs Group J Initial Test Scores (S vs JT_1)

(ml/kg/beat S.T.P.D.)

Subject	S	JT_1
1	0.139	0.158
2	0.225	0.191
3	0.201	0.219
4	0.232	0.203
5	0.147	0.149
6	0.185	0.135
7	0.192	0.179
8	0.194	-----
9	0.209	-----
10	0.165	-----
11	0.143	-----
12	0.211	-----
13	0.145	-----
14	0.178	-----
15	0.177	-----
16	0.217	-----
17	-----	-----
18	0.171	-----
19	0.178	-----
20	0.180	-----
21	0.191	-----
Mean	0.184	0.176
S.D.	0.027	0.028
t Ratio	0.63**	

**Not significant at the .05 level.

Body Surface Area. Table 12 shows the surface areas of group S subjects and group J subjects prior to the training period. Group J subjects had a larger mean surface area than group S subjects. The mean difference with a t score of 1.58 was, however, not significant at the .05 level of confidence.

Sedentary Group Scores vs Jogging Group Final Scores (S vs JT_2).

Vital Capacity. The vital capacity of group S subjects and the post-training vital capacity of group J subjects is listed in Table 13. The means showed that group J subjects had a larger vital capacity than group S subjects. But this difference with a t score of 1.88 was not significant at the .05 level.

Pulmonary Ventilation. As shown in Table 14, group J subjects moved a lot more air at 150 BPM, during the post-training testing, than group S subjects. Group J subjects moved 66.49 liters of air per minute as opposed to 54.51 liters/minute moved by group S subjects. This showed a mean difference of 11.98 liters/minute, resulting in a t score of 2.18, which was found to be statistically significant at the .05 level of confidence.

Oxygen Removal Rate. The means of the oxygen removal rate showed that subjects in group J removed less oxygen per liter of air they ventilated, than subjects in group S, even much less than during the pre-training test. The t score of 1.26 was, however, not significant at the .05 level. (See Table 15)

Oxygen Consumption. Table 16 shows group S' oxygen consumption and the amount of oxygen consumed by group J at 150 BPM during the

Table 12

Body Surface Areas-Group S Scores vs Group J Initial Test Scores (S vs JT_1)

(Square Meters)

Subject	S	JT_1
1	2.34	2.08
2	1.50	1.94
3	2.06	2.04
4	2.09	2.22
5	1.98	2.32
6	2.14	2.30
7	2.08	1.98
8	2.10	----
9	1.76	----
10	2.00	----
11	2.10	----
12	1.94	----
13	2.00	----
14	2.06	----
15	1.84	----
16	2.30	----
17	1.98	----
18	2.04	----
19	1.90	----
20	1.94	----
21	2.02	----
Mean	2.01	2.13
S.D.	0.172	0.143
t Ratio	1.58 **	

**Not significant at the .05 level.

Table 13

Vital Capacity-Group S Scores vs Group J
Final Test Scores (S vs JT_2)

(Liters B.T.P.S.)

Subject	S	JT_2
1	6.141	5.664
2	5.577	6.402
3	6.076	5.642
4	4.752	6.293
5	4.991	6.033
6	4.666	5.881
7	5.772	5.273
8	6.510	-----
9	4.015	-----
10	5.490	-----
11	5.447	-----
12	6.185	-----
13	5.100	-----
14	5.859	-----
15	5.208	-----
16	5.707	-----
17	4.731	-----
18	5.664	-----
19	4.557	-----
20	4.774	-----
21	5.968	-----
Mean	5.390	5.884
S.D.	0.634	0.366
t Ratio	1.88**	

**Not significant at the .05 level.

Table 14

Pulmonary Ventilation at 150 BPM-Group S Scores vs Group J Final Test Scores (S vs JT_2)

(Liters/Minute S.T.P.D.)

Subject	S	JT_2
1	47.09	47.81
2	53.27	67.72
3	47.77	53.30
4	64.39	73.70
5	46.71	54.20
6	66.91	100.88
7	65.99	67.79
8	64.48	-----
9	50.83	-----
10	49.21	-----
11	52.37	-----
12	47.77	-----
13	54.27	-----
14	41.59	-----
15	45.59	-----
16	80.19	-----
17	-----	-----
18	57.83	-----
19	46.66	-----
20	41.81	-----
21	65.52	-----
Mean	54.51	66.49
S.D.	9.996	16.526
t Ratio	2.18*	

*Significant at the .05 level.

Table 15

Oxygen Removal Rate at 150 BPM-Group S Scores vs Group J Final Test Scores (S vs JT_2)

(ml/L S.T.P.D.)

Subject	S	JT_2
1	45.02	38.90
2	52.56	33.67
3	54.01	50.28
4	46.13	43.83
5	39.18	42.44
6	37.51	21.81
7	40.01	40.86
8	40.48	-----
9	42.89	-----
10	40.03	-----
11	34.75	-----
12	45.43	-----
13	34.64	-----
14	51.70	-----
15	40.58	-----
16	41.03	-----
17	-----	-----
18	39.43	-----
19	42.43	-----
20	47.12	-----
21	34.95	-----
Mean	42.49	38.83
S.D.	5.543	8.363
_t_ Ratio	1.26**	

**Not significant at the .05 level.

Table 16

Oxygen Consumption at 150 BPM-Group S Scores vs Group J Final Test Scores (S vs JT_2)

(ml/kg/min S.T.P.D.)

Subject	S	JT_2
1	20.61	20.35
2	33.29	29.84
3	30.51	34.27
4	33.59	32.86
5	22.27	22.59
6	27.20	24.10
7	30.77	29.78
8	29.42	-----
9	32.43	-----
10	25.57	-----
11	21.44	-----
12	31.20	-----
13	22.26	-----
14	26.28	-----
15	27.36	-----
16	33.90	-----
17	-----	-----
18	27.30	-----
19	27.06	-----
20	26.59	-----
21	28.63	-----
Mean	27.88	27.68
S.D.	3.980	4.954
_t_ Ratio	0.10**	

**Not significant at the .05 level.

post-training test. Even though group J subjects worked for a longer time than group S subjects, group J subjects still consumed less than group S subjects. The slight difference in the means was not significant at the .05 level.

Oxygen Pulse. The mean oxygen pulse scores at 150 BPM showed that subjects in group J had a little less oxygen pulse since they consumed less oxygen than group S subjects at 150 BPM. The *t* ratio of 0.17 was not significant at the .05 level. (Table 17)

Body Surface Area. The body surface area of group S subjects and the T_2 body surface area of group J subjects are shown in Table 18. The means showed that even though subjects in group J had less body surface area at T_2 than they had at T_1, their mean body surface area was still larger than that of subjects in group S. The difference with a *t* score of 1.39 was not significant at the .05 level of confidence.

SUMMARY

The study was conducted to investigate changes in selected cardio-respiratory parameters in middle age men following the first ten weeks of a jogging program. In addition, a comparison was made to determine what differences, if any, existed in the cardio-respiratory parameters of jogging subjects and sedentary men of comparable occupation, chronological age and body surface area. The findings support the first null hypothesis, in that there were no significant changes in the cardio-respiratory efficiency of the jogging group

Table 17

Oxygen Pulse at 150 BPM-Group S Scores vs Group J Final Test Scores (S vs JT_2)

(ml/kg/beat S.T.P.D.)

Subject	S	JT_2
1	0.139	0.136
2	0.225	0.199
3	0.201	0.221
4	0.232	0.219
5	0.147	0.151
6	0.185	0.155
7	0.192	0.192
8	0.194	-----
9	0.209	-----
10	0.165	-----
11	0.143	-----
12	0.211	-----
13	0.145	-----
14	0.178	-----
15	0.177	-----
16	0.217	-----
17	-----	-----
18	0.171	-----
19	0.178	-----
20	0.180	-----
21	0.191	-----
Mean	0.184	0.182
S.D.	0.027	0.032
t Ratio	0.17**	

**Not significant at the .05 level.

Table 18

Body Surface Area-Group S Scores vs Group J Final Test Scores (S vs JT_2)

(Square Meters)

Subject	S	JT_2
1	2.34	2.10
2	1.50	1.94
3	2.06	2.03
4	2.09	2.20
5	1.98	2.32
6	2.14	2.20
7	2.08	1.98
8	2.10	----
9	1.76	----
10	2.00	----
11	2.10	----
12	1.94	----
13	2.00	----
14	2.06	----
15	1.84	----
16	2.30	----
17	1.98	----
18	2.04	----
19	1.90	----
20	1.94	----
21	2.02	----
Mean	2.01	2.11
S.D.	0.172	0.127
_t_ Ratio	1.39**	

**Not significant at the .05 level.

following the first ten weeks of the jogging program. However, the findings did show that there was a significant difference in the pulmonary ventilation of the jogging group and sedentary group. There was a t ratio of 2.18 which was significant at the .05 level of confidence.

Figures 3 a through f show graphic representation of the means of the parameters measured.

DISCUSSION OF THE FINDINGS

The findings of the study did not show much difference between the sedentary group and the jogging group during a sub-maximal test except in the pulmonary ventilation. The heart rates and oxygen consumption of the subjects in the jogging group showed that the sub-maximal test was not taxing enough, especially after the training period, to bring out the actual cardiovascular adjustments found in those who train. Probably, more significant differences would have been seen between the post-training cardiovascular efficiency of the jogging group and the cardiovascular efficiency of the sedentary group, if the maximum oxygen consumption (Max.$\dot{V}O_2$) of the two groups had been tested. However, considering the age group and level of activity of the subjects used for this study, a maximum oxygen consumption test would be unsafe. Such a test would require special safety equipment which was not available for use during the course of this study.

Some of the findings, however, can be discussed in line with some known physiological principles.

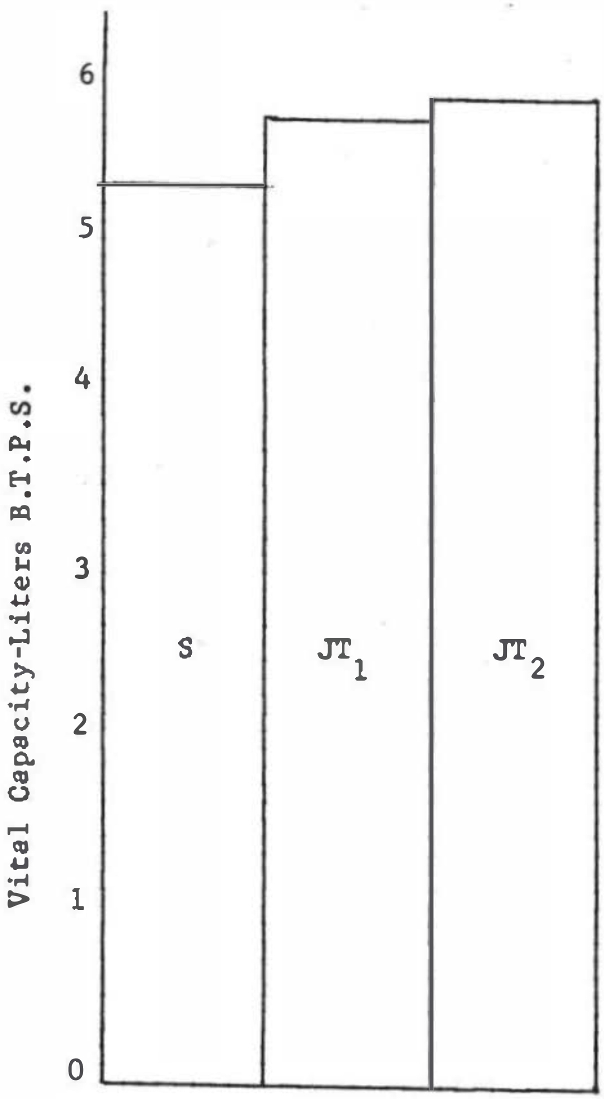


Figure 3 a

Mean Vital Capacity

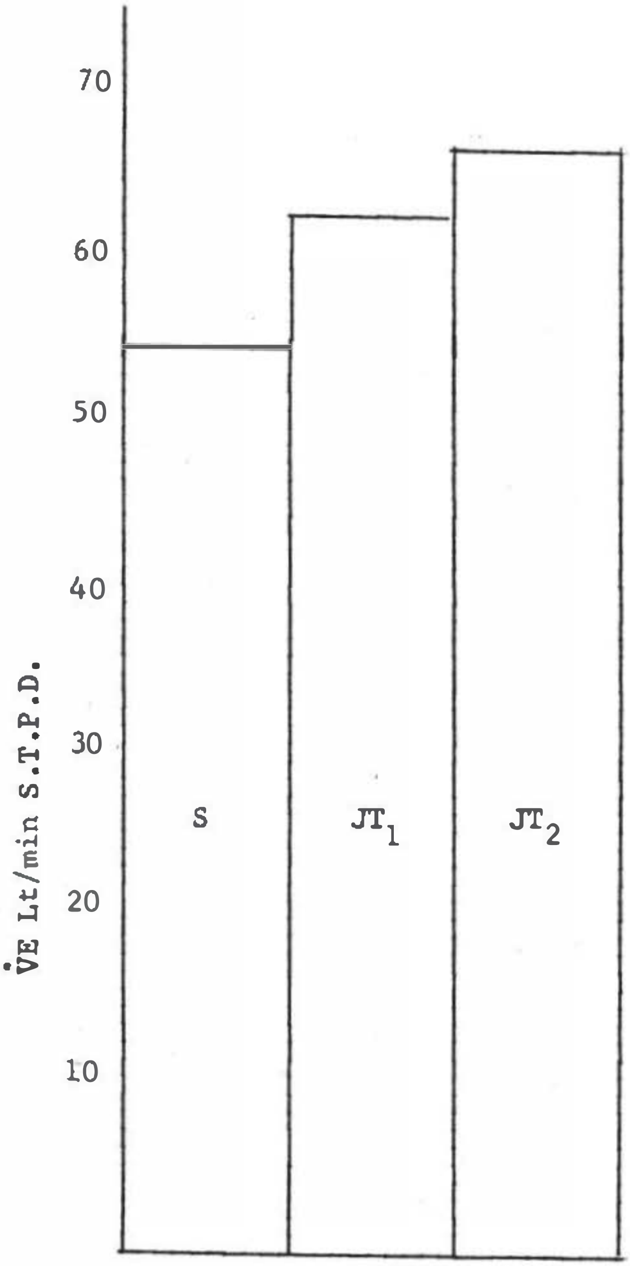


Figure 3 b

Mean Pulmonary Ventilation at 150 BPM

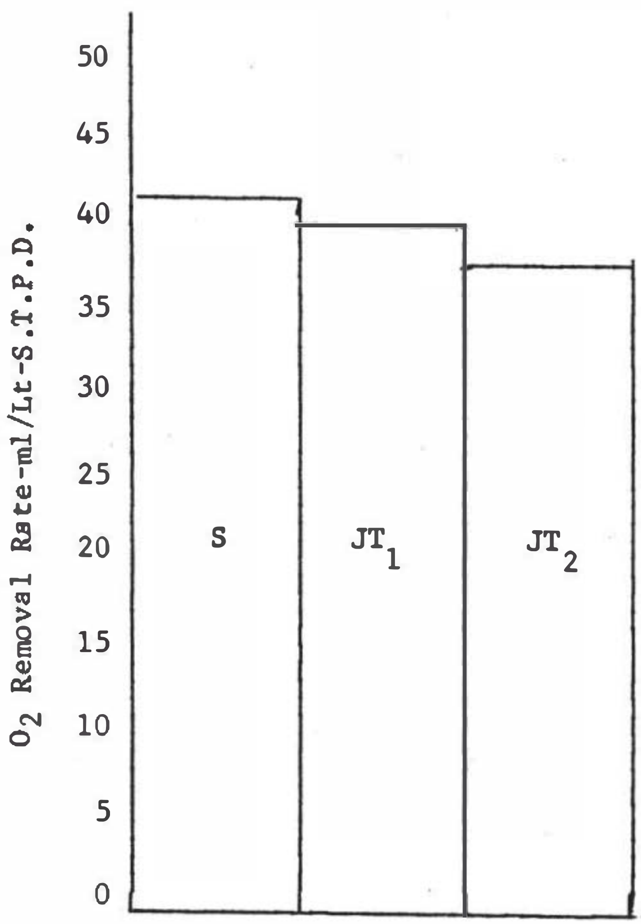


Figure 3 c

Mean O_2 Removal Rate at 150 BPM

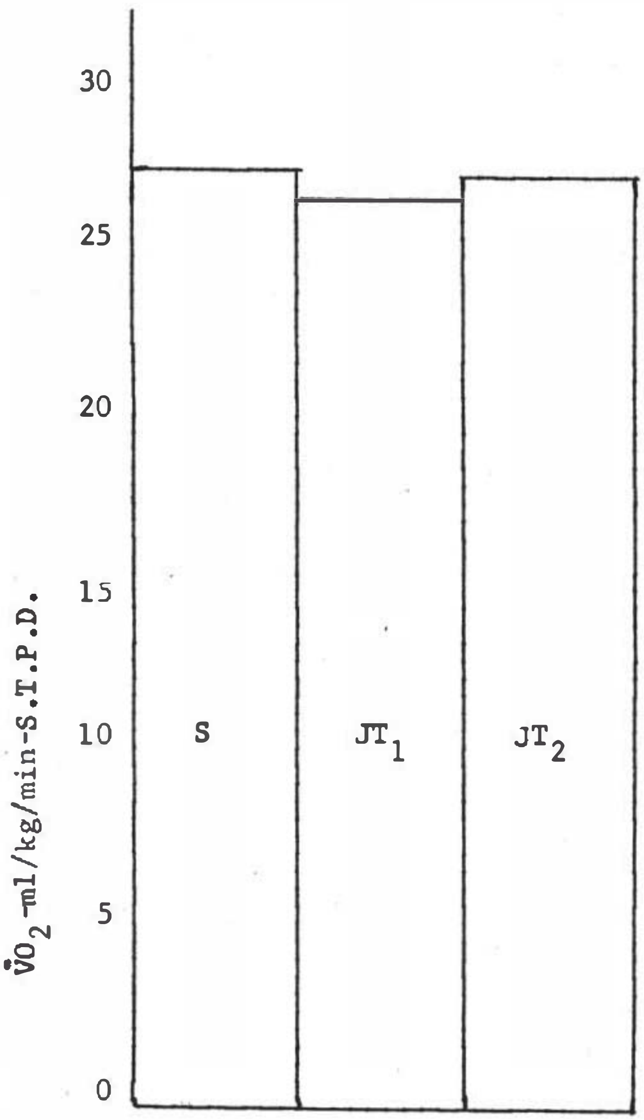


Figure 3 d

Mean Oxygen Consumption at 150 BPM

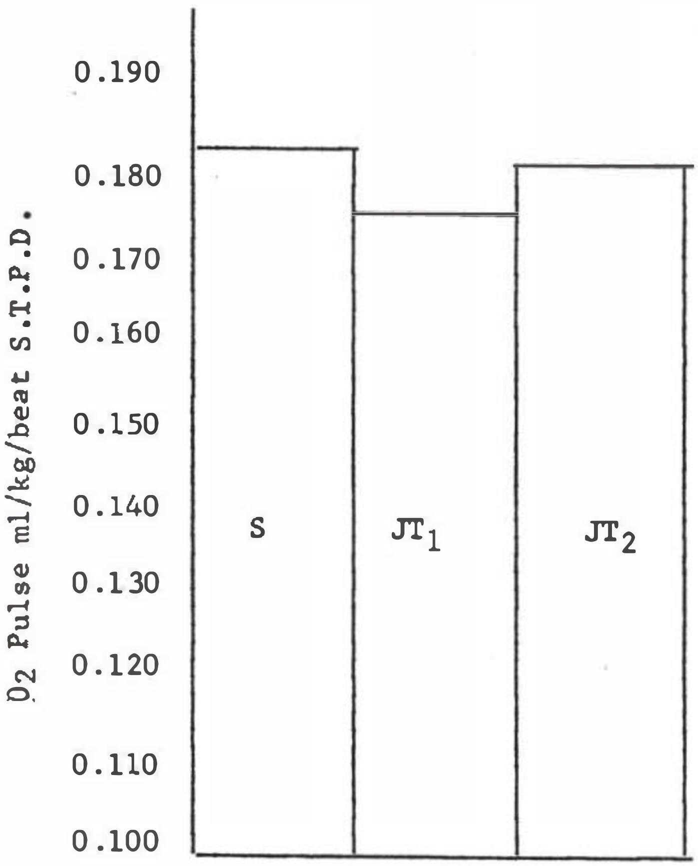


Figure 3 e

Mean Oxygen Pulse
at 150 BPM

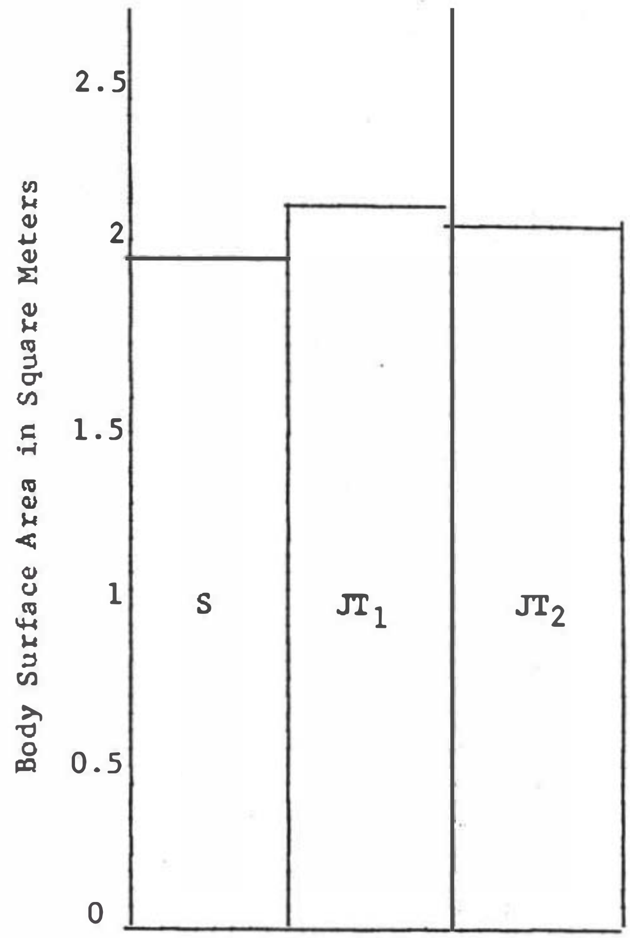


Figure 3 f

Mean Body Surface Area

Heart Rate

Training effect on heart rate has been reported by many studies. Jokl, Carlsten and Chapman et al.,[3,4,5] have all reported that training reduces the heart rate at rest and during work. Thus, for maximal work, the trained subject will be able to perform more work before he reaches his maximum heart rate than the untrained. This concept is demonstrated by the lower heart rates of group J subjects during the Balke Test especially during the T_2 as shown by Figure 1. As expressed earlier, the statistical significance of this lower heart rate was not computed.

Vital Capacity

Vital capacity is the maximum volume of air that can be expelled from the lungs following a maximum inspiration. It is a demonstration of the total air space available in an individual's lungs and the individual's ability to fill them up. Although a large vital capacity does not make a champion, its magnitude bears an important relation to the physical fitness of a person. There is some relationship between participation in physical work and vital capacity. West[6] showed that the

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[3]Ernest Jokl, Heart and Sports (Springfield, Ill.: C. C. Thomas Publisher, 1964), p. 11.

[4]Arne Carlsten and G. Grimby, The Circulatory Response to Muscular Exercise in Man (Springfield, Ill.: C. C. Thomas Publisher, 1966), p. 69.

[5]Carl B. Chapman and Jere H. Mitchell, Scientific America, May 1965, pp. 88-96.

[6]H. West, "Clinical Studies on the Respiration, VI. A Comparison of Various Standards for the Normal Vital Capacity of the Lungs," Arch. Int. Med. (Chicago) 25: 306, 1921.

ratio of the vital capacity to the skin surface area is greatest in athletes and least in sedentary women. Also, college students who took part in physical activity during their college course were found to have gained 625 cc. in vital capacity, while their sedentary colleagues gained only 295 cc. A group of adolescent boys who took regular exercise gained 130 cc. in vital capacity in four months.[7] The findings in this study showed that subjects in group J had a mean gain of 88 ml or cc. in vital capacity after ten weeks of jogging. Though this gain was not significant at the .05 level, it did show some respiratory adaption to the initial phase of a training program they have gone through.

<u>Pulmonary Ventilation and Oxygen Removal Rate</u>

Table 14 shows that the only statistically significant difference between the sedentary group and the jogging group was the post-training pulmonary ventilation. The jogging group moved 11.98 Liters/minute more than the sedentary group. This mean difference, with a *t* ratio of 2.18 was significant at the .05 level of confidence. This increase in pulmonary ventilation showed that the fastest significant adaption to the training program occurs in the respiratory system.

The insignificant increase in oxygen consumption (due to the increase in work done before achieving 150 BPM during the T_2) in relation to the high pulmonary ventilation, resulted in a reduced oxygen

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[7]L. Schwartz, R. H. Britten and L. R. Thompson, "The Effect of Exercise on the Physical Condition and Development of Adolescent Boys," <u>Pub. Health Bull</u>. No. 179, 1928.

removal rate. According to Karpovich,[8] for the same task, decrease in oxygen removal rate would mean uneconomic ventilation by the subject. However, Karpovich[9] himself believes that when exertion is moderate and steady, the minute-volume and frequency of breathing continue to increase proportionately to the load of work, for several minutes, up to the crest load. Thus, the increased work load coupled with an increase in vital capacity, resulted in the necessary increase in pulmonary ventilation of the jogging group

With the significant increase in the ability to ventilate a lot of air and lower heart rates recorded, the jogging group's ability to deliver more oxygen to the muscles under a more strenuous situation is ensured. However, the findings in the study showed that the circulatory system is yet to be developed enough to make the jogging group able to utilize their respiratory capacity to the fullest.

Oxygen Consumption and Oxygen Pulse

At a given sub-maximal work-load, the untrained individual will consume more oxygen than the trained. Table 16 shows that even though group J subjects did about 17 percent more work than group S subjects, group J subjects still consumed less oxygen at 150 BPM heart rate than group S. Although the difference was not statistically significant at the .05 level, the lower oxygen consumption and oxygen pulse at a higher

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[8]P. V. Karpovich, Physiology of Muscular Activity (Philadelphia: W. B. Sanders Co., 1959), pp. 144-145.

[9]Ibid., p. 148.

level of sub-maximal work showed that group J subjects were more cardiovascularly fit after the training period than group S subjects.

Chapman and Mitchell[10] believe that under moderate stress, the heart of a trained athlete increases its stroke volume more rapidly than that of a sedentary person. The sedentary person's heart increases its pulse rate instead. Musshoff et al.[11] reported that studies on the cardiac output during standard exercise repeated during a course of training, indicates that cardiac output is maintained at the same level. The reduction in heart rate should then mirror an increase in stroke volume. According to Astrand and Rodahl,[12] if the above statement is the case, the heart rate (HR) will inversely vary with the individual's stroke volume (SV); i.e., the larger the stroke volume, the lower the heart rate, since HR x SV = Q.

The findings of this study agreed with the above cited literatures. Although not statistically significant at the .05 level, the lower heart rate during the post-training test resulting in increase in the work capacity before achieving the 150 BPM heart rate and the corresponding slight increase in the oxygen pulse at the 150 BPM heart rate, all mirror an increase in the stroke volume of the jogging group. It showed their ability to supply the increased demand of oxygen resulting from the increased work-load, without any increase in the heart rates.

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[10] Carleton B. Chapman and J. H. Mitchell, *loc. cit.*, pp. 88-96.

[11] Musshoff et al., "Stroke Volume, Arteriovenous Difference, Cardiac Output and Physical Work Capacity and Their Relationship to Heart Volume," *Acta Cardiol*, Brux., 14: 427, 1959.

[12] Per-Olaf, Astrand and Kaare Rodahl, *Textbook of Work Physiology* (McGraw-Hill Book Company, 1970).

Body Surface Area

This study showed that subjects in group J were originally a bit heavier than those in group S. With only a very slight reduction in their body surface area at the end of the training period, they were still heavier. The reduction in body surface area was also not significant.

Summary

In summary, the findings in this study showed that there were no significant changes especially in the cardiovascular efficiency of the jogging group after the ten week-initial phase of a training program they went through. The significant increase in their pulmonary ventilation at the end of this initial training period showed a very impressive improvement in their respiratory capacity.

These findings correspond with the findings of some previous studies. Karpovich[13] believes that the effect of training shows itself so gradually that only after weeks may a slight evidence be observed. His study on two subjects showed that the respiratory system adjusts to training more and faster too, than the circulatory system, since there was only a slight increase of 0.56 to 0.84 percent in absorption of oxygen while pulmonary ventilation decreased by 15 to 23.5 percent during a task of maximum oxygen consumption after a strenuous training program. A similar situation was found in this study with a significant increase in the pulmonary ventilation of the jogging group and a very slight difference in the oxygen consumption.

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[13]P. V. Karpovich, loc. cit., pp. 144-145.

Sjostrand[14] has reported the effect of training in an athlete who lost his fitness. After a period of training, the athlete's physical work capacity, determined with heart rate at sub-maximal work loads, increased more than the relative increase in the total amount of hemoglobin and heart volume. It was suggested that those results might be due to more efficient peripheral circulatory adaption to muscular work, resulting in a larger utilization of the blood oxygen than before training. The findings of this study showed that subjects in the jogging group increased their work-load capacity by about 8 percent with a corresponding increase of only about 0.04 percent oxygen pulse at 150 BPM heart rate. Though these changes were, however, not significant at the .05 level, they did agree with Sjostrand's report. Sjostrand's assumption is consistent with the observation by Hollmann[15] that physical training of moderate intensity or of high intensity but of very short duration mainly results in a decrease of the heart rate during work without measuable changes in the circulatory dimensions. The findings of this study were no exception to Hollmann's findings.

Though no statistically significant changes at the .05 level were found except in the pulmonary ventilation, the results of the various measurements in this study showed that there were some improvements in all the selected cardio-respiratory parameters, mirroring an

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[14]T. Sjostrand, Clinical Physiology (Svensker Bok forlaget, Stockholm, 1967).

[15]W. Hollmann, Korperliches Training als Pravention von Herz-Kreislanfkheiten, Stuttgart: Hippokrates-Verlag, 1965).

increase in the maximal aerobic power of the middle age men in the jogging group as a result of their particpation in the initial phase of a training program. (See Figure 3) According to Hollman,[16] a regular physical training can rather effectively counteract the age-induced decrease in maximal aerobic power. Older individuals may be less trainable as they have to progress more cautiously than the younger ones. It should be kept in mind, however, that some effect of training may be noticed even at a very old age.

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[16] Ibid.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The study was conducted primarily to investigate changes in selected cardio-respiratory parameters in middle age men following the first ten weeks of a jogging program. In addition, a comparison was made to determine what differences, if any, existed in the cardio-respiratory parameters of jogging subjects and sedentary men of comparable occupation, chronological age and body surface area.

Twenty-eight male Eastern Illinois University faculty members and civil servants within the Charleston community between age 24 and 65 were subjects for the study. Seven of the men, who elected to participate in the initial phase of the "Run For Your Life" program at Eastern, were placed in the jogging group and each walked and jogged 3 days a week, at least 2 miles each day, for 10 weeks. The remaining 21 men, who formed the sedentary group, just did their normal daily activities.

Each of the groups was given the same Vital Capacity Test, Modified-Balke Treadmill Test of Optimal Work Capacity during which the time taken to achieve 150 BPM heart rate, Pulmonary Ventilation, Oxygen Consumption, Oxygen Removal Rate and Oxygen Pulse at 150 BPM

were measured. A measurement of Body Weight and Height was used to compute Body Surface Area. Subjects in the jogging group were given the same test battery after the ten weeks of walking and jogging.

In order to determine the statistically significant differences between the groups of subjects, three _t_ scores were computed: (1) between the jogging group-initial test mean scores and final test mean scores (JT_1 vs JT_2); (2) between the sedentary group-mean scores and the jogging group initial test mean scores (S vs JT_1); and (3) between the sedentary group mean scores and the jogging group-final test mean scores (S vs JT_2). The 0.05 level of confidence was established for the study to show statistical significance.

CONCLUSIONS

Based on the findings of this study, the following conclusions appear justified:

1. There is no significant change in the cardio-respiratory efficiency of middle age men following the ten week initial phase of a walking and jogging program.
2. There is a significant difference only in the pulmonary ventilation of the walking and jogging subjects and sedentary men of comparable occupation, chronological age and body surface area following the ten week initial phase of a walking and jogging program.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations appear warranted:

1. A longitudinal study should be done on the participants in the "Run For Your Life" program as at Eastern Illinois University, to determine the cardio-respiratory effects of this program, beyond the initial phase.
2. A similar study of the cardio-repisratory effects of the initial phase of the jogging program could still be conducfed with the data collected from a standardized work load, rather than predetermined heart rate, as in the Balke Test, or with proper safety precautions, a more strenuous test.

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