THE EFFECTS OF STEAM BATHS ON
THE CARDIOVASCULAR SYSTEM

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PREFACE

This study was conducted at Oklahoma State University, Stillwater, Oklahoma. Its purpose was to determine whether a controlled use of steam baths would effect a change in the cardiovascular system as measured by the electrocardiogram and the Schneider Index. A corollary purpose was to determine whether plateaus in heart rate occur during the steam bath.

A survey of the literature showed that activities that caused the heart rate to increase above one hundred and fifty beats per minute are adequate for increasing cardiovascular fitness. The author was interested to see if steam bathing could be one of these activities.

The writer wishes to express his appreciation to the Stillwater Young Men's Christian Association for the use of their facilities; to those subjects who made many sacrifices for the sake of research; to Dr. John G. Bayless for his encouragement; to Dr. Robert S. Brown and Dr. John D. Hampton for their suggestions and guidance in the statistical treatment of the data used in the study.

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CHAPTER I

INTRODUCTION

Statement of the Problem

The steam bath as it is known today has its origin in antiquity. The early Greeks utilized the steam bath as a part of their physical fitness and recreation program. Steam bathing was one of the activities in which the Greeks and Romans took great delight. There was a bath near every gymnasium. The Greeks and Romans took steam baths of some sort after participating in vigorous activities.

The temperature of these steam baths varied.

> In the tepidrium, one of the most highly ornamented chambers, warm air or vapor conditioned the bodies of the men sitting on benches for the hotter bath that was to follow. The coldarium, a chamber subjected to much more intense heat, provided tub or vapor baths (Van Dalen, 1953, p. 64).

Participants had choices of temperatures at which they could start. They could disregard the steam bath and start with the dry heat bath. From Van Dalen's description, this ancient bath seemingly compares with the sauna bath of today.

According to Schaffgotsch (1964) the steam bath had its origin in Central Asia. Whereas, the Romans used the baths for health and physical fitness, in Russia their most common use denoted submission to a higher celestial power. The bath houses were heated until they were extremely hot. Then the bathers poured hot water over themselves and beat their bodies with birch leaves until they were weak. These people, who were usually monks, were very religious and believed in subjugating the body in order to elevate the soul.

Today the steam bath still plays an important role in the lives of the Russian people. The steam bath is used for various therapeutic procedures. According to Schaffgotsch (1964), some of these procedures included cupping, venesection, and massaging of arms and legs.

Steam bathing is beginning to be used more and more as a means of relaxation. Consumer's Report (1966) had a panel of volunteers take the steam bath in a portable steam cabinet. Each subject reported a sense of well-being after a steam bath.

The need to create new means, methods, techniques, and activities that will serve man in a rapidly changing society is apparent. Man needs activities that can be utilized quickly and yet produce the kinds of results that will increase physical fitness. The tenor of American life has changed to a degree that can only be described in terms of enumeration of events that have affected the lives of all Americans. The first major change was probably the industrial revolution.

The industrial revolution in the United States, beginning about the last quarter of the nineteenth century to the first half of the twentieth century, created a diversity in the American way of life that has proliferated beyond imagination. Automation, ushered in by man's necessities and ingenuity, has given him more free time to do those things that are not directly connected with making a living. Prior to the industrial revolution man had to labor from fourteen to sixteen hours each day in order to provide his family with the basic necessities of life. Man had very little time for leisure and pleasurable pursuits. He often labored from early morning until late evening performing tasks that required tremendous expansion of energy and continuous utilization of the muscular and the cardiovascular systems of the body.

The complex and profound changes in economy and technology which attended the development of modern industrialism have had complex and profound effects on man and his mode of living. According to the Monthly Labor Review (1969), man works on the average of approximately forty hours per week. This represents approximately one-half of the number of hours man used to work at laborious tasks. The work he does today not only requires shorter hours but also less expenditure of energy, and less involvement of the entire organism. This decreased involvement of the systems of the body only serves to weaken the body and predispose man to the ravages of diseases. According to Weisz (1963), Lamark was credited with the law of use and disuse. This law postulates that use brings about growth; disuse brings about atrophy. In order for the body to grow and be strong it must be placed under considerable physical stress at regular intervals.

Today, people have more time that is not utilized in making a living than in any other period of modern history. However, there are those who might argue this point. They might disclaim the theory that automation has given them more time. Some sedentary workers claim that automation has given them more work to do. The work to which they refer, however, requires little physical effort and a tremendous expenditure of mental energy. To combat this, many sedentary workers become weekend golfers, some join bowling leagues, some do push-ups daily, and still others lift weights. According to Cooper (1968, p. 24) these activities are not the type to produce and maintain optimal physical fitness. He said:

> The muscles that show - the skeletal muscles - are just one system in the body, and by no means the most important. If your exercise program is directed only at the skeletal msucles, you'll never achieve real physical fitness.

Bowling, golfing, calisthenics, push-ups, and weight lifting have proven to be inadequate due to the low level of physical stress that is placed on the cardiovascular system. Cooper (1968, p. 40) further stated that:

> ...if the exercise is vigorous enough to produce a sustained heart rate of 150 beats per minute or more, the training-effect benefits begin in about five minutes after the exercise starts and continues as long as the exercise is performed.

Brouha et al. (1963) have shown that heart rate is a sensitive indicator of the total strain induced by the simultaneous action of work and heat.

Preliminary studies by this investigator at Maryland State College in 1966 with a portable steam cabinet revealed that heart rate often increased above 150 beats per minute. It was also noted that systolic blood pressure rose and body temperature increased. These observations, coupled with the findings of Taylor (1929), Brouha (1963), and Cooper (1968) led this investigator to hypothesize that cardiovascular efficiency could be improved by exposing the body to steam heat that will increase heart rate to 150 beats per minute or above.

None of the activities such as golfing, bowling, push-ups, weight lifting, and calisthenics are of such a nature that it will cause heart rate to rise up to or above 150 beats per minute for five minutes or more.

Administrators, businessmen, professors, lawyers, doctors, secretaries, clerks, and general clerical workers are in need of activities that will allow them to gain and maintain optimal cardiovascular fitness. The sedentary worker who is concerned about his physical fitness wants activities that will keep his cardiovascular system in good condition, utilizing a minimum amount of time, effort, and with no more inconvenience than taking a shower. This study will attempt to determine if steam bathing could be such an activity.

Purpose of the Study

The purpose of this study was to determine whether a controlled use of steam baths would effect a change in the cardiovascular system as measured by certain electrocardiogram measures and the Schneider Index. The electrocardiogram measures were: a. T-waves, b. P-waves, c. Rest-work ratio, and d. Heart rate. A corollary purpose was to determine whether plateaus in heart rate occurred during the steam bath.

Limitations of the Study

This study of necessity was limited to a small population. Statistically, it would have been better to have had a larger sample. However, the nature of the study, at this time, precluded a larger sample. This study was limited to forty selected males at Oklahoma State University. Further limitations are the short duration of the study, the low number of treatments, and possibly the fluctuations of the temperature in the steam room. Because of these limitations this investigator will not attempt to generalize these results to any group other than the group directly concerned with this study.

Definitions of Terms

The following terms will be used extensively in this study:

Cardiac Waves - Cardiac waves are electrical impulses given off by the heart as the result of cardiac activities. These cardiac waves are represented by upward and downward deflection of the stylus of the electrocardiograph. The deflections are grouped into six waves called P, Q, R, S, T, and U waves.

1. P-wave - refers to that part of the electrocardiogram that designates atrium contraction. It is the first wave in the electrocardiogram (Fig. 1). The deflection is usually upward in all standard leads. According to Cureton (1951) the average P-wave range is from 0.3 to 2.0 mm with a mean of 0.92 mm. Cureton's studies showed that people who are fit have lower P-wave amplitudes than those who are unfit.
2. QRS complex - The QRS complex is that part of the electrocardiogram that represents contraction of the ventricles. According to Sigler (1940) the QRS complex begins with the earliest encroachment of the ventricular myocardium by impulse and terminates after the entire ventricular muscle has been involved. According to Cureton (1951) normal young men's mean QRS duration was 0.065 in Lead 1, 0.068 in Lead 2, and 0.067 in Lead 3.

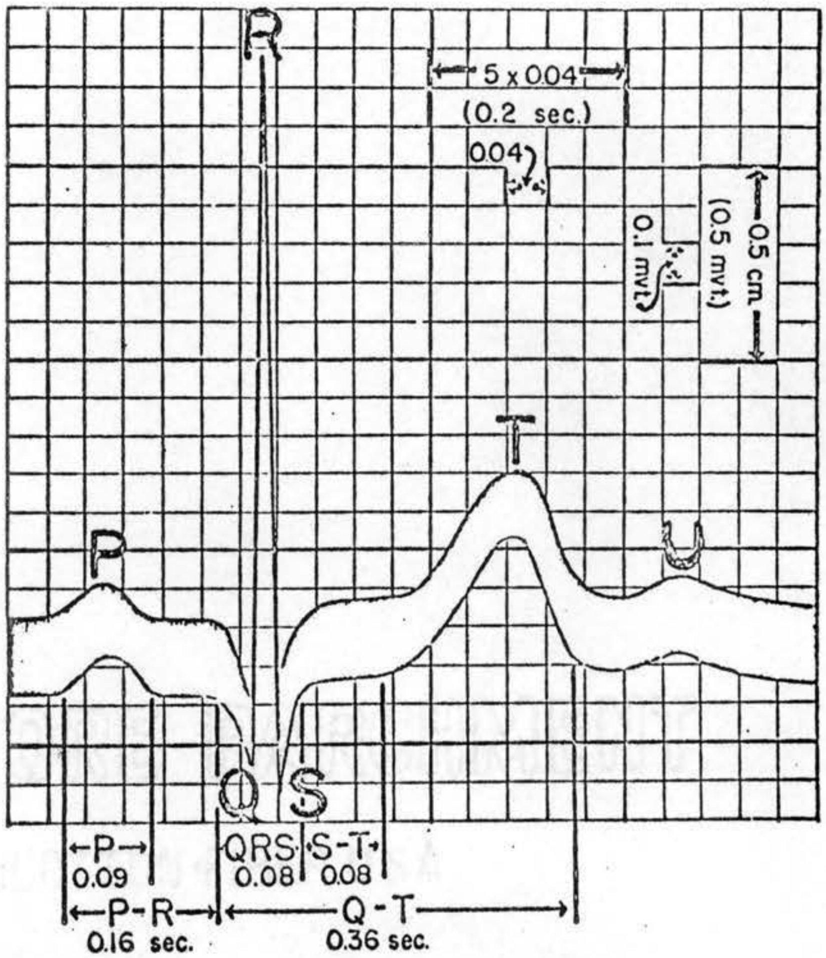

Figure 1. Drawing of Actual Electrocardiogram Enlarged About Five Times.

Each single square of the graph represents 1 mm. Each group of 5 mm is marked off in the horizontal and vertical by thicker lines. Measured in the horizontal, each millimeter represents a time interval of 0.04 second, therefore, 5 mm equals 0.2 second. Measured in the vertical, each millimeter represents 0.1 mv of current, if we employ the usual standardization, 1 cm of deflection = 1 mv of current. Hence, 5 mm or 0.5 cm of deflection equals 0.5 mv of current. The duration of the P-wave, P-R interval, QRS interval, S-T interval, and Q-T interval, respectively, for this normal electrocardiogram, is shown in the corresponding sections of the tracing.

3. T-waves - T-waves refer to that part of the electrocardiogram that indicates relaxation of the ventricles. Generally, the T-wave displays an upward deflection. However, there are instances when the T-wave is inverted. This usually happens in Lead 3. According to Cureton (1951) subjects who were trained had higher T-wave amplitudes than those who were untrained. Cureton found that normal young men had amplitudes ranging from -1.7 to 8.5 mm in Lead 1, with a mean of 2.7 mm. In Lead 2 it ranged from 0.8 to 8.5 mm in amplitude with a mean of 4.2 mm. Lead 3 amplitudes ranged from -1.7 to 14.6 mm and had a mean of 1.87 mm.

Cardiac waves are recorded on a roll of paper, so treated that the heat from the stylus makes an imprint as it rolls through the electrocardiograph (Fig. 2). As the heart beats, the various waves are formed (Fig. 1). These waves are the results of electrical impulses given off by the heart. The impulses travel by leads (Fig. 3) to the electrocardiograph (Fig. 2).

Cardiovascular - Cardiovascular is the name given to that system of the body that includes the heart and the blood vessels. Morris (1953) and Fox (1964) have suggested that lack of activity is probably a major cause of disease that affects this system.

Cardiovascular Fitness - Cardiovascular fitness is the efficient operation of the heart and blood vessels including the arteries, capillaries, veins, and venules. Efficient operation means maximum heart output with minimum effort by the heart as measured by the electrocardiogram and the Schneider Index.

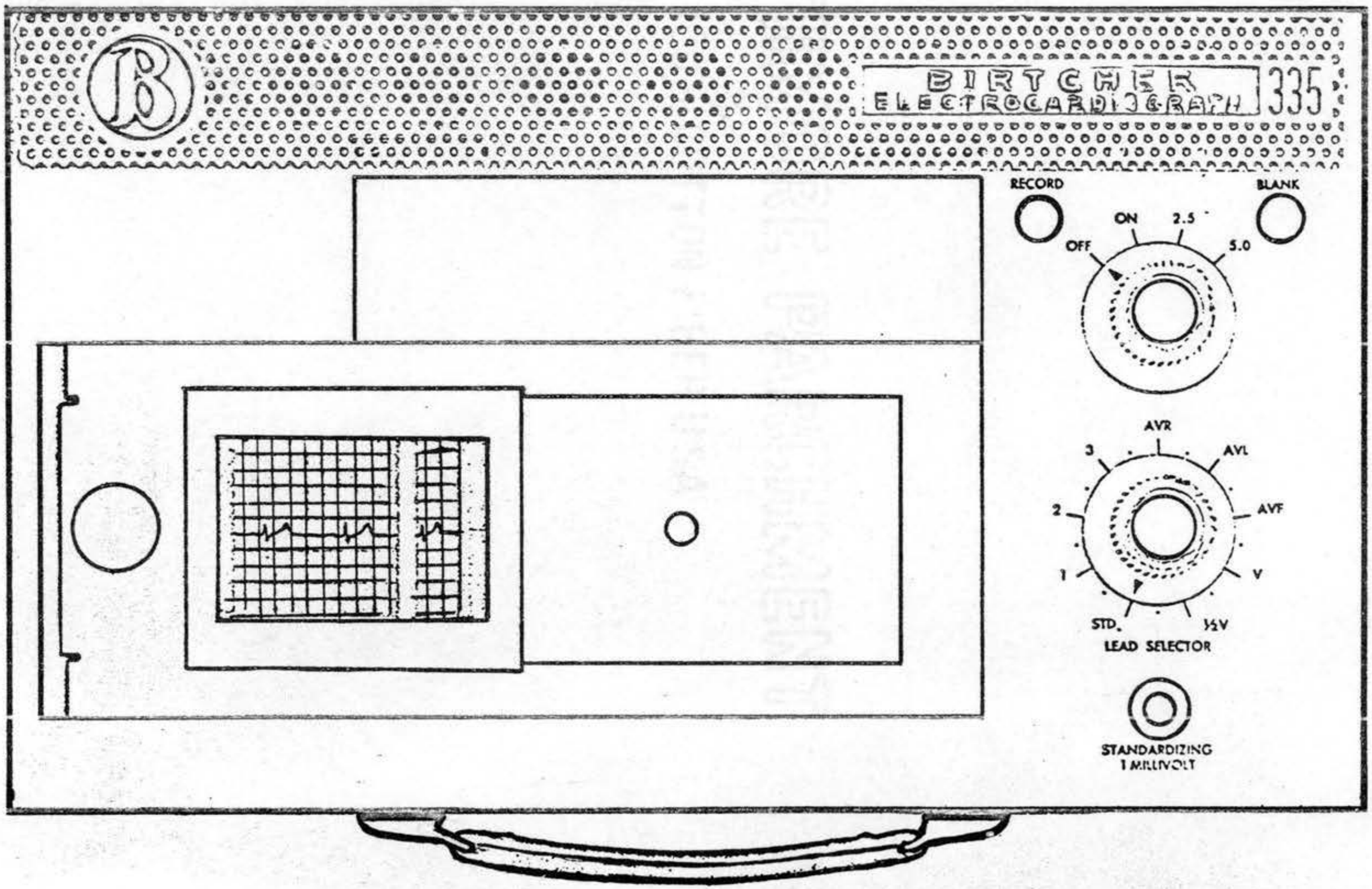

Figure 2. The Birtcher Electrocardiograph 335.

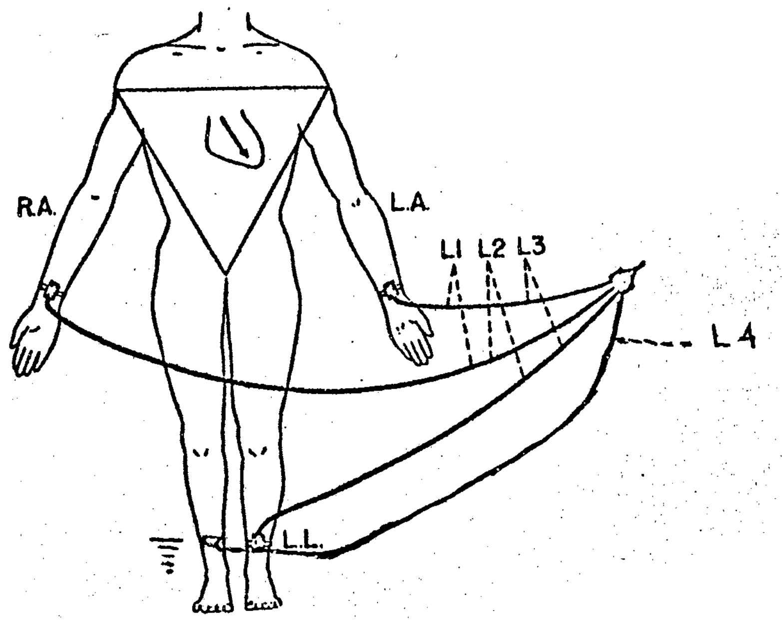

Figure 3. Method of Obtaining Three Standard Leads and the Ground.

R.A. = right arm L1 = first lead
L.A. = left arm L2 = second lead
L.L. = left leg L3 = third lead
R.L. = right leg L4 = ground lead

(Modification of Sigler)

Electrocardiogram - The electrocardiogram is a graphic representation of the electrical activity of the heart (Fig. 1).

Electrocardiogram Rule - The electrocardiogram rule is an instrument used to give an accurate measure of the waves recorded on the electrocardiogram to determine general heart condition.

Electrocardiograph - The electrocardiograph is an instrument designed to record the electrical impulses given off by the heart during cardiac activity (Fig. 2).

Heart Rate - Heart rate refers to the number of beats that the heart takes each minute.

Leads - Leads are the wires and electrodes that are attached to a subject's body which relay electrical impulses to the electrocardiograph (Fig. 3).

Monitor - To check by means of a receiver; in this case by means of a stethoscope. Specifically, monitoring heart beats is listening to the subject's heart beat and recording the results.

Rest-work Ratio - This ratio indicates the amount of rest a person's heart gets as opposed to the amount of work it does. It is the ratio of the S-T segment time and the time from the end of the T-wave to the beginning of the S-wave. Cureton (1951) found that the mean rest-work ratio was 2.55. This is considered a good ratio. As one becomes more fit the rest-work ratio increases indicating that the heart is getting more rest in proportion to the work performed.

S-T Segment - The S-T segment refers to that part of the electrocardiogram that represents the period when all parts of the ventricles are in a contracted state.

Sauna Bath - Sauna bath refers to the subjection of the body to dry heat while sitting or standing in a room designed especially for that purpose.

Schneider Index - According to Karpovich (1965) the Schneider test attempts to combine measurement of the effect that standing has on pulse rate and pulse pressure with measurement of the effect that exercise has on the cardiovascular system. This test is composed of recording reclining pulse rate, reclining systolic pressure, standing pulse rate, standing systolic pressure, and pulse rates immediately after exercise, continuing at intervals until the pulse rate returns to normal.

The Schneider Index (1922) was derived from a statistical study of the pulse rate and the arterial blood pressures in recumbency, standing, and after a standard exercise. This study originally was an attempt to find scientific conclusions with respect to normal circulatory conditions by using cardiovascular reactions for estimating the physical fitness of men. Tests were run on 2000 men at the Medical Research Laboratory and School for Flight Surgeons, Mitchell Field, Long Island, New York. As was stated previously, the Schneider test assesses cardiovascular fitness by measuring the effect that exercise has on the cardiovascular system. There have been several tests developed for this purpose. The Crampton Blood Ptosis Test is based on the changes that the vasomotor control of the splanchnic area undergoes when a person moves from recumbency to standing. Crampton included pulse rate and systolic pressure lying down and standing up. According to Cureton (1947) the Crampton Test has been compared with the Schneider test on several occasions. Scott (1921) studied 410 men at Mitchell Field, Long Island, in 1921 and found that the Crampton test failed to separate men who were physically qualified to be pilots from those who were not. The Schneider test made such a distinction. Out of 14 tests ranked the Schneider test was second in correlation, .44 as opposed to the Barach test which was first with an r of -.49. McCloy's 5-Variable Test with an r of .40 was third.

Cureton further substantiated the Schneider Test (1945) by showing that good endurance in mile running goes with rather stable systolic blood pressure in the postural change test.

The superiority of the Schneider Test can be seen in that it includes all of the parameters that are tested in the aforementioned tests. Moreover, it correlates very highly with other cardiovascular tests such as the Crampton Ptosis Test, the Barach Test, and the McCloy's 5-Variable Test. The Schneider Test presents a broader base and appears to be the most appropriate one for screening for cardiovascular fitness. For scoring of the Schneider Test see Appendix A.

Sedentary Worker - An individual who perform a task that does not require undue physical stress on the body.

Standardization - Standardization is an international calibration of the electrocardiograph that consists of adjusting the instrument to produce a deflection of one centimeter for one millivolt of applied voltage.

Steam Bath - Steam bath refers to the subjection of the body to humid heat while sitting or standing in a room designed especially for that purpose.

Steam Room - A steam room is a chamber filled with mist, formed by the condensation and cooling of water vapor. The steam room in this study was 9' x 12'8" with a concave ceiling extending 8'2½" at the centermost part tapering off to 6'11½" on both sides. The room was maintained at a mean temperature of 125°F.

Hypotheses to be Tested

The question of the effects of training on the body, particularly the heart, have been asked by probably all physiologists who are interested in human performance under various environmental conditions. Cureton (1951) reported that there were higher T amplitudes (see definition of terms), in champion athletes than in normal men. Wang (1961) found that stroke volume was greater in those who participated more in strenuous activities than those who did not. His study showed that heart rate decreased and that this decrease was due to training. Ricci (1968) supported Wang's views. According to Ricci a decrease in heart rate is one of the gains of training. These and many other studies clearly demonstrate that training, through physical activities, have positive effects on cardiovascular fitness.

According to Cooper (1968) the activities that contribute to cardiovascular fitness are those activities that require increased heart rate above 150 beats per minute sustained for at least five minutes. Preliminary studies by this investigator revealed that heart rate frequently reached above 150 beats per minute during steam bathing. Although the stress that causes this increase is different from those generally associated with physical activities, the net results are the same in terms of heart rate.

The general question raised by this study was whether or not the heart becomes more efficient as the result of taking steam baths over an eight week period. This question provided five specific hypotheses to be tested:

1. Steam bathing will cause an increase in the electrocardiogram T-wave amplitude.
2. Steam bathing will produce a decrease in the electrocardiogram P-wave amplitude.
3. Steam bathing will cause a decrease in the electrocardiogram heart rate.
4. Steam bathing will cause an increase in the electrocardiogram rest-work ratio.
5. Steam bathing will cause the heart rate to rise at a consistent rate and reach a plateau at approximately 180 beats per minute.

The Schneider test, a test of cardiovascular fitness, was used to further assess the cardiovascular fitness of the subjects. For further explanation of the Schneider test the reader is referred to the definition of terms and Appendix A. Another specific hypothesis to be tested is as follows:

6. The Schneider Index will show an increase in cardiovascular efficiency as indicated by a higher index.

Significance of the Study

This study should help to give some indication of the relative importance of steam bathing to cardiovascular fitness. If the hypotheses are tenable this study will open a new avenue to a vital aspect of physical fitness.

Basic Assumptions

This study assumed that the instruments were used properly to produce reliable and valid measures. Moreover, it was assumed that the subjects followed the instructions given to them regarding daily activities, and their weekly time sheets were accurate. It was further assumed that 15 minutes of bathing would be sufficient to produce the changes being investigated. Time beyond that will not affect the overall results.

Summary

This chapter dealt primarily with introducing the reader to the problem. It presented the purpose and the hypotheses to be tested. Moreover, it considered the significance and limitations of the study. Finally, this chapter provided definitions and clarification of terms basic to this study.

The next chapter will deal with a review of the literature relative to this study.

CHAPTER II

REVIEW OF THE LITERATURE

Although a review of the literature revealed a paucity of research with similar intent of this investigation, studies in three related areas seem pertinent to this research. Those areas are: (1) heat acclimatizations in abnormal temperature, (2) the effects of exercise on heart function, and (3) the effects of the sauna bath on human subjects.

Studies of acclimatization to high temperature with reference to heat stress on the body are legion, and many are well known. There appear to be several that have implications for the present research. Taylor (1929) reported that the primary adjustment involved in acclimatization to heat is an improvement in cardiovascular efficiency. Also, that a decrease in the accumulation of heat, as measured by the rectal temperature during work, is probably secondary to cardiovascular improvement. Cardiovascular improvement, according to Taylor, is best achieved by placing the heart under stress.

According to Adolph's (1947) desert study, the requirement for peripheral blood increases with the faster dissipation of heat at the surface of the body. Upon coming from a cool temperature of 70°F to a hot temperature of 120°F, Adolph found that the pulse rate rose from a lying rate of 69 to 76 beats per minute and from a standing rate of 86 to 99 beats per minute. Adolph concluded that above average skin temperature increases man's circulatory strain as much as does work which involves energy expenditures that equalled two times the basal rate.

Williams (1960) studied 10 volunteer students at three different temperatures and found that at effective temperature of 25.4°C, after the first hour, their heart rate rose to 105 beats per minute. After the second hour it had risen to 108 beats per minute. At the end of the third hour it had reached 115 beats per minute. At a temperature of 32.2°C after the first hour the heart rate was 150 beats per minute. At the end of the second hour the rate was 158 beats per minute. According to Williams a steady state was reached at approximately 158 beats per minute at 32.2°C.

In a study of six men and five women Brouha (1961, p. 139) found that "heart and cardiac cost variations showed increasing degrees of stress from normal temperature to warm-dry and to warm-humid conditions." According to Brouha, heart rate and cardiac cost were greater at higher temperatures during work and recovery. He said:

> ...the cardiovascular reactions, expressed as heart rate or cardiac cost or cardiac efficiency, are markedly modified by the environmental conditions and by sex. They are the most faithful index of the stress produced by the combination of work load and heat load and can accurately differentiate the effects of environmental conditions (p. 140).

Brouha (1963) supported his earlier findings in a study where men performed in severely stressing environments such as extreme heat. Heart rate increased tremendously. He found that it is probably not wise to base the estimation of physiological recovery solely on the evidence of oxygen consumption unless the environment is normal, that is, average temperature. Brouha found that physiological recovery lagged far behind oxygen consumption in high temperature. It would appear that these findings would support the contention that heart rate is an excellent indicator of the physiological stress induced by work in a warm environment.

Edholm and Bacharach (1965) claim that improvement in the cardiovascular system response to work is essential in heat acclimatization. Edholm and Bacharach intimated that exposure to heat is beneficial to the cardiovascular system. They said:

> Unacclimatised subjects who collapse on exposure to heat stress often exhibit signs of cardiovascular insufficiency; this may take the form of postural hypotnesion or a complete fainting episode....with acclimatisation the cardiovascular condition improves (p. 68).

Iampietro (1965) studied ten healthy young men whose mean age was 23.0 years, to determine their tolerance limits in a hot and very humid environment. Among other parameters, Iampietro found that tolerance time for men working in a very hot humid environment can be predicted by the heart rate in the first 10 minutes of work.

Garden (1966) studied 38 young adult males for two weeks in a chamber heated 90°F wet bulb and 98°F dry bulb to determine the optimal time for acclimatization to hot-wet conditions. The men were required to do a modified Balke test before exposure and at the end of each week. It was found that daily exposure to heat for 2 hours and 1 2/3 hours produced acclimatization. Daily exposure to heat for 1 hour resulted in no significant change in heart rate.

Pentti (1966) subjected 8 sedentary male subjects between the ages of 18 to 45 years to heat stress in a chamber with mean temperatures ranging from 83° to 88°C. The subjects were nude and were instructed to lie in the chamber from 27 to 28 minutes. Pentti found that the S-T segment shortened, the T-wave flattened, and no obvious changes in the QRS complex. He found that the mean heart rate was 66 beats per minute at rest. The heart rate increased to 109 beats per minute after 25 minutes exposure to the heat. There was a range from 96 to 141 beats per minute.

Murry (1966) studied the effects of brief intense heat on male volunteers ranging from 20 to 23 years of age. He found that heart rate varied. The peak, mean heart rate during the exposure to 150°C was 98 beats per minute. During the 205°C stress the heart rate reached 128 beats per minite. According to Murry there were no significant changes in P-waves, T-waves, or QRS patterns in the single electrocardiographic lead recorded. Moreover, cardiac output rose to peak values at the height of both heat stresses, 150°C and 205°C. However, changes in stroke volume were not significant.

Rowell (1967) studied seven sedentary men with ages ranging from 21 to 27 years exercising in a temperature of 48.4°C dry bulb and 25.6°C wet bulb to ascertain central circulatory responses to work in dry heat before and after acclimatization. He found that cardiac output was virtually unchanged. There was a definite decrease in heart rate after acclimatization. These results support the views of Taylor (1929) that acclimatization brings about improvements in the cardiovascular system.

Numerous studies on heart function due to stress from exercises lend themselves well to this investigation and are therefore included in the review of the literature.

Skubic (1967) studied two women during participation in five sports: archery, badminton, tennis, golf, and bowling. She found that heart rate is directly proportional to the intensity of the activity involved. Tennis and badminton were significantly more strenuous than archery, bowling, and golf but none of these in the latter group required a mean heart rate higher than 106 beats per minute. For the 20 minute period of activity, the mean heart rates per minute were: archery, 95; badminton, 138; bowling, 89; golf, 95; and tennis, 146. This study showed the relative increase in heart rate due to activity. It also points out that the intensity of the activity determines the amount of stress placed on the heart.

According to Cureton (1951), Hoogerwerf studied 260 athletes in the 1928 Olympic games using a string galvanometer. He found that the athlete had a higher T-wave than the non-athlete. He further found that the QRS-complex decreased after exercise. Moreover, the study revealed that the P-wave was rarely higher than one-tenth of a millivolt. In general, the duration of the P-wave was quite short. Hoogerwerf concluded that the athletes, who are usually in superb condition, have higher T-waves and P-waves of short duration. This phenomenon, undoubtedly, is the result of physical training.

Cureton (1951) reported that training not only causes the T-wave to become higher but also lowered the ventricular peaks, greatly increased the duration of the QRS-complex, and slowed the pulse rate. He concluded that the electrocardiogram shows a widened QRS-complex when the above condition exists.

The studies of Lewis (1912) and Pardee (1941) with the electrocardiogram have thrown some rather interesting light on the subject of widened QRS-complex as a result of activity. Lewis and Pardee studied a group of sedentary workers and found that these subjects consistently revealed narrowed QRS-complexes.

Pardee (1941) investigated a more athletic group and found that the QRS-complex for this group was substantially wider than the QRS indicated by the sedentary group in the investigation by Lewis.

Cureton (1951) compared P-wave amplitudes in 14 champion track and field athletes and 21 Olympic swimmers and divers by group averages with the control group of 81 normal young men. It was shown that there was a trend for the amplitudes to be less for the P-wave in the trained athletes. He concluded that fast heart rate produces a shorter P-wave, whereas, a slow heart rate produced a longer P-wave. He further concluded that this longer P-wave was due to increased muscle mass which came as a result of training. Here, the muscle mass to which Cureton referred was the muscle in the heart itself.

Franks and Cureton (1960) studied the effects of training on time components on the left ventricle of 61 middle-aged males and found that vigorous physical training three to five times per week, about one hour per day, increases resting and post-exercise systole and diastole.

The third area of related research is that of the sauna bath. DeVries (1968) studied 16 men with a mean age of 43.4 years. They showed that heart rate rose during sauna by almost 50 per cent.

Mittinen and Karvinen (1963) undertook a study that included 19 policemen and firemen between the ages of 24 and 53 years. The men were diveded into two groups, experimental and control. The sauna bath was given to the experimental group. Upon subjecting the men to various tasks afterwards, it was found that the resting heart rate of the experimental group was significantly lower than the rate of those of the control group. It was concluded that greater cardiac output is inversely proportionate to heart rate. That is, the more blood that is pumped by the heart, the less beats the heart will make.

There is probably no concensus of opinion regarding the effects of steam bathing on people. The literature, however, points out some interesting observations that may have implications for investigations in this area. Braverman (1963) noted that after thousands of moist eight-hour days working in the baths, some Luxor attendants in their seventies have the vigor of men twenty-five years younger.

Newsweek (1963) reported, after interviews with people who had taken regular steam baths, that steam bathers claimed that the absence of the common cold in themselves was due primarily to steam bathing.

Consumer's Report (1966) had a panel of volunteers take the steam bath in a portable steam cabinet. Each member of the panel reported a sense of well-being after a steam bath. Consumer's medical consultants suggested that this effect of the steam bath may be largely psychological. They added that heat often does relax muscles and sometimes relieves pain of some muscular disorders, including arthritis in certain cases. They also concluded that steam bathing substantially increases the heart rate.

Summary

This chapter has been concerned with research that has been done on steam bathing. It revealed that three related areas seemed pertinent: (1) heat acclimatization, (2) the effects of exercise on heart function, and (3) the effects of the sauna baths on human subjects. The findings also pointed out that steam bathing appears to have positive effects on human beings. Chapter III will deal with the design and experimental procedures that will be utilized to attempt to determine the effects of steam bathing on the human cardiovascular system.

CHAPTER III

METHOD AND DESIGN

Introduction

This study was an attempt to determine if there was a measurable change that occurred in the cardiovascular system after being exposed to humid heat three times per week for eight weeks. Further, an attempt was made to determine at what point the heart rate peaks during a steam bath. This chapter will present the environmental and control conditions important to this study.

Experimental Design and Procedure

Subjects for the study were sought from staff and faculty personnel at Oklahoma State University. Letters (sample in Appendix F) were sent to male members of the sociology and psychology departments. Letters were also sent to members of the Division of Student Affairs and members of the Student Union Staff. These particular groups were chosen as the source for analysis because it was felt that they would probably be representative of the more sedentary population at Oklahoma State University.

Sixty-five responses of agreement to participate were received from an initial mailing of 200 letters. Forty of the 65 respondents were screened for inclusion. Some of the members were eliminated because of current participation in a training program. Others decided that they could not afford the required time.

The subjects were randomly assigned, through the use of a table of random numbers, to two separate groups. This randomization, it was assumed, controlled for initial group differences such as body size, physical condition, age, previous experiences with the steam bath, and normal physical activity.

An electrocardiogram was taken from each subject using a Birtcher 335 Electrocardiograph (Fig. 2, p. 9). This test represented the pretest for all subjects for this investigation. The subject was asked to lie down on a table and four electrodes were attached to his body (Fig. 3, p. 10). One electrode was placed on each arm approximately one inch above the wrist, one was attached to each leg approximately three inches above the ankle. The one placed on the right leg was used for grounding purposes. The lead designated as 1 conducted impulses from the right arm to the left arm, Lead 2 conducted impulses from the right arm to the left leg, and Lead 3 conducted impulses from the left arm to the left leg. After the electrodes were connected to the subject, the electrocardiograph was standardized according to instructions in the operation manual. This standardization established a deflection of one centimeter for each millivolt of applied voltage.

The subjects were instructed to lie still on the table for a few minutes before the test was started. The electrocardiograph was turned to Lead 1 and allowed to run until a satisfactory baseline was achieved. The lead was marked for later identification. The same procedure was followed for Leads 2 and 3. The electrocardiograph was turned back to inactivity and the electrodes were disconnected. Each subject's name, age, weight, height, and the testing date were recorded on the subject's electrocardiogram.

Upon completing the electrocardiogram each subject was given the Schneider test for cardiovascular fitness. This test consists of taking the pulse rate and blood pressure in the lying and standing positions, a five-step exercise on a bench 18½ inches high and taking pulse rate until pulse returns to subjects standing pulse rate. The Schneider Index, consisting of six ratings, was used to determine the subject's cardiovascular fitness. For further explanation of the Schneider test the reader is referred to the definition of terms and Appendix A.

The two groups were randomly assigned to be the control and experimental groups by the flip of a coin. The control group was instructed not to participate in any physical training program. They were instructed not to take steam or sauna baths for the entire eight-week experimental period. They were also told that they would be retested at the end of the eight-week period.

The experimental group took a steam bath three times each week with at least a fifteen-minute exposure each time. The temperature in the steam room was 125°F at all times. These baths were taken at the Young Men's Christian Association, Stillwater, Oklahoma. The researcher, not being able to observe each subject at each treatment, had to rely on the honesty of the subjects in recording their time accurately. The subjects were instructed to record the length of time they remained in the steam bath on a form provided for that purpose.

At the end of each week the data sheets were collected and the results filed in the subject's folder.

During the first steam bath each subject in the experimental group had his heart rate monitored while he was in the steam room. Prior to entering the room each subject's heart rate was recorded. After five minutes in the steam room their heart rates were taken again and recorded. This was done with all experimental subjects at five-minute intervals as long as the subject could remain in the steam room. Each subject was required to remain in the steam room at least fifteen minutes.

At the end of the fourth week each subject in the experimental group was again given the heart rate check. The same procedure was used as was employed in the first heart heart check. All subjects were given the heart rate check again at the end of the eighth week. These time intervals were used in order to establish a pattern of heart rate rise over the experimental period.

At the end of the eight-week period an electrocardiogram was taken from each subject in the control and experimental groups. The subjects were also given the Schneider test for cardiovascular fitness. The same procedures were followed as were utilized during pretesting.

Measurement of Waves

After all data were collected and classified, precise measurements were made with the Vernier Calipers, the electrocardiogram rule, and the Schneider Index scale.

The Vernier Calipers were used to measure the amplitudes of T and P waves of the EKG. The measurements were made from the outer edges of both points in question. The T-wave was measured from the baseline of the electrocardiogram to the apex of the T-amplitude (Fig. 1, p.7). The P-wave was measured from the baseline of the electrocardiogram to the apex of the P-wave amplitude.

The rest-work ratio was obtained by measuring the time of the S-T segment and the time from the end of the T-wave to the beginning of the S-wave. The S-T segment represents the work time and the time from the end of the T-wave to the beginning of the S-wave represents the rest time. These two values were then computed for the rest-work ratio.

Heart rate was determined by placing the large arrow of the electrocardiogram rule on any R-wave and counting two complete cycles. The heart rate was noted below the third R, the end of the second cycle.

Heart rate changes were monitored by the use of a stethoscope with a six-foot extension. The subject sat in the steam room with the stethoscope on his chest while his heart rate was monitored by the investigator in an adjacent room through the door that was left slightly ajar. This procedure made it more comfortable and feasible for the investigator to properly administer this check. The heart rate was derived from a count of fifteen seconds.

A measure of cardiovascular fitness was also obtained by use of the Schneider Index. Measurements were made of lying and standing pulse rates, lying and standing systolic and diastolic blood pressure, pulse rate immediately after exercise, and subsequently until pulse rate returned to the subject's normal rate. Pulse rate after exercise was taken in a standing position.

Statistical Treatment

The statistical technique used to test the significance of the results of this study was the t-test. A level of 0.05 was set for significance.

The t-test was the statistical technique utilized to determine if the differences between two means were significant with respect to what might be expected by chance alone. Clarke (1945) and Popham (1967) stated that the function of the t-test is to test hypotheses that two group means are not significantly different, that is, the means are so similar that the sample groups can be considered to have been drawn from the same population.

The t-test was to determine if differences existed between the means of the following groups:

1. Pretest measures of the experimental and control groups.
2. Posttest measures of the experimental and control groups.
3. Pretest and posttest measures of the experimental group.
4. Pretest and posttest measures of the control group.

Summary

This chapter has been a consideration of the description of the population, design, and procedures involved in the study. Moreover, it considered the measuring devices and statistical treatment.

The subjects for this study were forty selected males at Oklahoma State University. The subjects were tested and randomly assigned to control and experimental groups. The experimental group took steam baths three times each week with at least a fifteen minute exposure each time. Cardiac waves and heart rates were recorded by a Birtcher Model 335 Electrocardiograph and calculated with a Burdick Electrocardiogram Rule and Vernier Calipers. The t-test was used to analyze the differences between group means with the criterion for significance set at the 0.05 level.

The next chapter will present the findings and analyses of these findings.

CHAPTER IV

RESULTS AND DISCUSSION OF THE RESULTS

This investigation was started the third week in January 1970, and terminated at the end of the third week in March 1970. The investigation covered eight weeks. Forty males were selected to participate in the study. These subjects were sedentary employees at Oklahoma State University between the ages of 25 and 45 years. The subjects were randomly assigned, through the use of a table of random numbers, to two separate groups. The Schneider Index and the electrocardiogram were used as pretests. The same two instruments were used as criterion variables. The raw scores of all tests are listed in the appendices.

Statistical Treatment

The t-test was the statistical technique utilized to test hypotheses one, two, three, four, and six. The t-test was used because, with proper application, it will test hypothesis that two group means are or are not significantly different. Hypothesis five was tested by inspection, that is, the subject's normal heart rate was observed along with his peak heart rate. The percentage of rise over normal rate was also observed. Statistical analyses of the pretest results revealed that there were no significant differences between the experimental and control groups.

Hypothesis 1

Steam bathing will significantly increase the electrocardiogram T-wave amplitude.

The hypothesis was tested by comparing the T-wave amplitudes for the experimental and control groups by means of the t-test. The results are summarized in Table I.

TABLE I

SUMMARY OF DATA FOR COMPARISONS OF T-WAVE AMPLITUDES*
Critical t = 1.684

	Pretest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	1.92	1.02	19	2.04	1.09	19	0.357
Lead 2	2.24	0.58	19	2.14	0.64	19	0.357
Lead 3	0.93	0.48	19	1.13	0.50	19	1.308
	Posttest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	2.08	0.90	19	1.90	1.11	19	0.558
Lead 2	2.39	0.89	19	2.00	0.96	19	1.306
Lead 3	1.24	0.46	19	1.10	0.59	19	0.831

*All means and SD are expressed in millimeters.

The reader will note that a separate t-test was run on each lead in the experimental and control groups. Each lead, therefore, has its own mean, standard deviation, degrees of freedom, and t ratio. Individual t's were necessary because each standard lead is different and there cannot be a composite of the three leads.

The value of t for each lead in the experimental and control groups on the pretest and posttest can be observed in Table I. The table value of t at the 0.05 level of significance with 38 degrees of freedom was 1.684 for a one-tailed test. This level of significance was used in all hypotheses. Hypothesis one was not supported by the data contained in Table I. Although the amplitude in each lead increased, the increase was not enough to be considered statistically significant. Leads 1 and 2 of the experimental group had increases of 0.16 and 0.15 mm, respectively; almost identical gains. Leads 1, 2, and 3 of the control group were 0.14, 0.14, and 0.03 mm, respectively.

When the experimental and control groups were numerically compared on the basis of mean increases in each lead, the experimental group exceeded the control group on the posttest.

Hypothesis 2

There will be a decrease in the electrocardiogram P-wave amplitude.

This hypothesis was tested by use of a t-test. The t-test was employed to test the significance of the difference between the means of the experimental and control groups. The data necessary to determine significance are summarized in Table II.

Since the leads are not interchangeable, each lead of each group had to be tested individually against each other; i.e., Lead 1 of the experimental group was tested against Lead 1 of the control group, and Lead 2 of the experimental group was tested against Lead 2 of the control group, etc. Each lead, therefore, had its own t value.

The t value of each lead for both groups on the pretest and posttest are summarized in Table II. The computed t values are located in the extreme right column of the table. The table t value needed for significance at the 0.05 level was 1.684 for a one-tailed test with 38 degrees of freedom.

TABLE II

SUMMARY OF DATA FOR COMPARISONS OF P-WAVE AMPLITUDES*
Critical t = 1.684

	Pretest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	0.81	0.46	19	0.87	0.43	19	0.423
Lead 2	0.94	0.57	19	0.92	0.51	19	0.144
Lead 3	0.51	0.51	19	0.62	0.46	19	0.702
	Posttest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	0.68	0.64	19	0.82	0.45	19	0.792
Lead 2	0.82	0.58	19	0.88	0.50	19	0.320
Lead 3	0.39	0.39	19	0.61	0.44	19	1.645

*All means and SD are expressed in millimeters.

In order for hypothesis two to have been accepted there had to be a t value of 1.684 which was not achieved in any of the leads. The computed t value in Lead 3 was 1.645 or 0.039 short of what was needed for support of the hypothesis. The P-wave in Lead 3 of the experimental group decreased 0.12 mm while the P-wave in Lead 3 of the control group decreased 0.01 mm (Table II). Although this hypothesis was not statistically significant, there appears to be a trend toward positive values with reference to cardiovascular efficiency. As can be seen in Table II, all leads in the control group decreased. The reason for this is not clear. Mayerson (1942) found that tilting the head upward caused changes in the P-wave. Green (1948) found that by tilting the head downward caused decreases in the P-wave amplitudes. Green (1948) verified this in his studies on intra-arterial blood pressure and alterations of the electrocardiogram induced in tilting.

Both of these possibilities are plausible. By tilting the head upward or downward tends to increase blood pressure. This invariably causes the P-wave to decrease. This investigator cannot verify the fact that either upward or downward head tilting caused the decreased P-wave amplitudes in the control group. Another possible explanation is increased muscle tension that accompanies a test such as the electrocardiogram. This increased muscle tension very well could have decreased systolic blood pressure which in turn would cause a decreased P-wave amplitude due to restriction of blood in the auricles.

Although all leads in the control group showed decreases, none of these decreases were nearly as much as the decreases in the experimental group.

Hypothesis 3

Steam bathing will cause a decrease in the electrocardiogram heart rate.

Hypothesis three was rejected on the basis of the results contained in Table III. None of the computed t's were sufficient to support the hypothesis at the 0.05 level. The greatest decrease was 4.05 beats per minute in Lead 3 of the experimental group when compared with its pretest. Lead 3 of the control group also had its greatest decrease when pretest scores were compared.

TABLE III

SUMMARY OF DATA FOR COMPARISONS OF HEART RATE*
Critical t = 1.684

	Pretest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	66.95	15.94	19	68.40	11.49	19	0.329
Lead 2	67.35	15.29	19	68.00	11.58	19	0.151
Lead 3	69.30	16.35	19	70.80	11.95	19	0.331
	Posttest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	65.00	13.68	19	67.70	12.17	19	0.659
Lead 2	65.15	13.16	19	68.05	13.53	19	0.686
Lead 3	65.25	14.29	19	70.00	12.87	19	1.104

*$\bar{X}$ values represent heart beats per minute.

The standard deviation for the experimental group got consistently smaller. One would suspect that the group distribution became more leptokurtic in its curve. The inference here is that the experimental group scores probably clustered more around a central point and that there were perhaps fewer extreme scores. It is apparent in Table III that there is a trend toward decreased heart rate for the experimental group. No such trend is evident in the control group data. The control group displayed no discernable pattern. The results in the experimental group are quite predictable. Even though the hypothesis was not supported, there appears to have been some variable that caused the experimental group to become more homogeneous within the eight weeks that they were taking the steam bath.

Hypothesis 4

The hypothesis that steam bathing will cause an improvement in the electrocardiogram rest-work ratio was not borne out by the evidence recorded in Table IV. The rest-work ratio of all leads in the experimental group improved. The experimental group increased its ratio in Leads 1, 2, and 3; .37, .33, and .27, respectively. The control group also showed improvement in all leads. The increases in Leads 1, 2, and 3 were .03, .06, and .04, respectively. It should be noted that the control group displayed a higher rest-work ratio than the experimental group during the pretest. However, during the posttest the experimental group had not only improved but also surpassed the control group.

Hypothesis 5

Steam bathing will cause the heart rate to rise consistently and reach a plateau at approximately 180 beats per minute was rejected in face of the empirical evidence contained in Table V. According to the information contained in Table VI, it is apparent that some subjects probably would have reached a plateau before 180 beats per minute was achieved. This could well mean that the steam bath, although it placed stress on the heart, did not produce enough stress to cause the heart to reach a steady state or 180 beats per minute.

TABLE IV

SUMMARY OF DATA FOR COMPARISONS OF REST-WORK RATIOS
Critical t = 1.684

	Pretest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	2.12	0.46	19	2.29	0.77	19	0.806
Lead 2	2.32	0.55	19	2.48	0.78	19	0.766
Lead 3	2.34	0.54	19	2.45	0.76	19	0.538

	Posttest						
	Experimental Group (N=20)			Control Group (N=20)			
	$\bar{X}$	SD	d.f.	$\bar{X}$	SD	d.f.	t
Lead 1	2.49	0.65	19	2.35	0.74	19	0.658
Lead 2	2.65	0.65	19	2.62	0.72	19	0.102
Lead 3	2.61	0.63	19	2.56	0.72	19	0.251

TABLE V

HEART RATE PLATEAUS

Subjects	Normal Heart Rate	Peak Heart Rate After 20 min in Steam Bath	Percent Above Normal
01	72	163	126.38
02	72	162	125.00
03	70	176	151.40
04	72	167	131.94
05	70	159	127.13
06	80	195	143.75
07	88	183	100.79
08	72	163	126.38
09	84	162	92.85
10	84	187	122.61
11	70	157	124.28
12	68	154	126.46
13	68	175	143.05
14	72	161	123.65
15	76	173	127.63
16	66	143	116.66
17	68	150	120.58
18	72	165	129.16
19	80	166	100.75
20	68	162	137.93
Means	$\bar{X}$ = 73.6	$\bar{X}$ = 166.15	$\bar{X}$ = 125.92

TABLE VI

MEAN SCORES FOR HEART RATE CHANGES DURING THE STEAM BATH

Experimental Group

	Minutes				
Subjects	0	5	10	15	20
01	72	112	135	148	163
02	72	110	134	146	162
03	70	112	130	162	176
04	72	111	135	154	167
05	70	111	133	144	159
06	80	120	148	177	195
07	88	139	162	175	183
08	72	112	135	146	163
09	84	121	136	154	162
10	84	144	164	175	187
11	70	109	133	144	157
12	68	108	131	141	154
13	68	113	136	168	175
14	72	111	134	145	161
15	76	115	141	153	173
16	66	98	123	135	143
17	68	105	125	130	150
18	72	108	133	157	165
19	80	120	136	152	166
20	68	112	138	152	162

Using Cooper's (1968) yardstick of 150 beats per minute, sustained for five minutes for training effects, it would seem that most of the subjects received training benefits. To support this contention the reader is again referred to Table VI to observe heart rates from the 15 to 20 minute interval. It should be noted that 19 of the 20 subjects have either reached or surpassed 150 beats per minute.

The mean heart rate prior to the steam bath of the experimental group was 73.60 beats per minute. The mean peak heart rate after 20 minutes in the steam bath was 166.15 beats per minute (Table V). It was hypothesized that the heart rate would reach a plateau and level off at approximately 180 beats per minute. Only three subjects' heart rates reached 180 beats or more per minute while steam bathing. Close inspection will show that these three achievements cannot be considered plateaus. At the end of the 20 minutes the heart rates of these three subjects were still going up (Table VI). These subjects obviously had higher heart rates before the bath began. The heart rate check had to be terminated at the end of 20 minutes due to physical discomforts to the subjects.

The extreme right column of Table V shows the percent of heart rate above normal after being in the steam bath for 20 minutes. Although the percent of heart rate increase over the normal rate varied from 92.85 to 151.40 beats per minute, the mean increase was 125.92 per cent.

The fact that a part of hypothesis five was tenable means that an incorrect hypothesis was stated in the outset. It would appear that there should have been two hypotheses stated. One should have concerned itself with the consistent rise in heart rate, while another should have dealt with final plateaus.

Hypothesis 6

The hypothesis that steam bathing will cause a significant increase in the Schneider Index was tenable. The t-test for unpaired samples was utilized to test for significant differences between two group means. As can be seen in Table VII the table t value was 1.684 and the computed t value was 2.203 at 0.05 level of significance.

The experimental group has a mean Schneider pretest score of 13.00. This group posttest score was 14.70, a gain of 1.70.

According to the Schneider Index a score of 12 or better is needed to be considered functionally fit.

TABLE VII

SUMMARY OF DATA FOR COMPARISONS OF SCHNEIDER INDEX*
Critical t = 1.684

Group (Pretest)	N	$\bar{X}$	SD	d.f.	t
Experimental	20	13.00	2.59	19	0.155
Control	20	13.15	3.43	19	
Group (Posttest)	**N**	**$\bar{X}$**	**SD**	**d.f.**	**t**
Experimental	20	14.70	2.29	19	2.203
Control	20	13.00	2.57	19	

*See Appendix A for source of $\bar{X}$.

The control group had a mean Schneider pretest score of 13.15. This group posttest score was 13.00, a drop of .15 over the eight-week period.

The Schneider Index is a rough cardiovascular screening device. However, it does give an appraisal of the effects of exercise on the cardiovascular system. The results in Table VII show that the two means are significantly different. Since the difference is positive toward the experimental group, the reader may conclude that whatever was done to the experimental group that was not done to the control group caused the change; namely, the steam bath.

A logical question at this point probably would be how does one explain the fact that hypothesis six was supported whereas none of the others held up. A plausible explanation lies in the nature of the Schneider test. The Schneider test evaluates the cardiovascular system in a near basal state as well as in a state of exercise. This kind of evaluation is more useful because it assesses man's cardiovascular fitness while the system is engaged in a stress activity such as stepping up on a bench. The electrocardiogram test simply measures near basal operation and makes no allowance for stress activities. This increases the possibilities of error because slight changes in heart impulses manifest changes in heart waves. Moreover, electrocardiogram measures change from day to day. Although these changes under normal circumstances are slight, they do occur and have to be considered.

Summary

This chapter dealt with the results and analyses of the results of this study. Hypotheses 1 through 5 were not supported by the results contained herein. Hypothesis 6, however, was supported by the results. All hypotheses displayed a numerical trend toward cardiovascular improvement.

Chapter V will summarize the first four chapters. Further, it will draw some conclusions from the results of the study. Moreover, Chapter V will indicate some recommendations that appear to be pertinent and perhaps useful to future studies.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The intent of this study was to determine whether or not steam bathing effected changes in the cardiovascular system. The effectiveness of the treatment was assessed through comparisons of experimental and control groups on the basis of cardiovascular changes as measured by the electrocardiograph and the Schneider Index.

The first chapter dealt primarily with familiarizing the reader with the problem by presenting the purpose and the hypotheses to be tested. Limitations, significance, and definition of terms basic to the study were considered.

The second chapter concerned itself with review of the literature. It attempted to cover (1) heat acclimatization, (2) the effects of exercise on heart functions, and (3) the effects of sauna and steam bathing on human subjects.

The third chapter involved the design and experimental procedures that were utilized in the attempt to determine the effects of steam bathing on the cardiovascular system. Cahpter III also covered the statistical treatment of the data and the measuring instruments.

Chapter IV dealt with the results and statistical analyses of these results. Of the six hypotheses tested, only one hypothesis was supported by the results. Although all other hypotheses were rejected, they showed definite numerical trends toward improved cardiovascular efficiency.

Conclusions

The data derived from this study tended to indicate that steam bathing does not effect changes in the cardiovascular system as measured by the electrocardiogram. Although this appears to be the case statistically, numerical values tend to indicate that steam bathing does have positive effects on the electrocardiogram.

The sixth hypothesis, dealing with the Schneider Index, was tenable and supports the contention of the general question preceding the specific hypotheses found in Chapter I.

With regards to the specific hypotheses of this study the following conclusions seem to be warranted.

1. The hypothesis that steam bathing will increase T-wave amplitude was untenable.
2. The hypothesis that there will be a decrease in the electrocardiogram P-wave amplitude was unsupported.
3. The hypothesis that steam bathing will cause a decrease in the electrocardiogram heart rate was not supported.
4. The hypothesis that steam bathing will cause an increase in the electrocardiogram rest-work ratio was untenable.
5. The hypothesis that steam bathing will cause the heart rate to rise at a consistent rate and reach a plateau at approximately 180 beats per minute was rejected.

However, one part of the hypothesis was supported by the results. The heart rate did rise at a consistent rate, but it failed to plateau or peak at 180 beats per minute. In other words, the subjects did not reach their crest load which is, according to Balke (1954) and Billings (1960), approximately 180 beats per minute.

There were probably many reasons why the subjects did not plateau. The most plausible appears to be that there was not enough stress placed on the cardiovascular system to bring about 180 beats per minute. The lack of stress was probably due to insufficient time in the steam bath. The major reason for insufficient time in the steam bath was that after 20 minutes the subjects suffered discomforts and had to terminate the treatment.

In regards to hypothesis five it was concluded that an incorrect hypothesis was stated. There should have been two hypotheses. The first should have dealt with the consistent rise of heart rate and the other with the plateaus of heart rate.

6. The hypothesis that steam bathing will increase the Schneider Index was found tenable.

All of the hypotheses tested numerically indicated that the effects of steam bathing are desirable. Although there are several variables that have not been considered, on the basis of this study, it would appear that steam bathing could be a very useful adjunct to any physical fitness program.

On the basis of hypothesis six a very definitive position can be taken with respect to the effects of steam bathing on the cardiovascular system. The Schneider Index is used frequently as a measure of cardiovascular fitness and it showed that steam bathing did effect favorable changes in the cardiovascular system of these subjects.

Recommendations

The results of the present study should be regarded as tentative until such time that it is replicated. Replication should include blood chemistry as testing components.

Another recommendation is the frequency of exposure to the steam bath. It is generally felt that in order to improve and maintain physical fitness, daily engagement in physical activities are necessary. This is perhaps what is needed in a replication of this study. Other aspects of frequency should be considered such as the length of time actually spent in the steam room in one treatment, a longer experimental period and more intense heat.

It is further recommended that this study include a smaller group for comparison. This group should be in excellent health and be willing to subject itself to steam for longer periods of time.

Another recommendation that appears to have merit is that larger groups be used as subjects. The larger groups may statistically show significant differences.

Another recommendation for future research is that more stringent controls be employed. Devices and instruments such as telemetry with printouts, cardiotachs with visual readouts, the physiograph, and the Birtcher electrocardiograph should be utilized to secure more accurate results.

A final recommendation is that continued study be given to the effects of steam bathing on the human organism, particularly the cardiovascular system. These studies should include athletic as well as sedentary groups. Physiologists in physical education should work cooperatively with other disciplines and human factor specialists in investigating the effects of steam bathing on the human organism.

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APPENDIX A

THE SCHNEIDER TEST AND INDEX

THE SCHNEIDER TEST

The Schneider Test is one of the cardiovascular tests to stand up over the years as a valid screening device to measure physical fitness. The six test items were arbitrarily established and tried out on 2000 aviators during World War I.

Equipment

Watch with second hand, blood pressure instrument, a table or cot for reclining, and a bench or stool to step up on, 18½ inches high.

Testing Procedures

1. Have the subject being tested recline on the cot or table for five minutes.
2. Take his pulse rate while he is in the reclining position for 15 seconds. Repeat at 15 second intervals until two consecutive counts are the same. Multiply this count by 4 to get pulse rate per minute.
3. While the subject is reclining, record the systolic blood pressure. This should be repeated twice for accuracy.
4. Have the subject stand for two minutes.
5. Measure pulse rate for 15 seconds. Repeat at 15 second intervals until two consecutive counts are the same. Multiply this count by 4 to convert to pulse rate per minute. Record the score.
6. Record the difference between the standing and reclining pulse rates.
7. With the subject standing, record the systolic blood pressure.
8. Record the difference between the standing and reclining systolic blood pressure.
9. Use a stop watch; have the subject step up on a bench or stool 18½ inches high five times in 15 seconds.
10. Record the pulse rate for 15 seconds immediately after the exercise. Multiply by 4 to obtain the rate per minute.

11. With subject still standing, continue taking pulse rate at 15 second intervals until the subject's pulse rate has returned to normal. Record the number of seconds it takes for the pulse rate to return to normal. This is accomplished by comparing the pulse rate after exercise with the first normal 15 second count. When the rate is not back to normal in a two minute period, record the number of beats still above normal.

Scoring

By referring to the Schneider Index, the pulse rate and systolic pressure changes, standing, after exercise, and during recovery, can be evaluated. A perfect score of 22 can be obtained. Anything less than a total of 9 is considered a deficiency and a medical examination is indicated. A score of 12 is considered fair.

NAME________________ DATE______________ SCHNEIDER INDEX ________

Lying Position: Pulse Rate____ Systolic BP____ Diastolic BP____

Standing Position: Pulse Rate____ Systolic BP____ Diastolic BP____

STEP EXERCISE (5 steps - chair 20" high): Pulse Rate Immed. After Exercise_____

Pulse Rate After Exercise: 30 sec____ 60 sec____ 90 sec____ 120 sec____

SCORING TABLE

A. Reclining Pulse Rate / B. Pulse Rate Increase on Standing

Rate	Points	0-10	11-18	19-26	27-34	35-42
41- 50	4	4	4	3	2	1
51- 60	3	3	3	2	1	0
61- 70	3	3	2	1	0	-1
71- 80	2	3	2	0	-1	-2
81- 90	1	2	1	-1	-2	-3
91-100	0	1	0	-2	-3	-3
101-110	-1	0	-1	-3	-3	-3

C. Standing Pulse Rate / D. Pulse Rate Change Immed. After Exercise

Rate	Points	0-10	11-20	21-30	31-40	41-50
51- 60	4	4	4	3	2	1
61- 70	3	3	3	2	1	0
71- 80	3	3	3	2	0	0
81- 90	2	3	2	1	0	-1
91-100	1	2	1	0	-1	-2
101-110	1	1	0	-1	-2	-3
111-120	0	1	-1	-2	-3	-3
121-130	0	0	-2	-3	-3	-3
131-140	-1	0	-3	-3	-3	-3

E. Return of Pulse Rate to Standing Normal After Exercise

Seconds	Points
0- 3	3
31- 60	2
61- 90	1
91-120	0
After 120 2-10 Beats Above Normal	-1
After 120 11-30 Above Normal	-2

F. Standing Systolic B.P. Compared with Reclining Systolic B.P.

Change in Millimeters	Points
Rise 30 and more	-2
Rise 21 to 30	-1
Rise 16 to 20	0
Rise 11 to 15	1
Rise of 6 to 10	2
No Rise Greater than 5	3
Fall of 6 to 10	2
Fall of 11 to 15	1
Fall of 16 to 20	0
Fall of 21 to 25	-1
Fall of 26 and more	-2

APPENDIX B

RAW SCORES FROM SCHNEIDER TEST

TABLE VIII

RAW SCORES FROM SCHNEIDER TEST

Subjects	CONTROL Pretest	CONTROL Posttest	EXPERIMENTAL Pretest	EXPERIMENTAL Posttest
01	15	15	14	16
02	14	13	15	16
03	21	20	13	13
04	15	13	11	13
05	7	7	14	15
06	12	12	9	11
07	18	16	10	14
08	16	16	17	17
09	10	10	13	16
10	15	11	8	13
11	12	13	14	14
12	10	11	12	15
13	10	12	13	14
14	8	11	15	16
15	16	16	10	11
16	15	14	16	20
17	12	12	16	16
18	13	12	14	16
19	14	13	10	11
20	10	11	16	17

APPENDIX C

RAW SCORES FROM ELECTROCARDIOGRAM

TABLE IX

RAW SCORES P-WAVE FOR CONTROL AND EXPERIMENTAL GROUPS

		CONTROL							EXPERIMENTAL					
		Pretest			Posttest				Pretest			Posttest		
Subjects	Leads	1	2	3	1	2	3	Leads	1	2	3	1	2	3
01		0.4	0.1	0.2	0.4	0.1	0.2		0.3	0.0	0.2	0.2	0.6	0.2
02		0.7	1.1	0.5	0.8	1.1	0.6		1.0	2.0	0.4	1.0	0.8	0.1
03		0.8	0.6	0.3	0.9	0.6	0.2		1.0	0.5	0.0	1.0	0.5	0.0
04		1.0	0.2	0.1	1.1	0.2	0.2		1.0	0.3	0.0	2.2	2.4	1.0
05		0.9	0.4	0.2	0.8	0.4	0.3		1.0	0.3	0.1	0.4	0.2	0.0
06		1.1	1.2	1.0	1.2	1.0	1.1		1.0	1.2	1.2	1.1	1.1	1.0
07		1.2	1.9	1.1	1.2	1.9	1.1		1.3	1.8	1.0	0.0	1.0	0.4
08		1.1	1.2	1.1	1.0	1.1	0.8		1.0	1.2	1.0	0.9	1.1	0.8
09		1.2	1.0	0.4	0.0	0.6	0.5		1.0	1.0	0.3	0.0	0.6	0.7
10		0.2	0.5	0.3	0.3	0.4	0.3		0.2	0.4	0.2	0.0	0.1	0.0
11		1.2	0.4	0.5	1.1	0.5	0.4		1.0	0.3	0.0	0.9	0.2	0.0
12		0.9	1.2	1.1	0.8	1.3	1.1		0.8	1.2	1.0	1.2	2.0	1.2
13		1.0	1.2	0.3	1.2	1.1	0.2		1.0	1.0	0.2	1.0	0.9	0.1
14		0.5	1.4	1.5	0.4	1.3	1.4		1.3	1.7	1.6	0.1	0.5	0.4
15		1.0	1.0	0.3	1.1	1.9	0.2		1.9	1.0	0.2	2.0	1.0	0.0
16		1.8	1.2	0.5	1.7	1.3	0.6		1.0	1.1	0.2	0.7	1.2	0.2
17		1.4	0.3	0.2	1.5	0.3	0.3		1.0	0.2	0.1	0.0	0.2	0.0
18		0.2	0.7	0.6	0.2	0.8	0.6		0.1	0.9	0.5	0.2	0.8	0.4
19		0.3	0.9	0.5	0.3	0.9	0.4		0.2	1.0	0.4	0.2	0.4	0.5
20		0.5	1.9	1.7	0.5	1.8	1.7		0.1	1.7	1.6	0.6	0.9	0.8

TABLE X

RAW SCORES T-WAVE FOR CONTROL AND EXPERIMENTAL GROUPS

	CONTROL							EXPERIMENTAL						
		Pretest			Posttest				Pretest			Posttest		
Subjects	Leads	1	2	3	1	2	3	Leads	1	2	3	1	2	3
01		2.0	3.0	2.0	2.0	2.5	2.0		2.0	4.0	1.5	1.9	3.8	1.7
02		3.5	2.0	1.0	3.4	2.0	1.0		3.0	3.0	1.0	3.1	3.2	1.2
03		2.0	2.5	1.0	2.1	2.7	1.0		0.5	1.5	0.5	1.5	1.5	0.5
04		3.5	3.0	2.0	3.5	5.0	2.0		2.0	1.5	0.5	3.0	2.8	2.0
05		1.0	2.0	1.5	1.0	2.0	1.4		3.0	3.0	0.5	2.8	3.0	0.7
06		4.0	3.0	1.0	4.1	2.9	1.1		2.0	2.5	1.5	2.0	2.7	1.5
07		1.0	2.0	0.5	1.3	1.3	0.5		1.0	1.0	0.5	2.0	2.0	1.5
08		4.0	3.0	1.0	3.5	2.5	0.5		3.0	2.0	0.5	3.0	2.1	1.0
09		2.0	2.0	1.0	2.0	2.1	0.1		3.0	3.0	2.0	3.0	2.9	1.8
10		2.5	2.5	1.0	1.5	2.0	0.5		1.5	1.0	0.5	1.5	1.0	1.5
11		1.5	1.5	0.5	1.5	1.5	0.5		1.5	3.0	1.5	1.5	3.0	1.6
12		1.0	2.0	1.5	1.5	2.0	1.5		1.0	1.5	0.5	1.5	2.0	1.5
13		2.0	1.0	1.0	2.0	1.0	1.0		1.0	0.5	1.0	1.1	0.7	0.9
14		2.0	2.0	0.5	0.5	0.5	0.5		4.0	4.5	1.5	3.9	4.5	1.5
15		3.5	3.0	2.0	3.5	3.0	2.5		3.0	2.5	0.5	2.5	2.5	0.5
16		0.8	1.0	0.6	0.5	1.5	0.5		3.0	2.0	0.5	3.2	2.1	0.8
17		2.0	0.7	1.6	2.0	1.5	1.5		1.0	2.0	0.5	1.4	1.9	1.5
18		1.0	2.4	1.4	1.1	2.4	1.3		1.0	2.5	1.5	1.0	2.5	1.5
19		1.1	1.9	0.4	1.0	1.7	0.5		1.0	2.0	0.5	1.0	1.8	1.0
20		0.8	1.3	0.9	0.5	1.2	1.1		0.5	1.5	1.0	0.7	1.5	1.0

TABLE XI

RAW SCORES WORK-REST RATIO FOR CONTROL AND EXPERIMENTAL GROUPS

	CONTROL							EXPERIMENTAL						
		Pretest			Posttest				Pretest			Posttest		
Subjects	Leads	1	2	3	1	2	3	Leads	1	2	3	1	2	3
01		1.68	1.50	1.75	1.57	2.20	2.33		1.66	1.40	2.66	2.83	2.16	3.00
02		1.37	1.86	2.00	1.60	1.85	2.00		1.50	2.50	2.50	1.75	2.50	2.60
03		2.50	2.95	2.91	2.60	2.90	2.91		2.50	1.86	2.58	2.45	1.96	2.60
04		2.00	2.33	2.50	2.00	2.12	2.40		2.53	2.53	2.54	2.83	2.80	2.50
05		1.91	1.71	1.60	1.90	1.95	1.50		2.50	2.50	2.80	2.75	2.85	3.00
06		1.44	3.00	1.71	1.50	3.01	1.80		1.15	2.20	1.83	2.16	2.60	2.60
07		4.00	3.75	3.80	3.82	3.75	3.90		1.83	2.00	1.75	1.71	1.81	1.71
08		2.00	2.83	2.50	3.13	3.80	3.60		1.85	1.85	1.75	1.85	1.80	1.78
09		1.33	1.57	2.00	1.36	1.60	2.00		1.98	2.14	2.43	2.00	3.66	2.20
10		3.00	3.75	4.00	3.00	3.50	4.00		2.60	2.40	2.14	2.75	2.55	2.50
11		2.50	3.40	2.00	2.55	2.16	2.43		1.84	2.50	2.25	1.84	2.50	2.28
12		3.00	2.60	2.41	3.00	2.60	2.75		2.87	2.65	2.20	3.33	2.50	2.40
13		4.00	3.83	3.20	4.00	3.83	3.40		2.83	2.50	2.14	2.80	2.55	2.14
14		2.60	1.25	2.00	2.33	2.50	1.80		2.14	2.00	2.50	2.60	3.40	2.71
15		2.66	2.15	3.00	2.60	2.65	3.00		1.67	1.85	2.16	2.80	2.50	2.28
16		2.00	2.40	2.20	2.00	2.50	2.17		1.90	2.57	3.33	2.00	2.55	3.40
17		2.14	2.00	2.00	2.20	2.00	2.20		2.92	4.11	3.12	4.20	4.44	4.43
18		2.10	2.45	2.82	2.06	2.32	2.80		2.22	2.59	2.83	3.33	3.40	3.60
19		2.15	2.21	2.60	2.21	2.16	2.50		2.15	2.28	2.62	2.20	2.60	2.50
20		1.42	1.71	1.90	1.52	1.60	1.82		1.50	1.80	2.00	1.76	1.90	2.16

TABLE XII

RAW SCORES HEART RATE FOR CONTROL AND EXPERIMENTAL GROUPS

Subjects	CONTROL							EXPERIMENTAL						
		Pretest			Posttest				Pretest			Posttest		
	Leads	1	2	3	1	2	3	Leads	1	2	3	1	2	3
01		66	71	70	66	72	70		58	60	60	58	58	60
02		88	89	87	86	87	86		55	62	62	55	62	62
03		43	41	42	42	40	42		60	60	65	60	60	64
04		60	56	66	60	55	65		68	60	75	65	60	70
05		90	94	98	90	92	96		53	55	52	50	51	55
06		71	80	75	70	80	76		82	80	86	80	80	80
07		55	55	55	45	46	46		94	94	96	75	75	75
08		65	59	66	60	55	62		72	75	77	72	75	76
09		80	84	80	80	84	80		72	72	78	72	72	76
10		60	62	60	60	55	65		92	92	98	84	80	80
11		65	70	70	65	69	68		56	55	60	56	54	59
12		69	64	67	69	64	70		50	52	50	52	50	50
13		56	55	58	58	59	60		64	67	65	64	66	65
14		75	78	80	75	76	80		65	67	65	60	64	58
15		65	65	63	65	66	64		70	72	74	74	72	72
16		60	62	60	62	64	62		38	39	39	40	40	40
17		70	72	75	72	74	75		58	58	60	56	58	57
18		72	70	73	72	72	72		78	72	68	75	72	74
19		80	78	84	80	77	83		100	100	100	98	98	97
20		78	75	77	77	74	76		54	55	56	54	56	55

APPENDIX D

RAW SCORES HEART RATE CHANGE

DURING THE STEAM BATH

TABLE XIII

RAW SCORES HEART RATE CHANGE DURING THE STEAM BATH

Experimental Group					
	Minutes				
Subjects	0	5	10	15	20
01	72	112	135	148	163
02	72	110	134	146	162
03	70	112	130	162	176
04	72	111	135	154	167
05	70	111	133	144	159
06	80	120	148	177	195
07	88	139	162	175	183
08	72	112	135	146	163
09	84	121	136	154	162
10	84	144	164	175	187
11	70	109	133	144	157
12	68	108	131	141	154
13	68	113	136	168	175
14	72	111	134	145	161
15	76	115	141	153	173
16	66	98	123	135	143
17	68	105	125	130	150
18	72	108	133	157	165
19	80	120	136	152	166
20	68	112	138	152	162

APPENDIX E

FORMS FOR RECORDING DATA

HEART RATE CHANGES WHILE
SITTING IN STEAM ROOM

Name____

Sitting Heart Rate ________

Minutes		0	5	10	15	20	25	30
Dates								

NAME____

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1st Week							
2nd Week							
3rd Week							
4th Week							
5th Week							
6th Week							
7th Week							
8th Week							

Place time in bath in appropriate block.

Must take bath three days each week.

APPENDIX F

FORM LETTER USED IN OBTAINING SUBJECTS

Dear Sir:

I am beginning a research project on "The Effects of Humid Heat on the Cardiovascular System of Males" here at Oklahoma State University, and I am soliciting your help.

As you know, the cardiovascular system involves the heart and all of the blood vessels of the body. Humid heat is simply a steam bath in a room designed for that purpose.

The theory behind our research is centered around improvement of the cardiovascular system by exposing the body to heat which will increase the heart rate. It is being theorized that this increased heart rate will be sufficient to improve the heart efficiency.

This project will require approximately thirty minutes of your time, three days per week for eight weeks. Your help in this project will be greatly appreciated.

Please fill in the necessary information below and return it to me at: Director's Office, Student Union. I hope to start the project on January 12, 1970.

Thank you very much.

Sincerely yours,

Mel Evans

. . . .

I (will - will not) be able to participate in your research. I will be available on the days and at the time(s) indicated below:

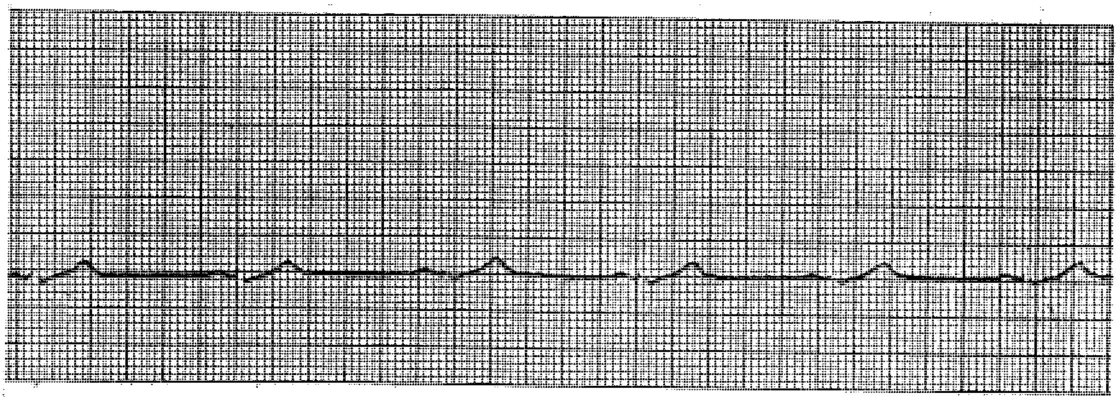
Monday	at	_______	Friday	at	_______
Tuesday	at	_______	Saturday	at	_______
Wednesday	at	_______	Sunday	at	_______
Thursday	at	_______			

____
Signature

____
Department

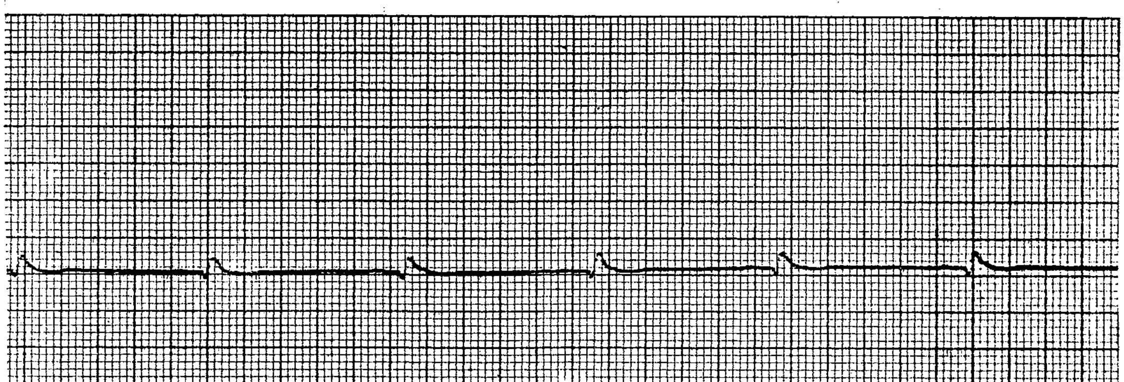
APPENDIX G

SAMPLE ELECTROCARDIOGRAM



Lead 1

Lead 2



Lead 3

Figure 4. Sample Electrocardiogram.

VITA

Melvin Ira Evans

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECTS OF STEAM BATHS ON THE CARDIOVASCULAR SYSTEM

Major Field: Higher Education

Biographical:

Personal Data: Born in Georgetown, South Carolina, October 6, 1932, the son of Mr. and Mrs. John Evans.

Education: Attended the elementary and secondary schools in Georgetown, South Carolina; graduated from Howard High School in 1950; received the Bachelor of Science degree from Allen University, Columbia, South Carolina, with a major in physical education and minors in biology, general science, and health in May 1954; received the Master of Science degree from Springfield College, Springfield, Massachusetts, with a major in physical education in 1959; completed requirements for the Doctor of Education degree at Oklahoma State University, in May, 1970

Professional Experience: Teacher and Assistant Athletic Coach at Sterling High School, Greenville, South Carolina, 1954; the United States Army, 1954-1956; Chairman of the Department of Health and Physical Education, Teacher, and Athletic Coach, Choppee High School, Georgetown, South Carolina, 1956-1957; Assistant Professor of Health and Physical Education, Head Track Coach, Allen University, Columbia, South Carolina; Dean of Men, Allen University, Columbia, South Carolina; Head Line Coach in football, 1960-1963, Assistant Basketball Coach, 1960-1961, Allen University, Columbia, South Carolina; Head Football Coach, Allen University, 1964-1965; Instructor in Health and Physical Education and Assistant Football and Baseball Coach, Maryland State College, Princess Anne, Maryland, 1965-1968. Acting Chairman Department of Health and Physical Education, Maryland State College, Princess Anne, Maryland; Administrative Assistant to the Director of the Student Union, Oklahoma State University, Stillwater, Oklahoma, 1968-1969; Instructor in Black Culture in America, Oklahoma State University, Stillwater, Oklahoma. Assistant to the Associate of Student Affairs, Oklahoma State University, Stillwater, Oklahoma, 1969-1970.

Professional Organizations: National Education Association; American Association for Health, Physical Education, and Recreation; Oklahoma Association for Health, Physical Education, and Recreation; Oklahoma Secondary School Activities Association; Central Intercollegiate Football Coaches Association; Young Men's Christian Association; Phi Delta Kappa.