THE INFLUENCE OF REGULAR, ORGANIZED EXERCISE ON CARDIOVASCULAR FITNESS AS DETERMINED BY PULSE RATE FOLLOWING A STEP-UP TEST

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THE INFLUENCE OF REGULAR, ORGANIZED EXERCISE ON CARDIOVASCULAR FITNESS AS DETERMINED BY PULSE RATE FOLLOWING A STEP-UP TEST

An Abstract

Presented to

the Committee on Graduate Studies

Austin Peay State College

In Partial Fulfillment

of The Requirements for the Degree

Master of Arts

in Education

by

Judy Gibson Browning

August, 1967

This study was an endeavor to determine the influence of regular, organized exercise on cardiovascular fitness as determined by pulse rate following a step-up test on a fifteen and three-fourths inch bench. The stepping rate was thirty steps per minute. The subjects studied included thirty-six male college students at Austin Peay State College during the regular school year of 1966-1967. The experimental group consisted of eighteen athletes from the varsity basketball team and the control group of eighteen subjects were non-athletes chosen from a men's basketball class. The athletes were tested for twenty-eight weeks at two-week intervals while the non-athletes were tested at two-week intervals for ten weeks. Test results for the first ten weeks were used for comparison between the athletes and non-athletes.

The results indicated that both sporadic and regular periods of organized exercise does affect pulse rates curves but there is no significant difference between the pulse rate curves, except at the one-minute interval after exercise. However, unless exercise is continuous pulse rate curves do tend to return to pretraining levels when exercise is terminated.

THE INFLUENCE OF REGULAR, ORGANIZED EXERCISE ON CARDIOVASCULAR FITNESS AS DETERMINED BY PULSE RATE FOLLOWING A STEP-UP TEST

A Thesis

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Master of Arts

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by

Judy Gibson Browning

August, 1967

August 4, 1967

To the Committee on Graduate Studies:

I am submitting herewith a thesis written by Judy Gibson Browning entitled "The Influence of Regular, Organized Exercise on Cardiovascular Fitness as Determined by Pulse Rate Following a Step-up Test." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts in Education, with a major in Health and Physical Education.

Loraine Stowe
Major Professor

We have read this thesis and recommend its acceptance:

Dave Aaron
Minor Professor

Elizabeth H. Stokes
Third Committee Member

Accepted for the Committee on Graduate Studies:

William H. Ellis
Director of Graduate Studies

ACKNOWLEDGEMENT

The author wishes to express her appreciation to Dr. Loraine H. Stowe who aided and counseled her for many hours during the course of this study; to all the athletes and non-athletes who cooperated during the testing periods to make this study possible; to Coach George D. Fisher for many hours of cooperation throughout the study; and to Dr. Elizabeth Stokes and Coach David Aaron for their helpful suggestions and critical reading of this thesis. To her husband she is grateful for the encouragement which he gave during the study.

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CHAPTER I

INTRODUCTION

Exercise causes profound changes in circulation from the pre-exercise stage to the recovery processes which may continue for several hours after a period of severe activity. With advance in knowledge of physiological processes it seems only natural that man should study the heart for evidence of physical fitness.

It is believed that a pulse rate curve following a step test may locate persons of low physical fitness and may indicate the significance of regular exercise in maintaining physical fitness.

I. THE PROBLEM

Statement of the Problem

The purpose of this study was to determine the influence of regular, organized exercise on cardiovascular fitness as determined by pulse rate following a step-up test. More specifically, the study was an attempt to obtain some data which might help to answer these questions:

1. Would regular organized exercise by athletes improve cardiovascular fitness and if there was a decline in cardiovascular fitness when regular organized exercise was terminated.

2. Would sporadic exercise by non-athletes improve cardiovascular fitness and if so, how would this improvement compare with athletes who were participating in a more vigorous exercise program.

Hypothesis

It was hypothesized that cardiovascular fitness would not be affected by regular vigorous exercise; that persons engaged in regular organized periods of vigorous exercise would not show a significantly higher degree of cardiovascular fitness than those engaged in sporadic periods of vigorous exercise; and that cardiovascular fitness, if affected, would not return to pretraining levels when organized exercise was terminated.

Importance of the Study

The degree of fitness of an individual depends on the innumerable functions of the tissues and organs, however, it is assumed that regular exercise increases or improves capacities of various physiological processes and thereby the physical efficiency of the individual. Clinical observations and research studies indicate that regular physical exercise acts to prevent conditions leading to coronary heart disease. Skeletal muscles are improved by regular exercise and it is generally believed heart muscles react in a similar manner and that regular exercise is an important factor in developing circulatory fitness. There seems to be an agreement among physiologists that a pulse rate curve during the period of recovery after exercise is the most useful single measure of circulatory fitness.

There are many unanswered questions pertaining to cardiovascular tests and it is hoped that this study has supported and contributed to former studies of step tests as screening devices for cardiovascular fitness.

II. LIMITATIONS OF THE STUDY

The following limitations applied to this study:

1. The subjects used in the study consisted of thirty-six male college students; eighteen basketball athletes and eighteen non-athletes chosen from a men's basketball class in physical education.

2. No attempt was made by the experimenter to control or standardize the exercise received during basketball practice by the varsity athletes or to control the exercise received by the non-athletes from the men's basketball class.

3. The basketball class met only three times per week on Monday, Wednesday, and Friday. The net total of vigorous exercise received per class meeting was approximately thirty minutes for a period of ten weeks.

4. The varsity athletes practiced six days per week and received approximately two hours of vigorous

exercise per practice. Basketball practice began October 17, and terminated February 27, for a total of nineteen weeks training.

5. The basketball coach was also the instructor of the men's basketball class used in the study.

III. DEFINITIONS OF TERMS USED

Athletes

Athletes refers to the varsity athletes used in the study. They were varsity basketball players for the Austin Peay State College team.

Cadence

The cadence was set at 120 beats per minute allowing thirty steps per minute. This permitted one complete step up and one complete step down every two seconds.

Metronome

An instrument used for marking a rhythmical beat.

Non-athletes

The non-athletes who participated in the study were chosen from a men's physical education class in basketball at Austin Peay State College.

Regular periods of exercise

Daily periods of exercise in which the athletes participated.

Sporadic periods of exercise

Exercise periods scheduled three times per week, in which the non-athletes participated.

IV. THE STUDY AS A WHOLE

Chapter II is concerned with the review of the related literature in the study area. Previous research which has been conducted in the study area is cited to support the research given in this paper.

Chapter III is concerned with the methods and procedures used in collecting the research data. An explanation of how the athletes and non-athletes were tested is included here. Also, the instruments used and the statistical formula used in the treatment of the data is listed here.

Chapter IV includes the presentation and analysis of the research data. Graphs showing the mean pulse rates of the athletes and non-athletes are included here for each statistical comparison.

Chapter V includes the summary and conclusions derived from the research data collected during the study.

CHAPTER II

REVIEW OF THE LITERATURE

Dr. George V. Mann, while delivering an address at the Middle Tennessee Association for Health, Physical Education and Recreation in 1965, strongly emphasized that exercise is the most important factor in developing and maintaining cardiovascular fitness and preventing circulatory ailments. Karpovich, a well known physiologist, states that "There seems to be an agreement that the pulse rate curve during the period of recovery after exercise is the most useful single measure of circulatory fitness."[1] In order to understand the full meaning of the pulse curve one must know the normal ranges of pulse rates. It is generally agreed that from fifty to one hundred beats per minute is the normal range for the average male,[2] and according to Mathews, seventy-eight is the average for male adults.[3]

Heart Rate and Training

Mathews, Stacy, and Hoover report that

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[1]Peter V. Karpovich, *Physiology of Muscular Activity* (Philadelphis: W. B. Saunders Company, 1963), p. 281.

[2]*Ibid*., p. 191.

[3]D. K. Mathews, R. W. Stacy, and G. N. Hoover, *Physiology of Muscular Activity and Exercise* (New York: The Ronald Press Company, 1964), p. 207.

the resting heart rate is often thought to be lower in persons in good physical condition, but if one eliminates the very slow rates associated with highly trained runners and other exceptional cases, this does not seem true.[4]

Most physiologists also agree that:

With training the heart becomes more efficient and is able to circulate more blood while beating less frequently. Contraction of the heart becomes more powerful, thus it empties itself more completely at each systole, and stroke volume and cardiac output is increased. For a standard amount of work the heart becomes slower as training progresses. These heart rate changes indicate a decreasing load on the cardio-vascular adaptation to exercise. Slow heart rates are observed even at rest and it is not exceptional for the resting pulse rate to be reduced by 10 to 20 beats per minute between the beginning and the end of a training period. This greater efficiency of the heart enables a larger blood flow to reach the muscles, insuring an increased supply of fuel and oxygen and permitting the individual to reach higher levels of performance.[5]

Efficiency and Time of Day

Kleitman and Jackson report that one's efficiency is not at a peak until about the middle of the waking hours. They also report that the waking period and the period immediately before bed-time is characteristic of a low performance period.[6]

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[4] *Ibid.*, p. 208.

[5] Warren R. Johnson (ed.), *Science and Medicine of Exercise and Sports* (New York: Harper and Brothers Publishers, 1960), p. 409.

[6] Nathaniel Kleitman and Dudley P. Jackson, "Body Temperature and Performance under Different Routines," *Journal of Applied Physiology*, 3:309, December, 1950.

Emotions and Pulse Rate

Karpovich states that normal resting pulse rates are sometimes difficult to obtain because of variations in emotional states. "The subject may appear relaxed, while his pulse rate tells a different story. Variations in the emotional state affect the pulse rate much more than postural changes."[7]

Grollman reports that

> Certain emotional changes which are accompanied by a slowing of the pulse and a general decline in the activity of the circulation, may possibly result in a diminished cardiac output, while certain psychic reactions may possibly be without effect on the cardiac output.[8]

Pulse Rate Before Exercise

Karpovich reports that a "start" pulse might be obtained instead of a resting pulse when taking resting pulse rates before an exercise involving an element of contest. This "start" pulse may be accelerated by the excitement of anticipating the contest. "One should not forget that a pulse rate obtained during a period of apparent rest may not necessarily be a resting pulse."[9]

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[7] Karpovich, *op. cit.*, p. 193.

[8] A. Grollman, "The Effect of Psychic Disturbances on the Cardiac Output, Pulse, Blood Pressure, and Oxygen Consumption of Man," *American Journal of Physiology*, 89: 587, 1929.

[9] Karpovich, *op. cit.*, p. 195.

Cogswell and co-workers report that:

> Relatively more reliability may be placed upon any assessment of individual fitness in healthy young men using pulse or blood pressure recovery rates if resting functions measured at the time of testing are included in the appraisal.[10]

White reports that in individuals who are extremely physically fit the heart rate may be as low as thirty-eight beats per minute. This was found to be true in a navy champion athlete who was running the mile in record time.[11]

Pulse Rate During Exercise

Most physiologists agree that the pulse rate will increase during a bout of exercise if the exercise is strenuous enough. There are many aspects regarding the significance of the increase in heart rate in different subjects. Brassfield reports that athletes' pulse rates are ten, twenty, or thirty beats slower than those found in men of sedentary habits.

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[10]Robert C. Cogswell, Charles R. Henderson, and George H. Berryman, "Some Observations of the Effects of Training on Pulse Rate, Blood Pressure and Endurance, In Humans, Using the Step Test (Harvard) Tread-mill and Electrodynamic Brake Bicycle Ergometer," American Journal of Physiology, 146:423, June, 1946.

[11]Martti J. Karvonen and Alan J. Barry, (ed.), Physical Activity and the Heart (Springfield: Charles C. Thomas Publisher, 1967), pp. 40-41.

Brassfield attributes this slower pulse to training and regular exercise participated in by athletes.[12]

Brassfield also states some of the physiological advantages of the well trained athlete's heart as compared to the untrained man's heart:

> While the trained man's heart has the advantage of starting at a slower rate of beating, on the whole it accelerates as many beats in response to the task as does the heart of the untrained subject.
>
> It has been maintained for some time that the efficiency of the heart begins to progressively fall off at rates between 160 and 180 beats per minute. With the high rates the diastole of the heart becomes too brief to allow the ventricles to relax and refill completely.
>
> The fundamental difference between the trained and untrained man for a particular task is that the heart of the trained man pumps more blood per minute with fewer strokes than does that of the untrained man.[13]

Mathews and co-workers agree that "heart rate and cardiac output increase progressively with increasing work load."[14]

Karpovich seems to be in agreement with Mathews and his co-workers and with Brassfield. He states that the work load and the individual will affect the results of the

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[12] Charles R. Brassfield, "Some Physiological Aspects of Physical Fitness," Research Quarterly, 14:108-109, 1943.

[13] Ibid., p. 109.

[14] Mathews, Stacy, and Hoover, op. cit., p. 208.

pulse rate obtained:

> At the beginning of muscular exercise the pulse rate increases rapidly. The greatest rise takes place within one minute. Sometimes half of this increase occurs within fifteen seconds. Gradually a plateau is reached. If the exercise is intensive, a secondary rise may occasionally be observed. As one may expect, the change in pulse rate depends on the individual.
>
> The frequency of the heart rate during a period of exercise, particularly if a steady state is established, is in linear relationship with the load of work. This linear relationship remains true up to a certain limit, depending on the individual.[15]

In recent research gathered at a symposium in Helsinki, Finland, one author reports on research related to heart rate and work load:

> The heart rate response to an increasing work load on a bicycle ergometer was measured. The resistance was set at zero and increased by 300 kg-m/minute every two minutes. Heart rate was determined at rest and during the last ten seconds of each minute of exercise until it reached 150 beats/minute, at which time the test was terminated. As training progressed, the subjects were able to pedal for longer periods against increasing resistance before reaching the termination point. Mean heart rates at each work load were at least ten beats/minute lower and the mean duration of the ride increased from 8.86 to 10.79 minutes.[16]

Henderson and co-workers report that

> The efficiency of the heart is nothing else than the volume of blood that it can pump in relation to the

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[15]Karpovich, _op_. _cit_., p. 195.

[16]Karvonen and Barry, _op_. _cit_., p. 81.

> oxygen requirement in the body. This applies to the athlete, to the man of sedentary habit, and to the cardiac patient.[17]

Henderson and co-workers seem to agree with Brassfield regarding the physiological advantages of the trained man's heart. The following statement supports Brassfield's research:

> In athletes the pulse rate tends to be much slower and the stroke volume distinctly larger both during rest and exercise than in non-athletes. This slowness of pulse is found to have the advantage of allowing longer diastoles with ample time for the ventricles to relax and fill. As a consequence also the stroke volume in athletes during exertion may be increased considerably, 50 per cent or more, over that during rest, with a corresponding gain in the minute volume of the circulation and its oxygen transporting capacity.[18]

Henry states that "the decrease in heart rate (which reflects the development of a more powerful heart with a larger stroke volume)"[19] is an effective test of changes in athletic condition.

Morehouse and Miller have a great deal to say about the pulse rate during exercise which is in agreement with

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[17] Y. Henderson, H. W. Haggard, and F. S. Dolley, "The Efficiency of the Heart and the Significance of Rapid and Slow Pulse Rates," American Journal of Physiology, 82: 512, 1927.

[18] Ibid., p. 523.

[19] F. M. Henry, "Influence of Athletic Training on the Resting Cardiovascular System," Research Quarterly, 25: 40, March, 1954.

the other research cited.

> The maximal heart rate reached during exercise and the rapidity with which the maximal value is attained vary with a number of factors, including the type of exercise (its intensity and duration), the emotional content of the exercise, environmental temperature and humidity, and the physical condition of the subject.
>
> The acceleration of the heart rate begins immediately after the commencement of exercise; it may, in fact, begin before exercise starts, coincident with the tensing of the muscles, as in "getting set" for a sprint.[20]

Return of Pulse to Normal

Many factors are connected with the period of recovery after exercise as related to heart rate. Most research points out that the work load or the intensity of the exercise, and the physical condition of the individual will determine to a great extent the time required to recover from a strenuous bout of exercise.[21]

Lowsley reports that in an experiment utilizing athletes in the midst of their training season with varying exercises of duration and intensity (bicycle riding, walking, swimming, tennis, baseball, shot putting, jumping, 100 yard dash, discus throwing, and a twenty mile marathon)

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[20]Laurence E. Morehouse and Augustus T. Miller, Physiology of Exercise (Saint Louis: The C. V. Mosby Company, 1963), p. 102.

[21]*Ibid.*, p. 104.

that the pulse rate returned to normal more slowly after more exhaustive exercises in nature than after less strenuous exercises.[22]

Elbel and Holmer report that:

> The circulatory system of the trained individual shows a more rapid return to the pre-exercise level than does the one possessed by the person not regularly engaging in exhaustive activity.[23]

This is in agreement with research reported by Michael and Gallon utilizing varsity basketball athletes. These varsity athletes were given a step-up test and it was found that after training season had begun their pulse rates returned to normal levels within two to three minutes following a step-up cadence of thirty-six steps per minute, as compared to a former five-minute period prior to training.[24]

Montoye reports that in a study conducted with twenty-one varsity oarsmen the maximum pulse rate decreased

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[22] O. S. Lowsley, "The Effects of Various Forms of Exercise on Systolic, Diastolic, and Pulse Pressures and Pulse Rate," American Journal of Physiology, 27:447, 1911.

[23] E. R. Elbel and R. M. Holmer, "The Relationship between Pre-Exercise Pulse Rate and Recovery Following Exercise," Research Quarterly, 20:367, 1949.

[24] Ernest D. Michael and Arthur Gallon, "Periodic Changes in the Circulation During Athletic Training as Reflected by a Step Test," Research Quarterly, 30:303-311, 1959.

with training.[25]

Karpovich reports that:

> A sudden and rapid primary fall of pulse rate may at times be followed by a plateau or constant rate, with a subsequent slower secondary fall. The pulse rate occasionally may fall below the pre-exercise level. This happens even in those whose resting pulse rates have been obtained under carefully controlled conditions.[26]

Morehouse and Tuttle report that "A secondary rise in pulse rate is a normal, but variable phenomenon,"[27] and they also agree that the pulse rate following the exercise is directly related to the strenuousness of the exercise.[28]

Karpovich, also, says that psychological upsets prior to the exercise may cause the subject's pulse rate to drop below the normal level after the exercise.[29]

Relative to the physical condition of the individual and the recovery pulse rate Tuttle and Dickinson have made this statement:

> It has been conclusively demonstrated that the physical condition of an individual has a pronounced

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[25]Henry J. Montoye, "Inter-Relation of Maximum Pulse Rate During Moderate Exercise, Recovery Pulse Rate, and Post Exercise Blood Lactate," Research Quarterly, 24:455, December, 1953.

[26]Karpovich, op. cit., p. 201.

[27]L. E. Morehouse and W. W. Tuttle, "A Study of Post-Exercise Heart Rate," Research Quarterly, 13:9, March, 1942.

[28]Ibid., p. 8.

[29]Karpovich, loc. cit.

effect on both the rate of increase due to exercise, and the time required for the heart to return to normal after cessation of the exercise. It has also been shown that the individual who is physically trained so that he possesses considerable endurance, will be less affected by a given amount of exercise than one in poor condition, and those possessing less endurance.[30]

Relation Between Resting and Postexercise Pulse Rates

Karpovich reports that "It is a common belief that, in a group of subjects after a standard exercise, pulse rates will be higher in those individuals whose resting pulse rates are also higher."[31]

Cogswell and co-workers state that "Some correlation does exist between resting and post-exercise function, especially when the exercise is of sufficient intensity to require strenuous exertion."[32]

Elbel and Holmer, in a study concerning male university students participating in a step-up test with a cadence of thirty-six steps per minute, reports an insignificant relationship between recovery time after exercise and pre-exercise pulse rates.[33] Morehouse and

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[30] W. W. Tuttle and R. E. Dickinson, "A Simplification of the Pulse-Ration Technique for Rating Physical Efficiency and Present Condition," Research Quarterly, 9: 73-74, 1938.

[31] Karpovich, op. cit., p. 203.

[32] Cogswell, Henderson, and Berryman, loc. cit.

[33] Elbel and Holmer, op. cit., p. 376.

Tuttle's research seems to be in close agreement with Elbel and Holmer in that they report

> The post-exercise increase in pulse rate above the resting level is directly related to the intensity of the exercise, and at mild intensities of exercise is inversely related to the resting pulse rate.[34]

Tuttle and Salit studied subjects exercising on the bicycle ergometer and found that there was "little or no relationship between resting heart rate and increase due to exercise."[35]

Karpovich explains the former research by the following statement:

> The negative sign may be explained in the following manner. Strenuous exercise causes the heart rate to become maximal, which is approximately the same for each individual. The higher the resting pulse, the smaller the difference between it and the maximal pulse. Thus, with an increase in resting pulse, there is a corresponding decrease in a possible exercise rise in the pulse rate.
>
> . . . .
>
> The chief complicating factor in studying the relationship between resting and postexercise pulse rates is the difficulty of obtaining a true resting pulse. It takes so much time and precaution that often the acceptable resting pulse is that which is obtained after an insufficient period of rest from all disturbing influences, at which two consecutive readings happened to check.[36]

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[34]Morehouse and Tuttle, loc. cit.

[35]W. W. Tuttle and E. P. Salit, "The Relation of Resting Heart Rate to the Increase in Rate Due to Exercise," American Heart Journal, 29:594, 1945.

[36]Karpovich, op. cit., p. 204.

Heart Rate and Step-Up Exercise

The step-up test can be considered a standard exercise because the experimenter can control the number of steps per minute and therefore the intensity of the work being done by the subjects being measured. Elbel and Green agree with the following supporting statement:

> Stepping-up tests have been used for the clinical evaluation of physical fitness based upon cardiovascular response to a standard amount of exercise. Due mainly to simplicity in administration and the relative ease with which the workload can be controlled, tests of this type received a renewed emphasis during the war. This was particularly true in appraising the fitness of soldiers before return to duty following periods of hospitalization.[37]

Brouha reports that

> A satisfactory estimate of a man's fitness can be obtained by exposing him to a standard exercise that no one can perform in a "steady state" for more than a few minutes and taking into account two factors: the length of time he can sustain it and the deceleration of his heart rate after exercise.[38]

Seltzer in an investigation of aviation cadets and college students found no relation between absolute stature

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[37]E. R. Elbel and E. L. Green, "Pulse Reaction to Performing Step-Up Exercise on Benches of Different Heights," American Journal of Physiology, 145:521, 1946.

[38]Lucien Brouha, "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, 14:31, March, 1943.

or leg length and the fitness index obtained by the step test.[39]

Elbel and Green studied the effects of the different heights of a bench to determine if variations in the height of the bench significantly affects the pulse reaction in normal subjects. Seventy-two aviation students were tested on benches twelve to twenty inches in height for periods of thirty to sixty seconds. Twenty-four steps per minute was the cadence used for the test. The subjects' pulse was taken for thirty seconds at two intervals after exercise: immediately after exercise through thirty seconds and again from sixty to ninety seconds. The results were as follows:

> The pulse rate for the 30 seconds immediately following the stepping-up exercise depends upon the height of the bench and the duration of the exercise. After 30 seconds of exercise, the average increment is 3.7 beats per minute greater for each additional two-inch increase in the height of the bench. After 60 seconds of exercise, the increment becomes 5.6 beats per minute greater for each additional two-inch increase.
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> The height of the bench and the duration of the step-up exercise as used in this study do not significantly alter the pulse rate if the pulse record is taken one minute after exercise.[40]

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[39] Carl C. Seltzer, "Anthropometric Characteristics and Physical Fitness," Research Quarterly, 17:10, 1946.

[40] Elbel and Green, op. cit., p. 526.

Elbel and Miller studied the effects of various cadences upon the pulse rate. College students were used in this study with a sixteen inch bench and cadences varying from eighteen, twenty-four, thirty-six and forty-two steps per minute. Resting pulse rates were taken and recovery pulse rates of one minute immediately after the exercise was used to determine the effect of cadence upon the pulse rate. The following results were reported as a result of this experiment with the five different cadences:

> The pulse rate immediately following exercise increased on the average of 9.15 beats for each increase in cadence of six steps per minute.
>
> After performing the exercise at a cadence of 18 or 24 steps per minute, the pulse rate taken one minute after exercise was on the average significantly lower than pre-exercise rate. The pulse rate taken one minute following exercise with cadences of 36 and 42 steps per minute was significantly higher than the pre-exercise rate. The pulse rate following the cadence of 30 steps was higher when taken one minute after exercise, but not significantly so.[41]

Taylor supports the use of the step-up test to a degree in his statement that "The step-up experiment offers promise in the measurement of the important physiological factors underlying individual physical capacity for

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[41] W. A. Miller and E. R. Elbel, "The Effect upon Pulse Rate of Various Cadences in the Step-Up Test," Research Quarterly, 17:268, 1946.

sustained heavy exercise."[42]

Keeney, a professor of Biology at Springfield College, states that the step-up test is adequate for "measuring some function or attribute that is commonly associated with a high degree of ability to work for a long time and recover rapidly from the effects."[43] He suggests the Harvard Step Test or the Tuttle Pulse Ratio test as examples.

Karpovich reports that trained subjects recover more readily from strenuous exercise than do untrained subjects. He states that

> The time necessary for the pulse rate to return to normal has a wide range. After a half minute of stepping-up on benches 12 to 20 inches high, the rate should be back to normal within a minute. After exhaustive exercise, it may not be back to normal for several hours.[44]

Effects of Temperature on Pulse Rates

In relation to environmental temperature and the effect it has upon the pulse rate, Karpovich has this to say:

> A high environmental temperature may greatly increase the frequency of heart beat. It stands to reason that a person with a weakened heart takes an

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[42] C. Taylor, "Studies in Exercise Physiology," American Journal of Physiology, 135:41, 1941.

[43] Clifford E. Keeney, "Work Capacity," Journal of Health, Physical Education, and Recreation, 31:29, September, 1960.

[44] Karpovich, op. cit. p. 202.

unnecessary risk when indulging in vigorous activity on a hot day. Besides the increased work of the heart to provide a sufficient amount of blood for the active muscles, an additional strain will be imposed because of an augmented peripheral (skin) circulation for the purpose of heat dissipation. The double work may sometimes be fatal.[45]

Acute Infections and Pulse Rate

Dawson reports that "An acute infection (nasopharyngitis) caused an increase in the pulse rate but no change in the blood pressures. In the trained subject the change was much less pronounced."[46] Research by Brassfield agrees with Dawson in that he reports acute infections have a much less pronounced influence in the trained man than in the untrained man.[47]

Need for Activity and Benefits of Exercise

The American Medical Association's Committee on Exercise and Physical Fitness which is staffed by six medical doctors has this to say about exercise and its

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[45] Karpovich, *op. cit.*, p. 206.

[46] Percy M. Dawson, "Effect of Physical Training and Practice on The Pulse Rate and Blood Pressures During Activity and During Rest, with a Note on Certain Acute Infections and on the Distress Resulting From Exercise," *The American Journal of Physiology*, 50:473, December, 1919.

[47] Brassfield, *op. cit.*, p. 108.

contribution to health:

> Regular vigorous activity appropriate to age, sex, and health status is beneficial to everyone but a medically-excepted few. Those whose handicaps preclude vigorous exercise will benefit from some adapted physical activity. Continuing research shows that adequate exercise and sports activity contribute significantly to good health. Regular exercise can be beneficial in controlling obesity, delaying degenerative disease, rehabilitating the ill or injured, and shortening recuperative periods. It is also unique in developing and maintaining physical fitness and in improving cardiovascular and respiratory efficiency.[48]

Golding and Bos report research which points out the significance of the statement made by the American Medical Association. Golding and Bos re-emphasize that the efficiency of the heart is developed by exercise.[49]

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[48]American Medical Association's Committee on Exercise and Physical Fitness, "Need for Varied Activities in Physical Education Programs," Journal of Health, Physical Education, and Recreation, 36:6, June, 1965.

[49]L. A. Golding and R. R. Bos, Scientific Foundations of Physical Fitness Programs (Minneapolis: Burgess Publishing Company, 1967), pp. 9-12.

CHAPTER III

METHODS AND PROCEDURES

I. THE DESIGN

This study was an endeavor to determine the influence of regular, organized exercise on cardio vascular fitness as determined by pulse rate following a step-up test. The subjects included the varsity basketball team at Austin Peay State College and selected members of a men's physical education class in basketball.

Testing Procedures

A. A one minute step-up test was given to the subjects participating. The resting pulse rate was taken for fifteen seconds before the test was given. After the test was given a fifteen-second count was taken at one, two, and three, minute intervals. These fifteen-second counts were multiplied by four to convert them into one minute readings.

B. The varsity athletes were tested at two week intervals beginning with the second week of practice. Testing was continued throughout the entire training period. They were tested for eight weeks after the season had terminated at two week intervals to determine the effect of detraining on their cardiovascular fitness.

C. The non-athletes were tested every two weeks beginning with the first week the basketball class met.

D. The room temperature was recorded during each test period to the nearest degree Fahrenheit.

E. The height, weight, and age of each subject was taken and recorded at the beginning of the study.

Variables to Control

A. The athletes acted as their own controls by participating in basketball practice regularly. At the end of the season they acted as controls by not participating in any vigorous organized exercise for eight weeks, during which time they were tested at the usual two week intervals to determine if the pulse rate was affected by detraining.

B. All the subjects were college male students enrolled at Austin Peay State College.

C. The non-athletes were chosen from a men's basketball class in physical education. Care was taken in the selection to find non-college-athletes.

D. The varsity athletes were tested on alternating Tuesdays when the season schedule permitted, but after the first five tests the schedule was inconsistent. When the athletes played one week-end game and a Monday game the coach would give them a day off, this was sometimes on a scheduled test day. When the day-off was a scheduled test day they were tested on the following Wednesday before practice as usual.

E. The varsity athletes were tested at 3:05 p.m. at two week intervals during the first ten weeks of training and the results were compared with the data obtained from the non-athletes.

F. The non-athletes were tested on Wednesday at 9:15 a.m. at two week intervals during the ten-week class period.

Sources of Error

A. It was not possible for the experimenter to control the diet of the subjects during the study; to control the amount of sleep or rest which the subjects encountered; or to control the temperature of the gymnasium where the tests were conducted.

B. If any of the subjects smoked this would have disturbed the homogeneity of the group as related to risk factors.

C. The time at which the subjects were tested varied. The athletes were tested before practice began at 3:05 and the non-athletes were tested before their physical education class began at 9:15 a.m.

D. There was difficulty in obtaining resting pulse rates.

E. Inaccurate counting by the subjects was difficult to detect, or never detected.

II. INSTRUMENTATION

Instruments Used During the Study

A. A standard mercurial Fahrenheit thermometer was used to determine the room temperature during each test period.

B. A Junghans stop watch was used to facilitate accurate timing of the test procedure.

C. A Seth Thomas metronome was used to facilitate accurate counting of cadence during the step-up test.

D. A fifteen and three-fourths inch bench was used during the experiment.

III. DATA COLLECTION

Procedure for Data Collection

A. The test was given in the Austin Peay State College Gymnasium.

B. The athletes were tested at approximately 3:05 p.m. on alternate Tuesdays, when possible, throughout the basketball training season to determine the effects of extended training on cardiovascular fitness of athletes and they were tested for eight weeks afterwards to determine the effects of detraining. Only the first five tests were used for comparison with the non-athletes.

C. The non-athletes were tested at approximately 9:15 a.m. on alternate Wednesdays for a period of ten weeks.

D. The metronome was set at 120 beats per minute allowing thirty steps per minute.

E. Test Procedures

1. The subjects were asked to sit down and relax for five minutes when they arrived at the testing station.

2. A fifteen second pulse count was taken from the radial artery of the left arm and recorded by the athlete's partner. The same partners were kept throughout the entire experiment.

3. One-half the subjects were tested while their partners recorded the pulse rates, then the second half of the group was tested using the first half as recorders. The order of testing was maintained throughout the experiment for both groups.

4. The subjects were asked to stand and face the bench. On the signal "up" they were told to step up on the bench with their right foot, bringing their left foot up on the bench at the count of two; on the count of three they were to step down

with their right foot and on four they were to bring their left foot down. Throughout the test the right foot remained as the lead foot. A military-like cadence was counted out as follows: up two-three-four, up two, three, four, etc. for the entire sixty seconds.

5. At the end of sixty seconds the subjects were told to "stop and sit down."

6. The recorders were then told to find the radial pulse and hold it until they were told to count.

7. One minute after the exercise the recorders were told "ready count." A fifteen second pulse count was then taken. At the end of fifteen seconds the recorders were told to "stop and record." This was repeated twice more for the two and three minute intervals after exercise.

8. The room temperature was recorded every time the test was given.

Time Schedule

A. The beginning test date was October 25, 1966, and the last test date was April 25, 1967, for the athletes.

B. The beginning test date was January 4, 1967, and the last test date was March 1, 1967, for the non-athletes.

IV. METHOD OF TREATING DATA

Each time the subjects were tested the results were plotted on a graph showing the resting pulse rate, and the three recovery pulse rates. Mean pulse rates were worked out after the testing period had ended.

An attempt was made to determine if there was a significant difference between the cardiovascular fitness of the athletes and non-athletes as determined by the pulse rate curves after the step-up test.

The following statistical formula was used to determine the significance of the difference between the two means:[50]

Standard Deviation:

$$SD = \sqrt{\frac{\Sigma x_1^2 + \Sigma x_2^2}{(N_1 - 1) + (N_2 - 1)}}$$

Standard Error of Difference:

$$SE_D = \sqrt{\frac{SE^2_{m_1}}{N_1} + \frac{SE^2_{m_2}}{N_2}}$$

Critical ratio or t-ratio $t = D/SE_D$
(D = the difference between the two means)

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[50] Henry E. Garrett, Elementary Statistics (New York: David McKay Company, Inc., 1964), pp. 122-124.

CHAPTER IV

PRESENTATION AND ANALYSIS OF RESEARCH DATA

This study was an endeavor to determine the influence of regular, organized exercise on cardiovascular fitness as determined by pulse rate following a step-up test.

The hypothesis stated that it was believed:

1. that cardiovascular fitness was not affected by regular vigorous exercise;

2. that persons engaged in regular organized periods of vigorous exercise would not show a significantly higher degree of cardiovascular fitness than those engaged in sporadic periods of vigorous exercise;

3. and that cardiovascular fitness, if affected, would not return to pretraining levels when organized exercise was terminated.

Subjects Studied

A total of eighteen athletes who were members of the Austin Peay State College varsity basketball team were chosen at the beginning of this study. Only twelve of the athletes finished the testing period without being absent during one of the first ten test periods. Only eight athletes were present for the fourteenth test. Eighteen non-athletes were chosen from a men's physical education class in basketball scheduled during the winter quarter at Austin Peay State College. Only twelve of the non-athletes were chosen for comparison with the athletes in this study. The non-athletes were chosen at random.

The subject's height, weight, and age were recorded at the beginning of the study. The athlete's mean age was twenty years, mean height was six feet and two inches, and mean weight was 178.25 pounds.

The non-athlete's mean age was eighteen and three-fourths years, mean height was five feet and nine inches, and mean weight was 160.33 pounds. The non-athletes were younger, shorter, and weighed less as a group than did the athletes.

The room temperature was recorded during each test period with a standard mercurial Fahrenheit thermometer. The average temperature was seventy-seven degrees Fahrenheit during the testing periods of the athletes, and the average temperature was seventy and four-tenths degrees Fahrenheit during the testing periods of the non-athletes.

TEST DATES: Athletes: October 25, 1966
Non-athletes: January 4, 1967

TEMPERATURE: October 25, 1966 79° F.
January 4, 1967 69° F.

SUBJECTS INVOLVED: Twelve athletes and twelve non-athletes were compared in this figure.

EXPLANATION OF FIGURE 1: This graph contains the comparative means obtained from the first test of the athletes and non-athletes. The pulse rates are plotted as follows for the athletes:

Resting	72
One-minute	75
Two-minute	70
Three-minute	71

The pulse rates for the non-athletes are plotted as follows:

Resting	81
One-minute	97
Two-minute	85
Three-minute	81

The t-test for significance indicated that the resting pulse rates were not significantly different (t=1.9). There was a significant difference between the one-minute rates at the .01 level (t=4.15), between the two-minute rates at the .01 level (t=3.26), and between the three-minute rates at the .05 level (t=2.29).

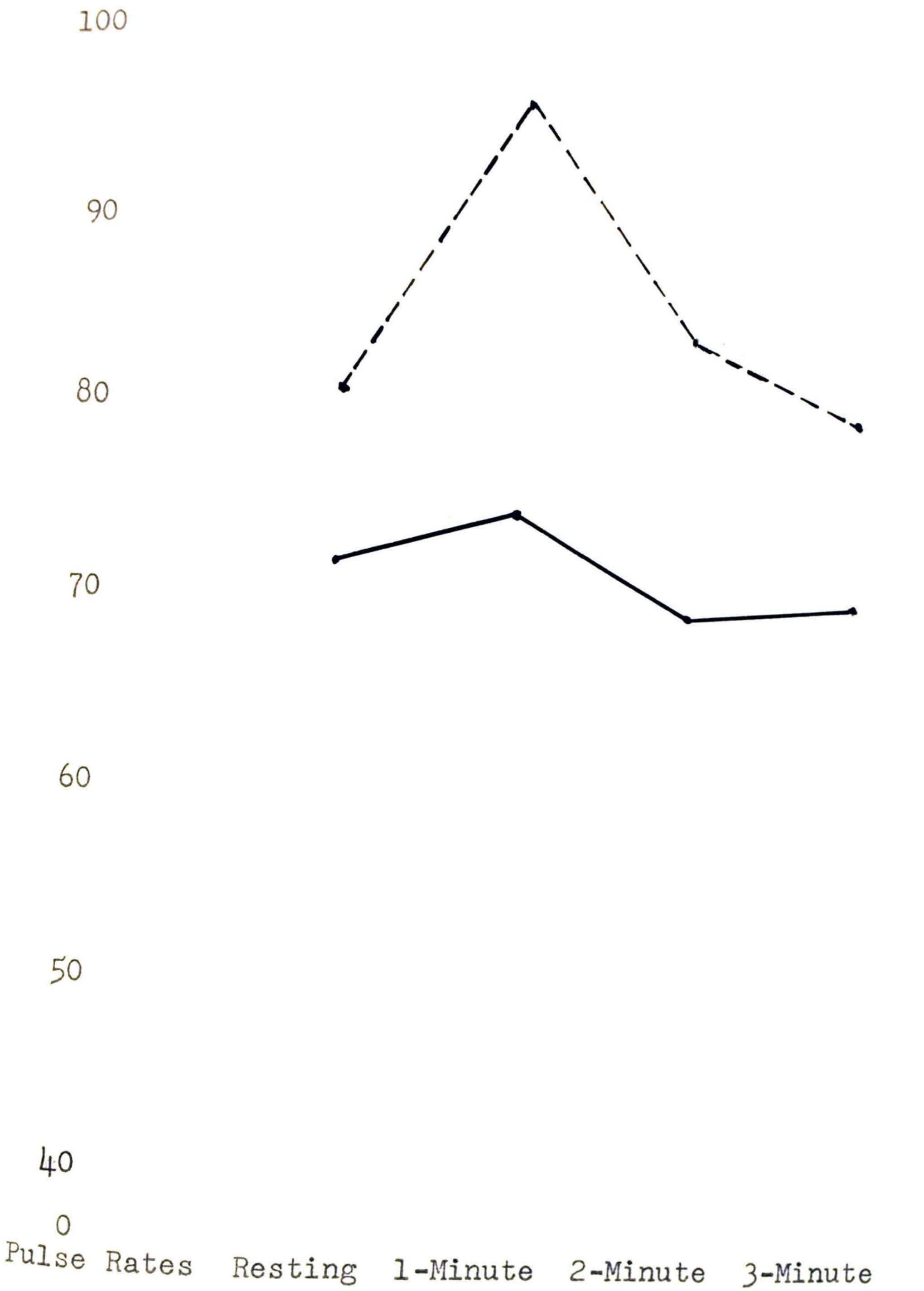

FIGURE 1

COMPARATIVE MEANS OBTAINED FROM THE FIRST TEST
OF ATHLETES AND NON-ATHLETES

ATHLETES ______ NON-ATHLETES _ _ _ _

TEST DATES: Athletes: December 15, 1966
Non-athletes: March 1, 1967

TEMPERATURE: December 15, 1966 75° F.
March 1, 1967 66° F.

SUBJECTS INVOLVED: Twelve athletes and twelve non-athletes were compared in this figure.

EXPLANATION OF FIGURE 2: This graph contains the comparative means obtained from the fifth test of the athletes and non-athletes. The pulse rates are plotted as follows for the athletes:

Resting	68
One-minute	69
Two-minute	67
Three-minute	66

The pulse rates for the non-athletes are plotted as follows:

Resting	73
One-minute	83
Two-minute	75
Three-minute	74

The t-values for significance indicated that the resting pulse rates were not significantly different with a t-value of 1.27. However, the one-minute pulse counts were significantly different at the .01 level with a t-value of 2.98. The two-minute counts were not significantly different with a t-value of 1.87 and the three-minute counts were not significantly different with a t-value of 1.83.

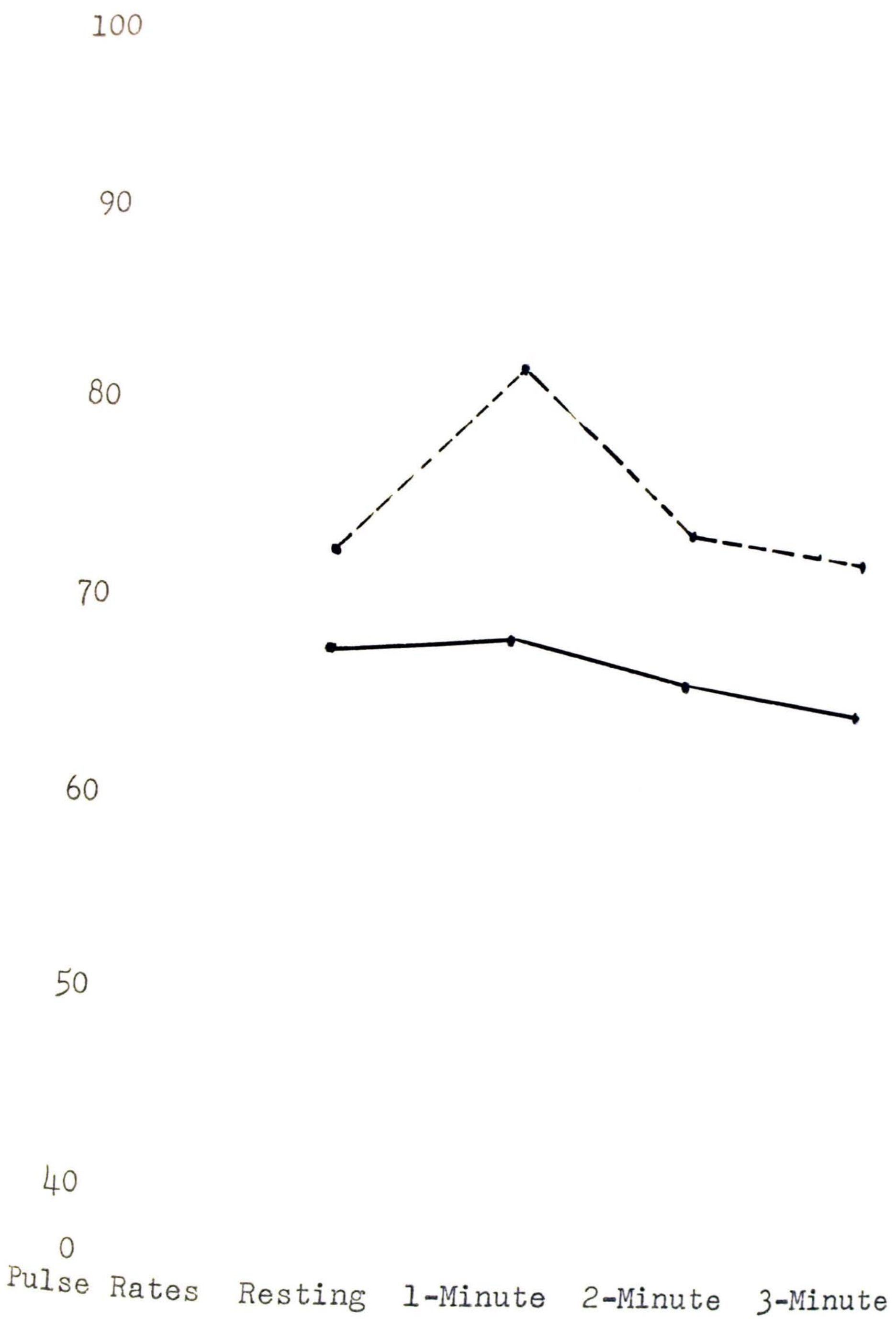

FIGURE 2

COMPARATIVE MEANS OBTAINED FROM THE FIFTH TEST
OF ATHLETES AND NON-ATHLETES

ATHLETES ______   NON-ATHLETES - - - -

TEST DATES: First test: January 4, 1967
Fifth test: March 1, 1967

TEMPERATURE: January 4, 1967 69° F.
March 1, 1967 66° F.

SUBJECTS INVOLVED: Figure 3 shows the comparison of results obtained from the first and the fifth test of the twelve non-athletes.

EXPLANATION OF FIGURE 3: This graph contains the comparative means obtained from the first test and the fifth test of the non-athletes. The pulse rates are plotted as follows for the first test:

Resting	81
One-minute	97
Two-minute	85
Three-minute	81

The pulse rates for the fifth test are plotted as follows:

Resting	73
One-minute	83
Two-minute	75
Three-minute	74

The t-values indicated that the resting pulse rates were not significantly different after ten weeks of training with a t-value of 1.67. The one-minute pulse rates when compared were significantly different at the .05 level with a t-value of 2.34. The two-minute pulse counts and three-minute pulse counts were not significant with t-values of 1.85 and 1.50 respectively.

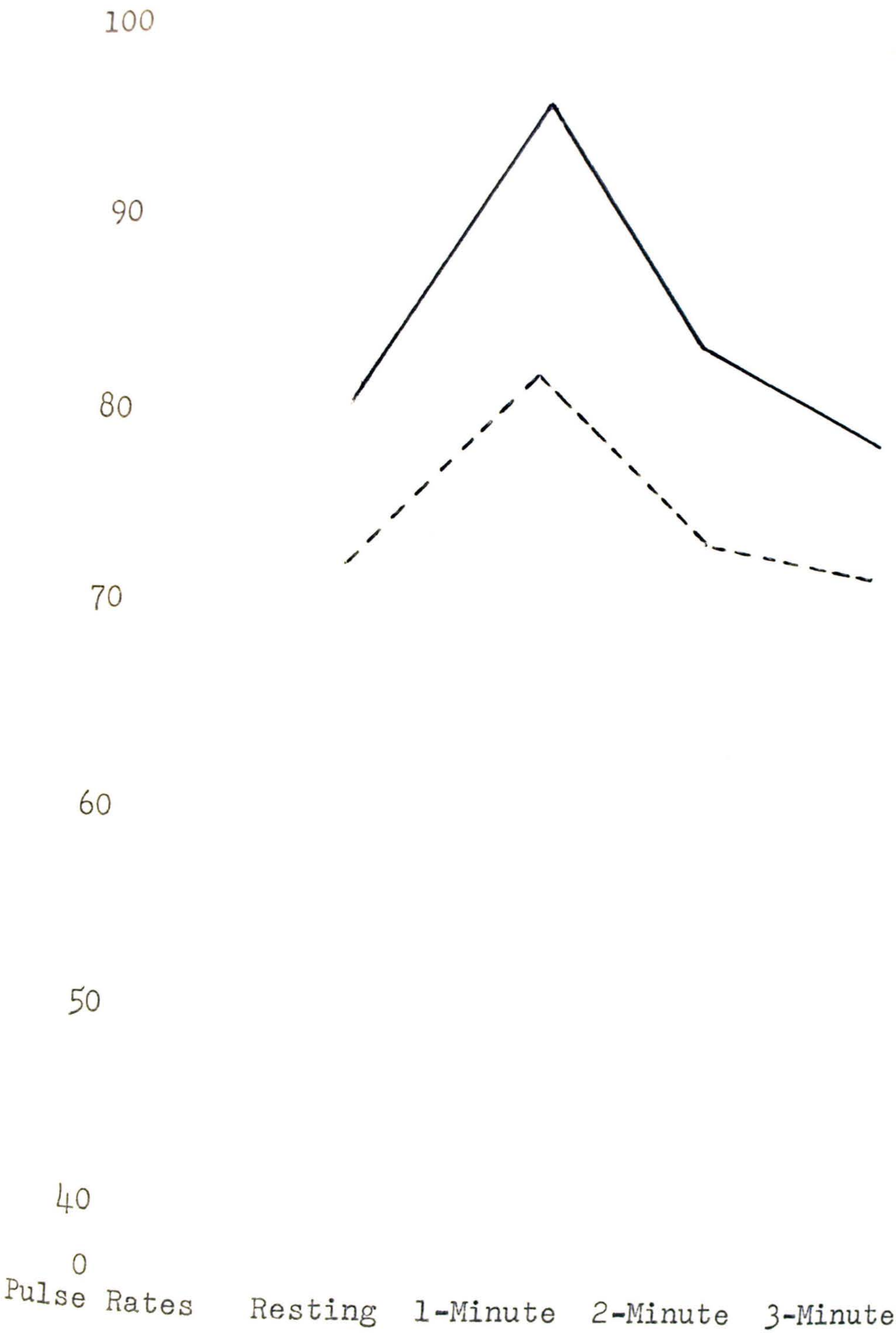

FIGURE 3

COMPARATIVE MEANS OBTAINED FROM THE FIRST AND FIFTH TESTS OF THE NON-ATHLETES

FIRST TEST ______ FIFTH TEST _ _ _ _

TEST DATES: First test: October 25, 1966
Fifth test: December 15, 1966

TEMPERATURE: October 25, 1966 79° F.
December 15, 1966 75° F.

SUBJECTS INVOLVED: Figure 4 shows the comparison of results obtained from the first and fifth test of the twelve athletes.

EXPLANATION OF FIGURE 4: This graph contains the comparative means obtained from the first test and the fifth test of the athletes. The pulse rates are plotted as follows for the first test:

Resting	72
One-minute	75
Two-minute	70
Three-minute	71

The pulse rates for the fifth test are plotted as follows:

Resting	68
One-minute	69
Two-minute	67
Three-minute	65

Not any of the t-values proved to be significant for the tests given to the athletes during the first nine weeks of training. The t-values are as follows: resting count t=1.06, one-minute counts t=1.59, two-minute counts t=.90, and the three-minute counts t=1.63.

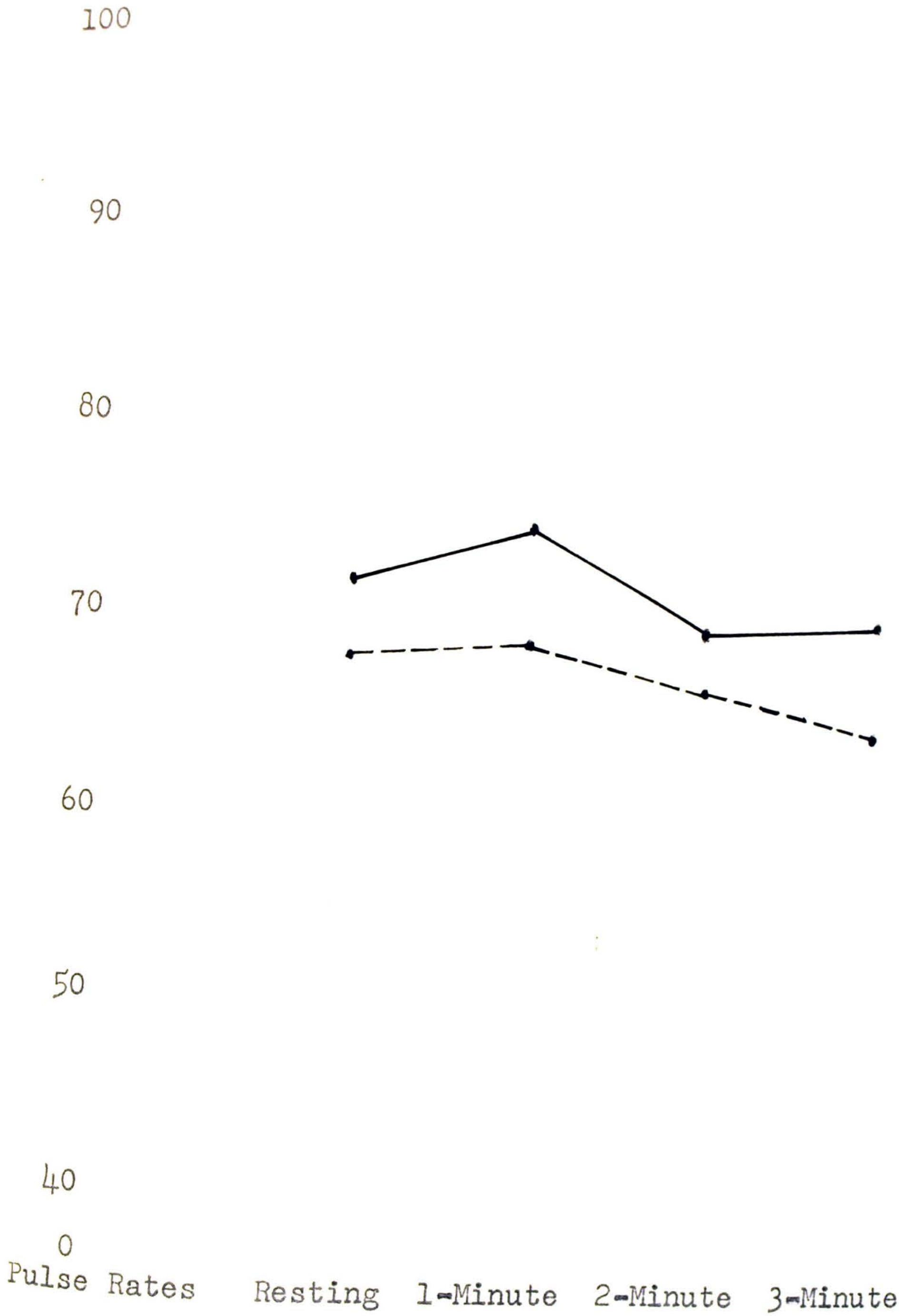

FIGURE 4

COMPARATIVE MEANS OBTAINED FROM THE FIRST AND FIFTH TESTS OF THE ATHLETES

FIRST TEST ______ FIFTH TEST _ _ _ _

TEST DATES: First test: October 25, 1966
Tenth test: March 1, 1967

TEMPERATURE: October 25, 1966 79° F.
March 1, 1967 75° F.

SUBJECTS INVOLVED: Figure 5 shows a comparison of the results obtained from the first and the tenth test of the twelve athletes.

EXPLANATION OF FIGURE 5: This graph contains the comparative means obtained from the first test and the tenth test of the athletes. The pulse rates are plotted as follows for the first test:

Resting	72
One-minute	75
Two-minute	70
Three-minute	71

The pulse rates for the tenth test are plotted as follows:

Resting	68
One-minute	69
Two-minute	68
Three-minute	67

Not any of the t-values proved to be significant for the tests given the athletes during the first nineteen weeks of training. The t-values are as follows: resting counts t=1.09, one-minute counts t=1.42, two-minute counts t=.50, and the three-minute counts t=1.05.

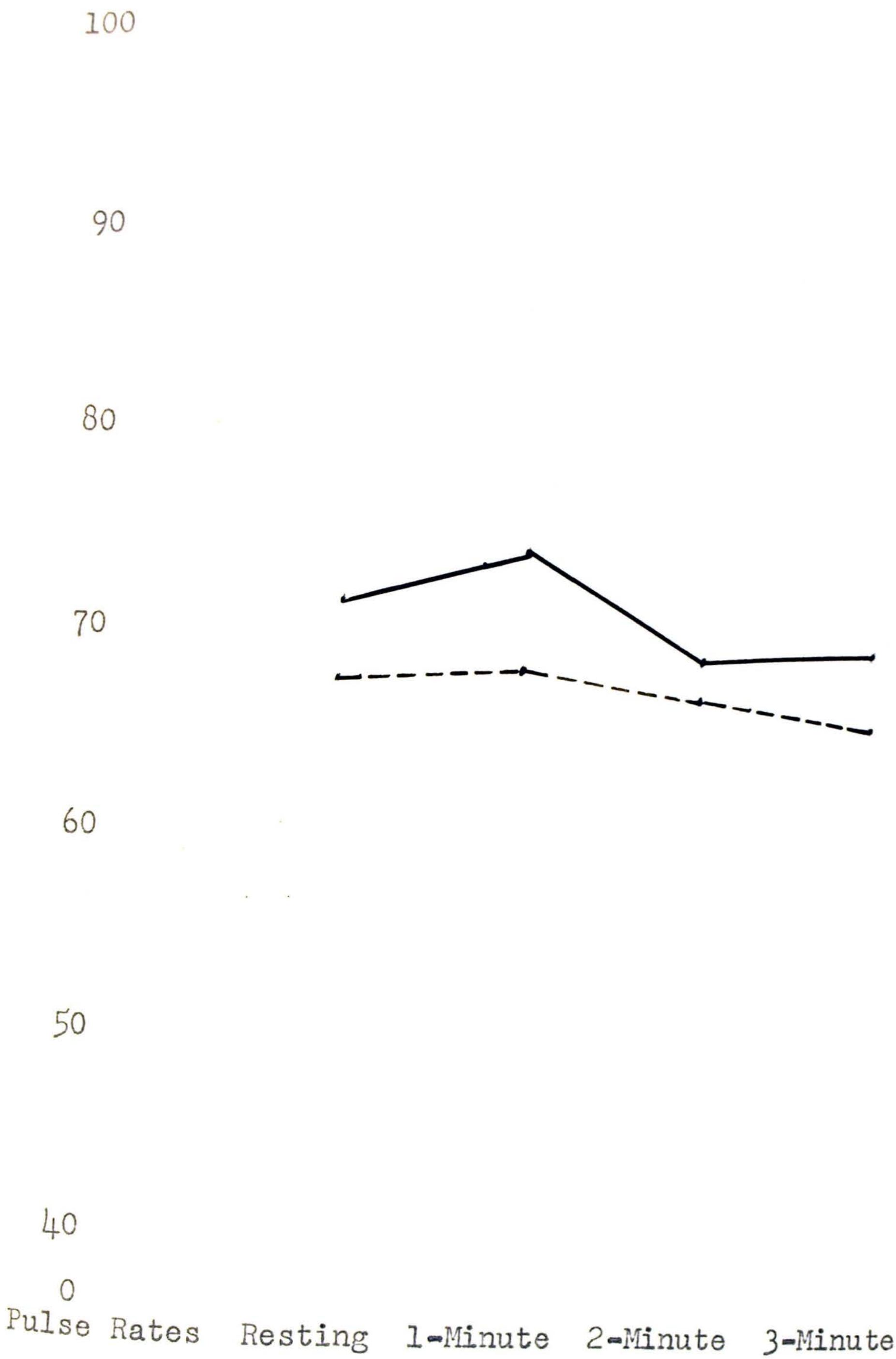

FIGURE 5

COMPARATIVE MEANS OBTAINED FROM THE FIRST AND TENTH TESTS OF THE ATHLETES

FIRST TEST ______ TENTH TEST - - -

TEST DATES: Tenth test: March 1, 1967
Fourteenth test: April 25, 1967

TEMPERATURE: March 1, 1967 75° F.
April 25, 1967 76° F.

SUBJECTS INVOLVED: This figure contains the comparative means of the tests given to the athletes who were present for the tenth test and the fourteenth test periods. Only eight athletes were present for the fourteenth test, therefore, only the same eight athletes were used for comparison.

EXPLANATION OF FIGURE 6: This graph contains the comparative means obtained from the tenth test and the fourteenth test of the athletes who were present for both tests. The pulse rates are plotted as follows for the tenth test:

Resting	68
One-minute	70
Two-minute	68
Three-minute	67

The pulse rates are plotted as follows for the fourteenth test:

Resting	80
One-minute	89
Two-minute	86
Three-minute	85

All of the pulse rates were significantly different when a comparison was made from the tenth and fourteenth tests. The resting counts were found to be significant at the .05 level with a t-value of 2.92. The one-minute counts were significant at the .01 level with a t-value of 3.07. The two-minute counts were significantly different at the .05 level with a t-value of 2.76. The three-minute counts were found to be significantly different at the .01 level with a t-value of 3.49.

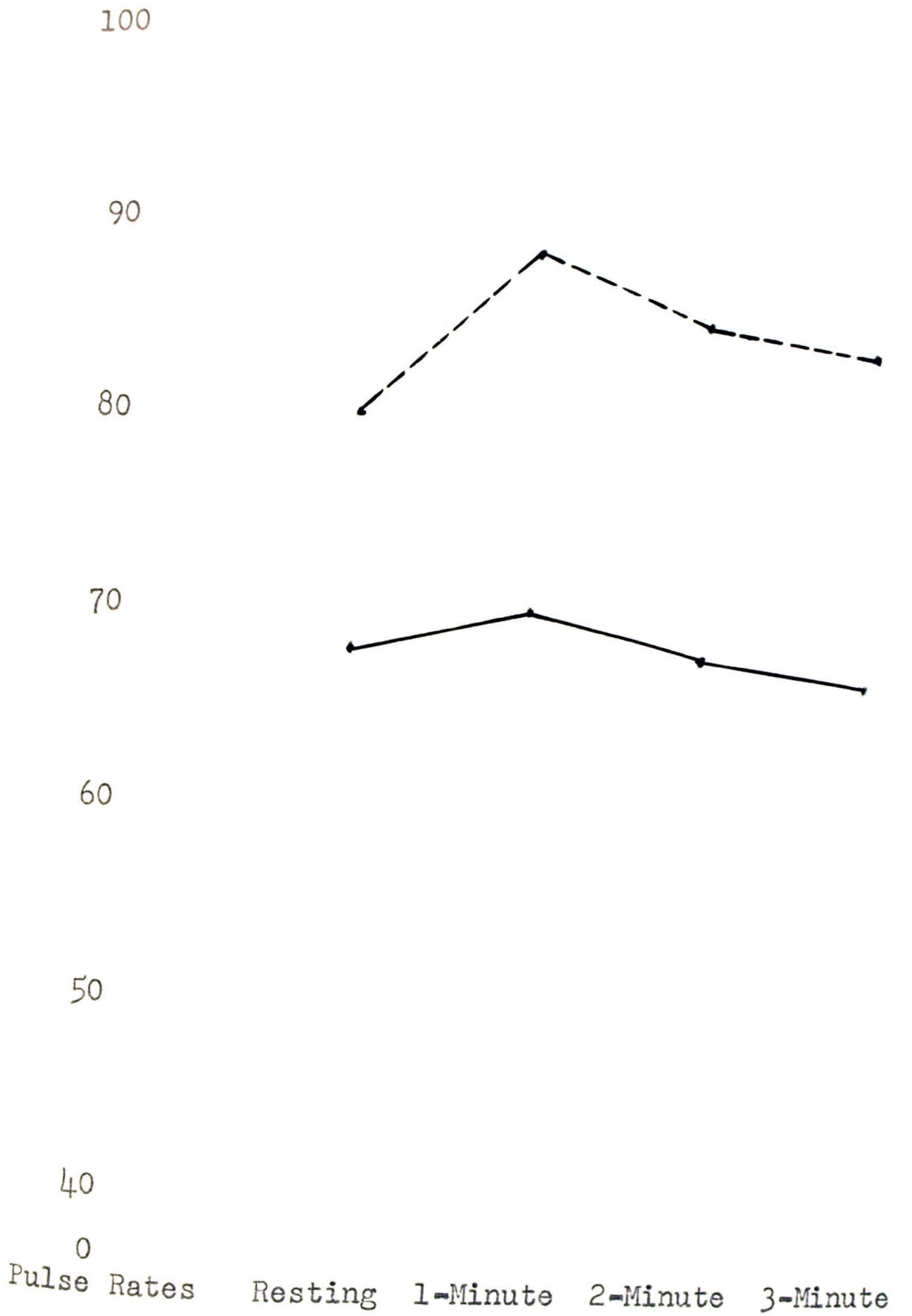

FIGURE 6

COMPARATIVE MEANS OBTAINED FROM THE TENTH AND FOURTEENTH TESTS ONLY OF ATHLETES WHO WERE PRESENT FOR BOTH TESTS

TENTH TEST ______ FOURTEENTH TEST - - -

TEST DATES: First test: October 25, 1966
Fourteenth test: April 25, 1967

TEMPERATURE: October 25, 1966 79° F.
April 25, 1967 76° F.

SUBJECTS INVOLVED: This figure contains the comparative means of the tests given to the athletes who were present for the tenth test and the fourteenth test, therefore, the same subjects were chosen from the tenth test.

EXPLANATION OF FIGURE 7: This graph contains the comparative means obtained from the first and fourteenth tests of the athletes who were present for both tests. The pulse rates are plotted for the first test as follows:

Resting	74
One-minute	78
Two-minute	70
Three-minute	73

The pulse rates are plotted for the fourteenth test as follows:

Resting	80
One-minute	89
Two-minute	86
Three-minute	85

The resting pulse rates were not found to be significantly different with a t-value of 1.89. However, the one-minute counts were significantly different at the .05 level with a t-value of 2.22. The two-minute and three-minute counts were significantly different at the .01 level with t-values of 3.30 and 4.06 respectively.

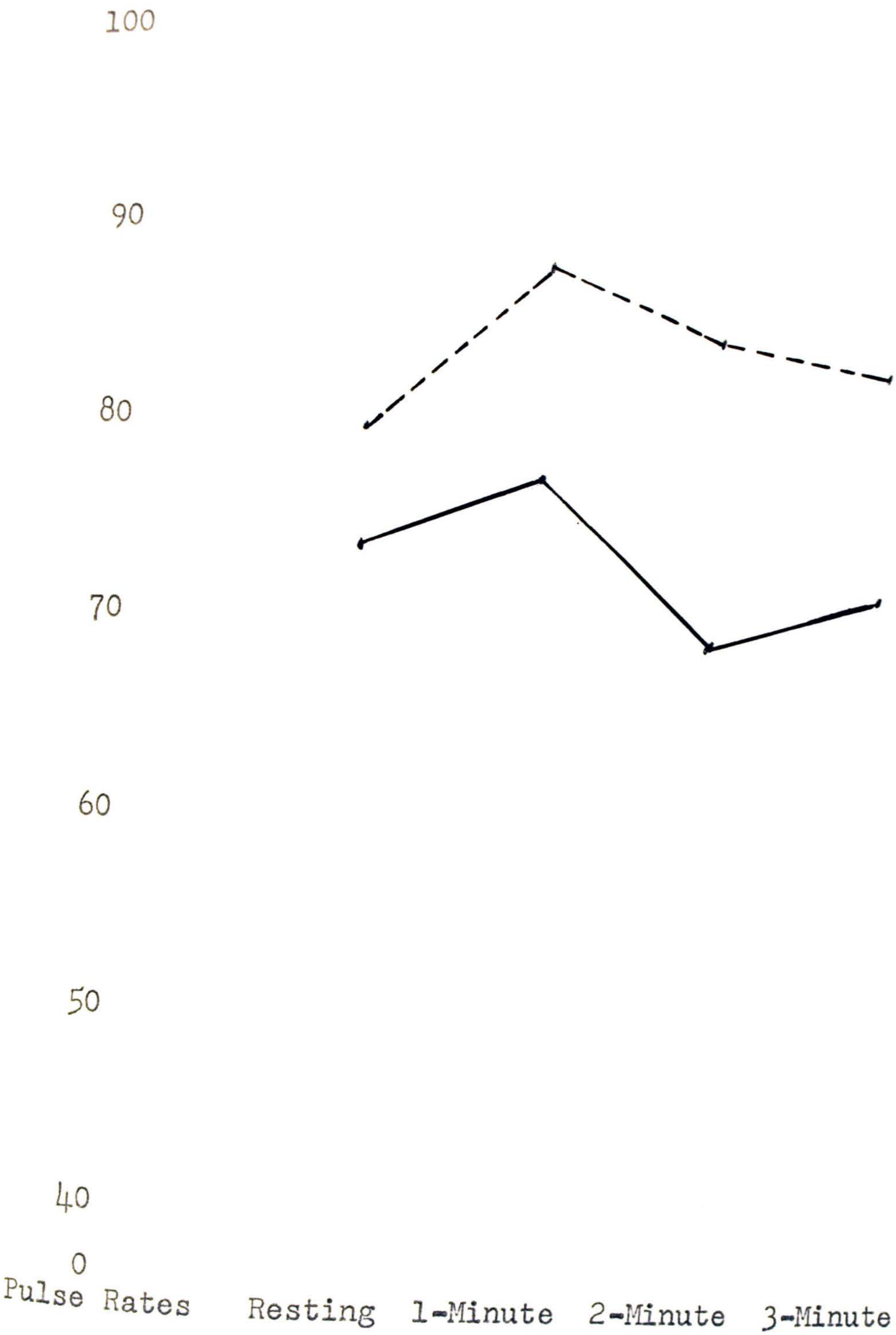

FIGURE 7

COMPARATIVE MEANS OBTAINED FROM THE FIRST AND FOURTEENTH TESTS ONLY OF ATHLETES WHO WERE PRESENT FOR THE FOURTEENTH TEST

FIRST TEST ______ FOURTEENTH TEST - - -

The following can be reported with regard to the first statement in the hypothesis:

1. The results obtained from the comparison between the first and fifth tests of the non-athletes found that sporadic periods of vigorous exercise do not significantly affect cardiovascular fitness, as determined by the pulse rate curve, except during the period immediately following the exercise. It can be seen, however, that the pulse rate curve did decrease after the ten week training period, but it was not a significant decrease except for the one-minute period after exercise.

2. According to the results obtained from the comparison between the first and fifth tests of the athletes there was a decrease in the pulse rate curve, however, it was not a significant decrease. Also, not any of the statistical comparisons between the first and tenth test means proved to be significantly different for the athletes. According to these results, extended training does not appear to have a significant affect on cardiovascular fitness as determined by pulse rate curves. Since the results showed some decrease in pulse rate we can reject, for the most part, the first statement of our hypothesis, that cardiovascular fitness would not be affected by regular vigorous exercise.

The following can be reported with regard to the second statement in the hypothesis:

1. A significant difference was found between the one-minute, two-minute, and three-minute pulse rates when the means from the first test of the athletes and non-athletes were compared statistically. There was not any significant difference between the resting pulse rates of the first test.

2. However, according to the results obtained from the fifth test of the athletes and non-athletes it would seem necessary for the most part to accept the null hypothesis, that persons engaged in regular organized periods of exercise do not show a significantly higher degree of cardiovascular fitness than those engaged in sporadic periods of exercise. Only the one-minute pulse counts proved to be significantly different when compared statistically.

The following can be reported with regard to the third statement in the hypothesis:

A comparison of the means from the tenth and fourteenth tests of only the athletes who were present for both tests proved to be significantly different at every interval. A period of eight weeks elapsed between the tenth test and the fourteenth test. During this period the athletes were not participating in any formal training. Since the test for significance found the two test scores to be significantly different we can reject the third statement in the hypothesis, that cardiovascular fitness would not return to pretraining levels when organized exercise was terminated.

A comparison of means obtained from the first and fourteenth tests of only the athletes who were present for both tests proved to be significantly different at the one-minute, two-minute, and three-minute intervals. This increase in the pulse rates of the athletes from the comparison made between the first and fourteenth tests may be explained by the fact that the athletes did not officially begin their training season until the third week of October, but they were participating in voluntary training sessions without the presence of a coach from the beginning of the fall quarter in September. This may account for the tremendous difference between the first and fourteenth tests.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was an endeavor to determine the influence of regular, organized exercise on cardiovascular fitness as determined by pulse rate following a step-up test. It was hypothesized that cardiovascular fitness would not be affected by regular vigorous exercise; that persons engaged in regular organized periods of vigorous exercise would not show a significantly higher degree of cardiovascular fitness than those engaged in sporadic periods of vigorous exercise; and that cardiovascular fitness, if affected, would not return to pretraining levels when organized exercise is terminated.

Only twelve subjects were used in the final analysis of the comparison between the athletes and non-athletes. Only twelve athletes finished the first ten tests without being absent. A comparison was also made between the athletes' first and fourteenth tests. Only eight athletes were present for the fourteenth test, therefore, only eight subjects were used for this comparison.

At the beginning of the study the athletes had significantly lower pulse rates than did the non-athletes except for the resting pulse rates. After the first five tests the athletes no longer had a significantly lower pulse rate except at the one-minute interval after the step-up test. Therefore, it would seem necessary to accept the null hypothesis that persons engaged in regular organized periods of vigorous exercise do not show a significantly higher degree of cardiovascular fitness than those engaged in sporadic periods of vigorous exercise.

It was found that exercise did affect the pulse rate curves in the athletes and non-athletes included in this study, but not significantly. The athletes and non-athletes both showed decreases in their pulse rate curves between the first and fifth test periods, but there was not a significant decrease at any interval except at the one-minute interval for the non-athletes after the fifth test.

After the first ten tests the athletes showed a slight decrease in their pulse rate curves. However, the comparison of means indicated that the decrease was not significant.

In the statistical comparison between the athletes' tenth and fourteenth tests every interval proved to be significantly different. Therefore, we can reject the hypothesis that cardiovascular fitness would not return to pretraining levels when organized exercise was terminated. This comparison included only eight athletes who were present for both tests.

It may also be mentioned here, that in a test of significance between the first and fourteenth tests, it was found that there was a significant increase in pulse rates at the one-minute, two-minute, and three-minute intervals from the first test to the fourteenth test.

It can be concluded that:

1. Cardiovascular fitness as determined by a pulse rate curve is affected by organized exercise.

2. Both regular periods of organized exercise and sporadic periods of organized exercise affect pulse rate curves, but there is not a significant difference between these pulse rate curves as determined by this study.

3. When periods of organized exercise are terminated pulse rate curves tend to return to pretraining levels.

4. In order for cardiovascular fitness to be improved by exercise, one should participate in a regular organized program of exercise.

At the end of the first ten weeks of training the athletes and non-athletes differed significantly only at the one-minute interval after exercise. Formerly they had significantly different pulse rates at the one-minute, two-minute, and three-minute intervals after the standardized exercise. This may be due to the fact that the hearts of the athletes adjust faster after exercise than do the hearts of non-athletes, although the hearts of the non-athletes did adjust back to normal levels within the three-minute period after exercise.

After training had terminated, the athletes' pulse rates showed a significant increase from the pulse rates obtained at the end of the training period. This indicates that unless training is continuous cardiovascular fitness, as determined by pulse rate curves, cannot be maintained.

Future studies in this area might be improved by obtaining a more strict control over the pretraining period, thereby eliminating the possible influence of informal training periods. Also, there is a need for a larger sample of subjects in order to make the results more reliable.

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