A STUDY OF RELATIONSHIP BETWEEN THE HARVARD STEP TEST AND A THREE MINUTE TREADMILL RUN AS MEASURES OF CARDIOVASCULAR EFFICIENCY OF COLLEGE MALES

511

A Thesis

Presented to

the Department of Health, Physical Education,

Recreation, and Athletics

Kansas State Teachers College of Emporia

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Marcus M. Goodrich

August 1969

Approved for the Major Department

Approved for the Graduate Council

DEDICATION

To my wife, Donna, I dedicate this thesis, for her assistance and constant encouragement throughout this study.

Also, in memory of Melvin (Shorty) Long, whose indirect encouragement and moral support prompted me to completion of this study.

ACKNOWLEDGMENT

Acknowledgment and appreciation is expressed to Dr. George Milton of the Department of Physical Education for his guidance and patience in the development and completion of this paper.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Physiological tests, especially of cardiovascular-respiratory nature, have been experimented with in this country since 1884. It was first believed that the ability of a muscle to perform was dependent upon the efficiency of the circulatory system. Since then, many other experimenters have worked in this field, such as Clarke and Cureton, measuring various qualities of cardiovascular efficiency, who also found that the cardiovascular system performs a vital service in the performance of sustained muscular activity.[1]

Whether referring to cardiovascular efficiency as cardiovascular function, functional health, physiological efficiency, organic condition, circulatory endurance, or any other term describing a person's ability to perform a physical task, is immaterial. Physical educators are concerned with the measurement of cardiovascular, or circulatory endurance. This form of endurance involves the continued activity of the entire organism, during which major adjustments of the circulatory and respiratory systems are necessary, as in running, swimming, and climbing. This

---

[1] H. Harrison Clarke, Application of Measurement to Health and Physical Education (New Jersey: Prentice-Hall, Inc., 1967), p. 179.

form of endurance is not only dependent upon the strength of the muscles involved in the activity but must rely greatly on the effective functioning of the cardiovascular system.[2]

II. THE PROBLEM

Statement of the problem. The purpose of this study was to investigate the degree of relationship which exists between the Harvard Step Test and a three minute Treadmill Test upon the cardiovascular efficiency of college males.

Statement of the hypothesis. There is no significant difference in the relationship of the Harvard Step Test and the three minute Treadmill Run on cardiovascular efficiency.

Importance of the study. This study was made in order to investigate cardiovascular efficiency through two cardiovascular tests, the Harvard Step Test and the Treadmill Run, and to determine the relationship of the two tests, if any. This could be used as a guide to help the trained physical education teacher in evaluating physical fitness and for the purpose of classification when the services of a physician are not immediately available, or when the need is for the determination of physical condition rather than of the relative degrees of health.[3]

---

[2] *Ibid.*

[3] Mary Agnes Murphy, "A Study of the Primary Components of Cardiovascular Tests," *Research Quarterly*, XI (1940), p. 57-59.

Limitations of the study. This study involved sixty male students who were enrolled full-time at Kansas State Teachers College of Emporia, during the spring semester of 1969. These students were enrolled in physical activity classes specifically designed for the development of physical fitness.

This study was not concerned with height, weight, age, classification, attitudes, or general background of the subjects. Nor was this study concerned with any other activities of the subjects being tested, such as eating, sleeping, forms of recreation, or emotional problems. This study was concerned with the testing of two qualities: (1) cardiovascular efficiency as measured by the Harvard Step Test, and (2) cardiovascular efficiency as measured by the Treadmill.

III. DEFINITION OF TERMS

Cardiovascular efficiency. Cardiovascular efficiency refers to the rapidity with which the heart can return to normal after having being subjected to a very strenuous exercise for a given length of time. 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: (1) the length of time he can sustain it, and (2) the deceleration of the heart rate after exercise.[4]

Harvard Step Test. The purpose of the Harvard Step Test is to measure the general capacity of the body. This test involves minimum skill which requires the subject to lift his weight a known height (the height of the bench) at a rate which can be determined by a rhythmic cadence.

Treadmill Run. The Treadmill Run is a measure of the general capacity of the body by means of a mechanical device. It brings about a slightly better involvement of large muscle masses than any other device used to measure cardiovascular efficiency since the arms and shoulders can and do enter into the activity.

---

[4]Lucien Brouha, M.D., "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, XIV (March, 1943), pp. 31-36.

CHAPTER II

REVIEW OF RELATED LITERATURE

It is the purpose of this chapter to present a summary of those studies which are related to measuring cardiovascular efficiency by means of (1) a step test, and (2) a treadmill test.

I. RESEARCH RELATED TO THE HARVARD STEP TEST

A study of the primary components of cardiovascular tests was conducted by Murphy to analyze statistically, for their common and group components, thirty-two cardiovascular test variables of young women at the college level. The second purpose of her study was to formulate combinations of items which would give high multiple correlations with common components. In the first stage of the development of cardiovascular testing the physiological functions were assumed; then tests were applied to attempt to prove or disprove the validity of the assumptions. Few of the tests were ever checked for either reliability or validity by use of any rigorous statistical controls. In the second stage of the development of cardiovascular testing was found the beginning of scientific validation. The criteria was selected, a number of variables studied, and a test or battery chosen which was valid as determined by the criteria.

During the third period no tests were proposed but a new method of analyzing tests was utilized, the analysis of multiple factors.[5]

In preliminary trials of the step test, Gallagher and Brouha found a wide range of size in boys between the ages of twelve and eighteen years. As a consequence, two heights of benches were used for the small and large boys. The division of the boys was made on the basis of body surface area, as follows:

Less than 1.85 square meters:	18-inch bench
1.85 square meters and above:	20-inch bench

The stepping rate was thirty steps a minute for four minutes, unless of course, the subject stopped sooner because of exhaustion. At the conclusion of testing 600 private school boys, the investigators presented the following distribution of scores:

Score of	
50 or less: Very poor physical condition	2 per cent
51-60: Poor physical condition	18 per cent
61-70: Fair physical condition	50 per cent
71-80: Good physical condition	25 per cent
81-90: Excellent physical condition	4 per cent
91 or more: Superior physical condition	1 per cent[6]

---

[5]Mary Agnes Murphy, Ph.D., "A Study of the Primary Components of Cardiovascular Tests," Research Quarterly, XI (1940), p. 57. (Microcard.)

[6]J. Roswell Gallagher and Lucien Brouha, "A Simple Method of Testing the Physical Fitness of Boys," Research Quarterly, XIV (March, 1943), p. 23.

Pulse wave and blood pressure changes during a physical training program were studied by Michael and Gallon in 1957-58, using seventeen members of the University of California, Santa Barbara, varsity basketball team as subjects. They ranged in age from nineteen to twenty-six years, their weight ranged from 139 to 223 pounds, and heights from 68.5 to 77.5 inches. The changes in physical conditioning were estimated using a step test which was administered each three weeks during sixteen weeks of training, again ten weeks after de-training, and after thirty weeks of de-training. During this period of time the blood pressure and pulse wave measurements were studied to investigate the effects of basketball conditioning on these measurements. The blood pressure measurements were taken by ausculation using a mercury manometer. The pulse wave was obtained indirectly from the brachial artery using a Cameron Heartometer and all pressures were taken on the left arm. The resting pulse wave and blood pressure measurements and the postexercise blood pressure measurements taken after a step test were also examined during this period of time.

It was found that the resting and postexercise systolic blood pressure measurements decreased significantly during training. These changes were significant after sixteen weeks, while the pulse rate changes indicated conditioning had changed in six weeks. During de-training these measurements reversed and made significant changes in ten weeks. The pulse wave measurements more closely followed those of the step test. They changed significantly in six weeks, leveled off, and finally reversed to the starting level during de-training.[7]

Hodgkins and Skubic conducted a study to develop national cardiovascular efficiency standards for college women as measured by a three-minute step test and to determine differences that may exist with regard to height, weight, major field of study, and geographical location. Recovery pulse rates following a three-minute step test were obtained for 2,360 college women who were enrolled in sixty-six colleges and universities representing the six districts of the AAHPER. The mean recovery pulse rate (thirty seconds pulse taken one minute after completion of the exercise) for all women who completed the three minutes of stepping was 64.43 with a standard deviation of 9.87 and a range of thirty-two to 120. The pulse rates were then converted to cardiovascular efficiency scores and national standards were established. These included six categories and ranged from excellent to very poor. Through their study, Hodgkins and Skubic concluded that scores from the Eastern district were

---

[7]Ernest D. Michael, Jr. and Arthur J. Gallon, "Pulse Wave and Blood Pressure Changes Occurring During a Physical Training Program," Research Quarterly, XXXI (March, 1960), p. 43.

better than all others; that physical education majors scored higher than majors in other disciplines; that there is no correlation between height and scores on the step test; and that women who weighed 150 pounds or more did not score as well as those who weighed under that amount.[8]

Recovery pulse rates following a three minute step test were obtained from 686 junior high school and 1,332 high school age girls who were students in fifty-five different secondary schools throughout the six districts of the AAHPER by Skubic and Hodgkins. The cardiovascular efficiency test consisted of stepping up and down on an eighteen inch bench at the rate of twenty-four steps per minute for three minutes. Following the exercise, subjects rested for one minute in a sitting position; the pulse was then counted for thirty seconds. The pulse was taken at the carotid artery by the palpation method. The mean recovery pulse rate for 652 junior high school girls who completed the three minutes of stepping was 63.78 beats, with a standard deviation of 10.25. Thirty-four girls, or 4.9 per cent, were unable to complete the test. The mean recovery pulse rate for 1,204 senior high school girls who completed the three minutes of stepping was 65.72, with a standard

---

[8]Jean Hodgkins and Vera Skubic, "Cardiovascular Efficiency Test Scores for College Women in the United States," Research Quarterly, XXXIV (December, 1963), p. 454.

deviation of 9.63. Of the total group, 128, or 9.6 per cent, did not complete the test. The pulse rates were converted to cardiovascular efficiency scores and from these, national standards were established for the nine through fourteen age group and for the fifteen through nineteen age group. The standards consisted of six categories from excellent to very poor. In addition, it was found that junior high school subjects scored better than high school subjects; that neither temperature nor time of day of testing had a significant effect on test scores; and that at the high school level the senior high school subjects in the Central district achieved the best scores of the six districts while at the junior high level the Central and Southern districts ranked together as best.[9]

Garrett, Sable, and Pangle conducted a study that compared four approaches to increasing the cardiovascular fitness of subjects participating in regular and systematic volleyball instruction. A secondary purpose was to determine whether or not such cardiovascular improvement could be obtained without minimizing the opportunity for skill development. The four treatments, each administered during the final three or four minutes of the scheduled teaching

---

[9]Vera Skubic and Jean Hodgkins, "Cardiovascular Efficiency Test Scores for Junior and Senior High School Girls in the United States," Research Quarterly, XXXV (May, 1964), p. 184.

period, were running in place, rope skipping, bench stepping, and continued volleyball instruction.

Students enrolled in two regularly scheduled sections of volleyball were divided randomly into two subgroups each. Thus, four treatment groups were formed with numbers of thirteen, eleven, seven, and nine, respectively. All subjects involved were male students at Peabody College who elected to enroll in these sections during the winter quarter of 1964. Although predominantly freshmen, the sample contained a few students of higher qualification. Ages ranged from eighteen to twenty-six years with the mean age being 19.52.

Working within a teaching period of approximately forty minutes a day, twice a week, each subgroup received a two-part treatment. The first part represented a common core of volleyball instruction given routinely, but independently, to both classes. During this time the treatment groups within each class functioned as a single group which constituted the first thirty-five minutes of the teaching period. The second and differentiating part of the treatment period consisted of the last three or four minutes during which the students assembled into their respective treatment groups and responded to the four different types of activities.

Scores on the Harvard Step Test provided the criterion measure of cardiovascular fitness. This test was administered initially during the first week of the quarter and on two subsequent occasions at three-week intervals. The Brady Skill Test was used to measure volleyball skill proficiency at the conclusion of the quarter. In both classes the skill testing was done as a part of the final course evaluation, and results were used as a partial basis for assigning student marks as well as for the purposes of the study.

The first hypothesis tested was that of no AB interaction ($F = .95$). In the absence of AB interaction there was no real need to test the B effects, even though both B and A comparisons were significant at the .05 level. In the absence of an AB interaction, whatever terminal differences existed in B at the end of the experiment was a function of initial differences present.

From the results of the study, one may conclude that cardiovascular fitness increased significantly over the experimental period. However, this gain cannot statistically be attributed to a single treatment approach. In terms of "absolute values" of gain score the treatment groups ranked; (1) running in place (+15), (2) rope skipping (+13), (3) bench stepping (+8), and (4) continued volleyball instruction (+14). Regardless of approach, each treatment population achieved equally in terms of demonstrating volleyball proficiency at the end of the quarter.[10]

[10]Leon Garrett, Mohammed Sabie, and Roy Pangle, "Four Approaches to Increasing Cardiovascular Fitness During Volleyball Instruction," Research Quarterly, XXXVI (December, 1965), p. 496.

Cureton did a study of various factor analyses of cardiovascular-respiratory test between 1936 and 1962. All tests were studied and the factors grouped into clusters of (1) resting state, (2) change of postural position from quiet sitting or lying to standing, (3) moderate circulatory performing capacity, (4) maximal performing capacity, (5) recuperative ability after exercise, and (6) respiratory capacity and reserve. The cardiovascular-respiratory tests were grouped according to three different types and periods of factor analysis. The factors from various studies were affected by the type of subjects, the body positions, and the relative state of fitness. The various tests in the quiet state indicated relative sympathetic or parasympathetic dominance, blood flow, cardiac output, and metabolism. The electrocardiographic and ballistocardiographic observations were included only in the last factor analyses. Moderate circulatory performing capacity tests indicated that there was relative economy to the work in terms of lower relative pulse rates, lower blood pressure during work, and lower relative oxygen intake for the relatively fitter men. From the results of the tests, Cureton concluded that the respiratory volumes appeared as relatively independent when compared to other factor analyses.[11]

---

[11]Thomas K. Cureton, "Comparison of Various Factor Analyses of Cardiovascular-Respiratory Test Variables," Research Quarterly, XXXVII (October, 1966), p. 317.

Howard conducted a study to determine the effects of a warm-up and a lack of a warm-up on the heart rate during specified exercise routines involving eight members of the University of North Carolina track and cross-country team. The variables of anticipatory increase in heart rate, maximum heart rate, and recovery decrease in heart rate were studied.

Each subject completed four exercise routines and the Harvard Step Test (short form). The routines were paired so that the only difference between the routines in any pair was the warm-up. The exercise routines were:

1.	Routine I	Fifteen 100-yd. runs at a moderate pace, in succession, without a warm-up, (twenty to twenty-five seconds per 100 yards).
2.	Routine II	Fifteen 100-yd. runs at a moderate pace, in succession, after a warm-up.
3.	Routine III	A 440-yd. run, executed in sixty-five seconds, without a warm-up.
4.	Routine IV	A 440-yd. run, executed in sixty-five seconds, after a warm-up.
5.	Routine V	A Harvard Step Test.

Routines I, II, and V were completed by the subjects on separate days, while routines III and IV were completed on the same day. Sufficient time for recovery and warm-up was allowed each subject between routines III and IV. The heart rate of the subjects was continuously relayed to a recording system by a radiotelemetry transmitter.

Statistical analysis of the various factors involved showed that there was a high negative correlation (r = -.8693) between the maximum heart rate achieved during strenuous exercise and the Harvard Step Test score. Mild exercise did not produce a high correlation between these two variables. Similarly, a correlation coefficient of +.7687 was obtained when the recovery rates for strenuous exercise were correlated with the Harvard Step Test scores. A pronounced trend for the anticipatory increase in heart rate to be limited by the initial heart rate was observed (r = -.5249), and a small positive correlation (r = .2485) between the anticipatory increase in heart rate and the recovery decrease in heart rate was noted. Howard found that there was no statistically significant differences between the maximum heart rates of exercises performed with and without a warm-up. The differences between recovery rates, and the differences between anticipatory rates were insignificant.[12]

In a study by Day, fifty-two volunteer male undergraduates at the University of Oregon were tested twice each, with a one-week interval to evaluate the reliability (temporal stability) of the Ryhming step test for prediction of aerobic capacity. The subject's pulse was counted during the last fifteen seconds of each minute while he performed.

---

[12]Gorden E. Howard, "Effects of Warm-up on the Heart Rate During Exercise," Research Quarterly, XXXVII (October, 1966), p. 360.

A steady value was reached after the second minute and this was the score. If no steady value was reached, then the last value became the score which was used in the prediction of the maximal oxygen consumption. All subjects layed quietly for five to ten minutes prior to the activity and then the pulse was taken manually at the radial artery. The average steady state heart rate from three trials was used in predicting the maximal oxygen intake. He found that the correlation between predicting aerobic capacity scores on the first and second test administrations was .795.[13]

A comparison study of rope skipping and jogging was conducted by Baker to determine the effects upon cardiovascular efficiency that result from programs of rope skipping and jogging. The Harvard Step Test was administered to ninty-two male college students in order to determine their level of cardiovascular efficiency. The subjects were then randomly divided into two groups; group I skipped rope for ten minutes daily for six weeks and group II jogged thirty minutes a day for six weeks. Upon completion of the conditioning programs the subjects again were administered the Harvard Step Test and comparisons were made from the pre-exercise and postexercise data. Baker's conclusions of this study were that a daily ten minute program

---

[13]James A. P. Day, "A Statistical Investigation of the Ryhming Step Test," Research Quarterly, XXXVIII (December, 1967), p. 539.

of rope skipping will significantly improve ($p = .05$) cardiovascular efficiency as measured by the Harvard Step Test, and that a daily thirty minute program of jogging will significantly improve ($p = .05$) cardiovascular efficiency as measured by the Harvard Step Test, and that a ten minute daily program of rope skipping is as efficient as a particular thirty minute daily program of jogging for improving cardiovascular efficiency as measured by the Harvard Step Test.[14]

Smith conducted a study to determine if a period of calisthenics, known as the Green Beret program, would significantly improve cardiovascular efficiency. This study concerned itself with 120 male members of the freshman class, between the ages of seventeen and twenty-one years, who were full-time students at Kansas State Teachers College of Emporia, during the fall semester of 1966. All subjects involved were enrolled in Physical Education Course No. 101, which was for the development of physical fitness. The subjects were randomly assigned to three groups with forty to each group. All initial and final testing was exactly alike.

The tests used to measure cardiovascular efficiency of the subjects was an eighteen and one-half inch modified

---

[14] John A. Baker, "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Males," <u>Research Quarterly</u>, XXXIX (May, 1968), p. 240.

Harvard Step Test which required a total of three class periods to administer. The training program prior to the final testing consisted of a six-twelve plan of calisthenics which is used by the army Green Beret in their physical fitness program. Six groups of exercises were involved with six exercises to each group with each group becoming progressively more difficult. Subjects took part in the six-twelve Green Beret program for thirty minutes a day, four days a week, for six weeks.

To establish the significance of the mean gains in the Harvard Step Test performance, the _t_ test was computed, comparing the initial and final cardiovascular efficiency scores for the total group. To reach significance, a _t_ of 2.00 was needed for the .05 level of probability and a _t_ of 2.66 was required to be significant at the .01 level of significance. A significant _t_ of 7.17 was found for the group which had a mean difference between the initial and final cardiovascular efficiency scores of 16.66, which was highly significant at the .01 level of confidence.

Smith concluded that the Green Beret six-twelve plan can produce a high level of cardiovascular efficiency and that the Harvard Step Test is a valid and reliable indicator of cardiovascular efficiency of college males between the ages of seventeen and twenty-one years.[15]

---

[15]Sidney L. Smith, "A Study to Determine the Effects of Six Weeks of Calisthenics Upon Cardiovascular Efficiency of College Males" (unpublished Master's thesis, Kansas State Teachers College, Emporia, August, 1968), pp. 4-30.

II. RESEARCH RELATED TO THE TREADMILL TEST

A study initiated to estimate the severity of sled pulling activities was conducted by Vanderbie. His study presents the metabolic rates and pulse responses to an exercise of a dual nature, pulling against a drag of 17.5 pounds, while walking on a treadmill.

A series of experiments were performed during control periods on twelve army enlisted men, before, during, and after the test subjects went to Fort Churchill, Canada, during the winter of 1951-52. The subjects, dressed in cotton fatigue uniforms and leather combat boots, were tested one and one-half hours after breakfast to acquire measurements of energy cost and pulse rates. The temperature in the test room was controlled at seventy degrees $\pm$ two degrees fahrenheit. The humidity control was set at forty per cent relative humidity. The exercise consisted of walking on a horizontal, motor-driven treadmill at 2.5 and 3.5 miles per hour, while pulling a weight. The weight was hung over a pully and attached to the body with a rope and a body harness. The angle of pull was twenty to twenty-five degrees above the horizontal. During exercise, the pull recorded from ten to twenty-six pounds, as measured with a spring scale. The static pull was 17.5 pounds. Metabolic rates were measured with a Tissot Spirometer, operating as a closed system. The caloric expenditure was computed from the total oxygen consumption by assuming an R. Q. of .82 and a caloric equivalent of 4.8 calories per 1000 cubic centimeters of oxygen. At frequent intervals the energy cost of each subject was measured from start to five minutes after the exercise. In all instances a steady state was reached after fifteen minutes. All figures were based on the oxygen consumptions measured during the last eight minutes of the thirty minute trials, uncorrected for oxygen debt. All pulse rates were obtained by wrist palpation during the final minute of the exercise.

Vanderbie concluded that the application of a posterior pull by means of harness, rope, pully, and weight is a convenient means for causing a marked increase in energy expenditure while walking on a treadmill. The metabolic rates and pulse rates indicated that sled-pulling can be classified as very hard work. At a speed of 2.5 miles per hour, the group average was 267.5 Cal/M^2/hr., which was higher than the metabolic rates for carrying an eighty pound backload at 3.5 miles per hour. The pulse rates averaged 136 beats per minute, which compares with pulse rates obtained while subjects carried a sixty-five pound backload at 3.5 miles per hour. The energy expenditure for simulated sled-pulling, in artic uniform and at a speed of 3.5 miles per hour was 366 Cal/M^2/hr., which was about twenty-nine per cent lower than figures obtained in the field (Fort

Churchill), for the same mean drag. This discrepancy can be attributed partly, to the added difficulties of walking over uneven and slippery snow surfaces and breakable crusts when compared to walking over the smooth, non-skid surface of the treadmill belt.[16]

The annual NCAA cross-country championship meet has been held regularly over the four-mile course at Michigan State University during the last decade. On one of these occasions, it was possible for Montoye, Mack, and Cook to record the resting brachial pulse waves on forty-eight of the sixty-eight participants. The runners included the best collegiate cross-country performers, who represented nineteen colleges and universities. A cardiorespirograph on loan from the Cameron Company of Chicago was used to record pulse waves during the two days preceding the meet. This instrument embodies the heartometer, and in addition it is possible to record respiration. In these tests the men sat quietly for about thirty minutes before the records were taken, and no preceding strenuous exercise was permitted on the day of the test. The men were not allowed to smoke for two hours prior to the testing, but there were no restrictions on food or liquid intake. The pulse waves were recorded at various pressures around eighty millimeters to

---

[16] Jan H. Vanderbie, "Metabolic Cost of Simulated Sled Pulling on the Treadmill," Research Quarterly, XXVII (March, 1956), p. 111.

secure maximum waves. All measurements were made according to procedure on three of the waves, and these values were then averaged. Run time on the four-mile cross-country course was plotted against age, height, and weight of the runners, and against each of the mean pulse wave measurements. The relationships appeared linear, hence product moment correlation coefficients were computed. Coefficients expressing the correlation between cross-country run time and age, height, and weight were -0.25, -0.22, and -0.06 respectively. None was significant at the five per cent level of significance. From the results of this study it was concluded that run time is more closely related to pulse rate than to any of the pulse wave measurements. On the other hand, when pulse rate and run time were correlated, with area under the pulse wave partialed out, the resulting coefficient of 0.40 was significant with a probability between 0.05 and 0.01. From this analysis it appears clear that the pulse wave as measured by the Cameron cardiorespitograph has no value in predicting cross-country run time other than what can be predicted from the resting pulse rate. The lower pulse rate among conditioned people and the significant correlation between pulse rate and cross-country run time reflects an increase in stroke volume which explains why the pulse rate was correlated significantly with many of the pulse wave measurements.[17]

---

[17]Henry J. Montoye, William Mack, and John Cook, "Brachial Pulse Wave as a Measure of Cross-Country Running Performance," <u>Research Quarterly</u>, XXXI (May, 1960), p. 174.

Koff, Bruce, Fernandes, Ovenell, and Cutler conducted a study on Cardiorespiratory responses to strenuous exercise in physically trained and untrained normal men. Twenty-eight normal men were tested for exercise tolerance by walking on a treadmill at five miles per hour and at eighteen per cent grade to evaluate cardiorespiratory performance. Twelve out of fourteen untrained sedentary normals were unable to continue this exertion for three minutes, and fourteen others in varying degrees of training continued for only ten minutes. This test usually differentiated subjects with an athletic background from untrained normals, but failed to differentiate between the athletes. Forty-eight additional normal men, who were selected for their athletic training experience, had a preliminary walk for three minutes at five miles per hour and eighteen per cent grade, and then ran at 6.5 miles per hour and twenty-five per cent grade to the limits of their physical endurance to estimate maximal oxygen consumption, ventilation or heart rate. It was concluded at the end of this test, that this procedure provides an expeditious method for measuring short term maximal work loads in normal, even physically trained men.[18]

---

[18]Arnold Koff, Robert A. Bruce, Kenneth Fernandes, David Ovenell, and Russell K. Cutler, "Cardiorespiratory Responses to Strenuous Exercise in Physically Trained and Untrained Normal Men," <u>Research Quarterly</u>, XXXIV (March, 1963), p. 41.

Two groups of six subjects were equated on the Balke-Ware Treadmill Test in a study conducted by Howell and Coupe determining the effect of blood loss upon performance. The twelve subjects involved were first-year university students who were selected from a large sample on the basis of performance on the Balke-Ware treadmill performance test. The mean ages of the control group was 19.8 and the mean weight 65.8 kgs. The mean ages of the experimental group was 19.6 with the mean weight being 70.05 kgs. The experimental group gave 500 cc's of blood, the control group did not give any blood but believed it had. The treadmill test was repeated (1) immediately following, (2) twenty-four hours after, and (3) seven days after the blood donation or supposed donation. A two-way classification analysis of variance was used to examine the sources of variance for the treadmill times for both groups. The treadmill speed was 3.4 miles per hour and remained constant throughout the test. The slope of the treadmill, initially on a zero grade, was increased one per cent per minute until the heart rate of the subject reached 175 beats per minute, when readings of the heart rate were taken every half minute. The treadmill was stopped when the heart rate of the subject reached 180 beats per minute. Heart rate was recorded at the end of each minute. Recovery heart rate was recorded at the end of each minute for five minutes.

After summarizing the treadmill performance means and the standard deviations of the treadmill test, Howell and Coupe concluded that there was no statistically significant changes in treadmill performance time, either immediately, twenty-four hours, or seven days after a blood donation or supposed donation of 500 cc's. However, there was a consistent decrease in pre-exercise oxygen consumption for the experimental group during the trials, but no such consistency appeared for the control group.[19]

An investigation at the University of Alberta at Edmonton, by Howell, Bakogeorge, and Kerr, utilized Balke's progressive treadmill performance test to study the effect of various exercise programs on certain physiological responses and as a measure of cardiorespiratory fitness. The purpose of this study was to establish normative tables in standard and T-score form for performance time and external work output in Balke's progressive treadmill walking test.

Data on 195 University of Alberta college males was collected and divided into three groups. Groups I and II were based on age: seventeen to twenty-one years and twenty-two to thirty-six years respectively. Group III

---

[19]Maxwell L. Howell and Ken Coupe, "Effect of Blood Loss Upon Performance in the Balke-Ware Treadmill Test," Research Quarterly, XXXV (May, 1964), p. 156.

consisted of subjects who had participated from five to six weeks in conditioning programs, varying from Hoffman's Functional Isometric Exercises to the Five BX Plan for Physical Fitness. In these investigations a motor-driven treadmill was employed. The speed was set at 91.2 $\pm$2.7 meters per minute (3.4 $\pm$0.1 miles per hour). In the first minute of the test the treadmill was running on the level. At the beginning of the second minute, it was raised to such an angle that the vertical ascent became one per cent of the belt travel in a given time. At the third and each subsequent minute the angle was increased one per cent. Heart rate was recorded each minute by means of a Sanborn Twin-Visa electrocardiograph. The test was terminated when the subject's heart rate was 180. The external performed work was calculated in meter-kilograms per minute for each subject using the method employed by Balke.

$$\text{External Performed Work} = \frac{\text{Speed X Sin} \quad \text{X Body Weight}}{100}$$

where Speed = 91.2 n/min.; Sin $<$ = gradient during the last minute of the test; Speed times Sin $<$ = vertical ascent in meters; Body weight = kilograms.[20]

A study to investigate the effects of selected pre-exercise conditions, upon the physiological functions of

[20]Maxwell L. Howell, A. P. Bakogeorge, and B. A. Kerr, "Progressive Treadmill Test Norms for College Males," <u>Research Quarterly</u>, XXXV (October, 1964), p. 322.

heart rate and oxygen uptake during and immediately following standardized exercise on a bicycle ergometer was conducted by Falls and Weibers. The subjects in this study were five Purdue University graduate students who volunteered to participate. Four of the subjects were physical education students and one was a student in chemical engineering. Their ages ranged from twenty-one to thirty-four years, and they were all in good physical condition.

Data was collected pertaining to the effects of four pre-exercise conditions on heart rate and oxygen uptake during work and recovery. The pre-exercise conditions were: (1) quiet resting for fifteen minutes, (2) a six minute cold shower, (3) a six minute hot shower, and (4) an exercise warm-up consisting of both formal and informal exercise. The work consisted of a five minute ride on a bicycle ergometer at 1080 kgm. per minute, with a recovery period of five minutes. Falls and Weibers concluded that there are definite physiological effects during exercise and recovery which are related to heating or cooling the body before exercise. Exercise heart rates are significantly lower after a cold shower than after a hot shower or an exercise warm-up. Oxygen consumed during a five minute recovery period after exercise is significantly less after the pre-exercise conditions of cold shower and complete rest than after a hot shower. There was a significant interaction between subjects and pre-exercise conditions on recovery heart rate.[21]

As cited earlier in this chapter, Cureton did a comparison study of various factor analyses of cardiovascular-respiratory tests between 1936 and 1962. All tests were studied and the factors grouped into clusters of (1) resting state, (2) change of postural position from quiet sitting or lying to standing, (3) moderate circulatory performing capacity, (4) maximal performing capacity, (5) recuperative ability after exercise, and (6) respiratory capacity and reserve. Cardiovascular-respiratory tests were grouped according to three different types and periods of factor analyses. From the results of the tests made by Cureton, he concluded that the respiratory volumes appeared as relatively independent when compared to other factor analyses.[22]

Holmgren and Harker made a study on characteristic pace as determined by the use of a tracking treadmill involving nineteen male subjects who had just completed six months of basic training. The subjects, whose average age was 19.7 years, wore regulation fatigue pants, tee shirt, and combat boots. All walking was performed in a temperature-controlled chamber at eighty degrees fahrenheit.

---

[21]Harold B. Falls and Jacob E. Weibers, "The Effects of Pre-Exercise Conditions on Heart Rate and Oxygen Uptake During Exercise and Recovery," <u>Research Quarterly</u>, XXXVI (October, 1965), p. 243.

[22]Cureton, <u>loc. cit.</u>

During the week prior to the data-taking sessions, each subject walked for thirty minutes on the treadmill for familiarization. The purpose of the familiarization was to allow the subjects to become adapted to walking on the treadmill and to become adjusted to the acceleration and deceleration of the treadmill as it matched their pace. The task for all subjects on each of the three days of testing was as follows: (1) two short walks starting from either a fast walk (five miles per hour) or a slow walk (two miles per hour) during which subjects either decelerated or accelerated their pace to reach their "comfortable-but-determined" (C-D) walking pace; (2) a thirty minute walk at their C-D pace; and (3) two short walks again starting with either a fast or a slow walk to adjust their pace to reach their C-D pace. For Group I, the short pre- and postwalk (fast start then slow start or slow start then fast start) was randomly determined and the walk lasted for four minutes. For Group II, the pre- and postwalking conditions were randomized but the walk lasted eight minutes. The main concern was with only the thirty minute walk.

In an effort to learn if the subjects revealed a characteristic pace during their thirty minute walk and if this pace was stable over time, two analyses of variance were computed. It was found that when the subjects walked on a tracking treadmill under a "comfortable-but-determined" walking instructional set for a minimum of thirty minutes on each of three testing days (1) subjects demonstrated a characteristic C-D pace that was stable on any given day, (2) the subjects C-D pace differed statistically from each other ($p < .001$), and (3) the subjects C-D pace measures were most reliable between Testing Days two and three ($p < .01$).[23]

Alderman made a study concerned with work capacity in bicycle ergometer work involving the observation of the relationship between heart rate responses to two different levels of work load.

Forty male college students served as subjects. The apparatus was an ordinary, friction-type bicycle ergometer with a wheel diameter of 1.86m and a pedal sprocket ratio of 2.2. Subjects were tested on four separate occasions with the test and retest separated by a forty-eight hour rest, and the second test-retest followed the first by a three-week period. In the first two exercise bouts, the subjects were required to pedal at a rate of 45.45 revolutions per minute; in the second bouts, the rate of pedaling was 54.54 revolutions per minute. During all four performances the friction resistance was progressively increased by one-half kilogram at the end of each minute of exercise. Subjects were required to pedal in cadence with the clicking of an

[23]Gary L. Holmgren and George S. Harker, "Characteristic Pace as Determined by the Use of a Tracking Treadmill," Journal of Applied Psychology, 51:278, 1967.

electric metronome. Test procedure on each occasion consisted of a five-minute pre-exercise rest period. Heart rate was monitored continuously throughout the three periods by means of a special preamplifier heart rate coupler.

Data was determined in terms of the amount of time required to reach particular levels of heart rate. Each of the test-retest were averaged to give a representative performance for each work load. The intercorrelation between the exercise times to 180 beats per minute for the work load was r = .933 after correction for attenuation. Therefore, Alderman concluded that eighty-seven per cent of the individual difference in variance in heart rate responses was common to the two work loads, while only thirteen per cent was specific to a particular work load.[24]

Bowles and Sigerseth conducted a study to investigate, by means of electrocardiographic radio telemetry, the heart rate responses of subjects during rest and during differently paced one-mile running efforts. The subjects used in this study were sixteen University of Oregon track athletes who had run the one-mile distance in four minutes and thirty seconds or less. They ranged in age from eighteen to twenty-four years. All of the subjects were training

---

[24]Richard B. Alderman, "Interindividual Differences in Heart Rate Response to Bicycle Ergometer Work," Research Quarterly, XXXVIII (October, 1967), p. 323.

for distance running, under the investigator's guidance, during the time the data was collected.

The heart rate responses of the sixteen track athletes were measured by means of radio telemetry under the following conditions: (1) while the subjects were at rest, (2) during a one-mile run at a steady pace, (3) during a one-mile run at a fast-slow pace, (4) during a one-mile run at a slow-fast pace, and (5) during recovery. The heart rates were obtained from the electrocardiographic tracings, and analysis of covariance was used to test the significance of differences between the pace patterns at the .05 level. In 100 tests, ninty-five of them showed the heart rate during the fast-slow pace pattern to be from 0.2 to 1.3 beats a minute faster than the heart rate during the steady pattern and from 0.7 to 1.7 beats a minute faster than the heart rate during the slow-fast pace pattern. Likewise, the heart rate during the steady pace pattern would be from 0.1 to 1.2 beats a minute faster than the heart rate during the slow-fast pace pattern.

Bowles and Sigerseth concluded that the heart rate response to exercise is very rapid, regardless of the pace pattern, and will reach the slope of the exercise heart rate response line before the subject has reached the end of the first 220 yards while running a mile. The fast-slow pace pattern brought about a significantly higher heart rate response than any other pace pattern in the one-mile runs. During recovery, there were no significant differences between the pace patterns followed in the time necessary for the heart to reach a rate which was within ten per cent of the warm-up heart rate. Eleven of the subjects were able to run the last 440-yard portion of the mile in the shortest time when they had followed the slow-fast pace pattern in running the preceding 1,320 yards of the mile run.[25]

---

[25]Charles J. Bowles and Peter O. Sigerseth, "Telemetered Heart Rate Responses to Pace Patterns in the One-mile Run," Research Quarterly, XXXIX (March, 1968), p. 36.

CHAPTER III

PROCEDURES

The purpose of this study was to investigate the degree of relationship which exists between the Harvard Step Test and a three-minute Treadmill Test Run upon the cardio-vascular efficiency of college males.

Nature of Program

Each student enrolled at Kansas State Teachers College of Emporia is required to receive four semester hours of activity courses, selected by the student to fulfill his requirements for graduation with a Bachelor's Degree.

The physical fitness class is encouraged for freshmen men which meets nine weeks of each semester, leaving the activity classes for the upperclassmen. The fitness program thus satisfies one of the necessary four credits required for graduation. Other activities included in the physical education program are: archery, badminton, basketball, bowling, dance, fencing, golf, gymnastics, handball, life saving, soccer, speedball, swimming, tennis, trampoline, and wrestling.

Subjects

This study involved sixty full-time male students who were enrolled at Kansas State Teachers College during the spring semester of 1969. The students were selected from three physical education activity classes: physical fitness, intermediate tennis, and weight lifting. These three activity classes were selected because (1) the investigator was teaching one of the classes, (2) the other two classes met at a time when there was no other conflict with the investigator, (3) because of the adequate number of students enrolled in each of the activity classes, and (4) each class was designed to develop a degree of cardiovascular efficiency within each of the individuals enrolled in the class.

The physical fitness class met Monday through Thursday of each week for nine weeks for thirty minutes a day during the spring semester of 1969. A student would follow a weekly program of: Monday, running for twelve minutes; Tuesday, classroom lecture; Wednesday, calisthenics; and Thursday, activities. A faculty member from the men's physical education department met with a section of the physical fitness class each day to provide professional advice and direction making a total of four faculty members involved in the program.

The students in the intermediate tennis class met two days a week for ninety minutes a day for a total of twenty class meetings during the second half of the spring semester. The tennis program consisted of basic fundamentals, essential skills, techniques, rules, equipment, values, and history of the game of tennis.

The students in the weight lifting class met three days a week for fifty minutes a day during the first half of the spring semester. Their program involved learning proper stance and means of lifting weights, different types of lifts, how to use the various types of weight lifting machines and apparatus, and how to develop the different regions of the body using the various types of lifts.

All tennis and weight lifting students were required to wear their physical education uniform, which consisted of gym shoes, athletic supporter, gym shorts, and tee-shirt, while in class and during the time of the testing procedures. The physical fitness students were allowed to dress in any presentable manner which would not interfer with their participation in class and during testing procedures.

Equipment and Facilities

Welch Football Stadium and a first floor office in the gymnasium, all located on the campus of Kansas State Teachers College of Emporia, were used as the testing sites for this study.

The equipment employed in this study was (1) the 16-inch stationary stadium bleachers in Welch Football Stadium which were made of two-by-six boards covered with aluminum and mounted on steel bolted into the concrete risers of the stadium; (2) a Quenton Electric, Model 18-49-C, Treadmill, located on the ground floor of the gymnasium, set at seven miles per hour and fifteen per cent grade, which consisted of a motor-driven conveyor belt that was large enough for a subject to walk or run upon and constructed so that the speed of the belt could be adjusted from 0-10 miles per hour and the incline from 0-40 degrees; (3) a Sony Tape Recorder and magnetic instruction tape of the Harvard Step Test; and (4) three Minerva Stop Watches.

I. TESTING PROCEDURES

All subjects were first administered the Harvard Step Test followed within two weeks by the Treadmill Run Test. The Harvard Step Test and the Treadmill Test both measure the general capacity of the body to adapt itself to hard work and to stress the cardiovascular systems. Both tests were given only once to each subject.

Harvard Step Test

The first test to be administered was the modified Harvard Step Test. The steps used in the modified Harvard Step Test were the stadium bleachers, which were 16-inches high, located in Welch Stadium on the campus of Kansas State Teachers College. Prior to testing, all subjects were orientated to the procedures involved in the step test. A Sony Tape Recorder and magnetic instruction tape was then used to give further directions and maintain a cadence of 120 counts per minute during the stepping procedures.

All subjects involved in this study reported to the stadium during their respective class periods and numbered off into groups of three. Each subject was given two four-by-six inch cards on which he wrote his name. The cards also had available space to record the three pulse rates of the Harvard Step Test and the three pulse rates of the Treadmill Run Test. Subjects two and three acted as pulse counters and recorders while subjects number one took the test. Subjects were told that when the tape recorder was turned on that the final instructions for testing would be given.

The tape recorder was then turned on stating that all subjects and pulse counters should remain as quiet as possible during the testing so that all subjects taking the test could hear the stepping cadence as it was being given by the recorder. All number one subjects were asked to stand and face the steps and prepare to take the test. On the command "up," each subject placed his favored foot upon the seat in front of him. If desired, the subjects could change their lead foot once or twice during the test, and move their arms freely so long as they didn't touch anything with their hands. On the count of "two," they brought their opposite foot upon the seat with both legs straight. On the count of "three," the lead foot returned to the starting position, and on the count of "four," the trail foot returned to the starting position. Each complete up-and-down cycle was performed in two seconds to the counters count of "up-2-3-4." Each subject was instructed to step at a rate of thirty complete steps per minute for a duration of five minutes keeping up with the cadence being given by the tape recorder.

At the end of five minutes, the tape recorder asked all number ones to "stop," and be seated between their two partners. The recorder then instructed subjects two and three to prepare to count the pulse of number one by checking the pulsation of the radial artery on the thumb-side of the inside portion of the right and left wrist respectively. They had sixty seconds to find the pulse and make necessary adjustments. At the end of sixty seconds, the command "count" was given and was counted for thirty seconds. The pulse rates were taken for three periods, each period lasting for thirty seconds. The first pulse counting period was from one minute to one minute and thirty seconds after the exercise; the second pulse counting period from two minutes to two minutes and thirty seconds after the exercise; and the third pulse counting period from three minutes to three minutes and thirty seconds after the exercise. Time was determined by the command from the tape recorder as to when to start and when to stop. At the end of each counting period the pulse counters recorded the number of pulsations on subject number ones' cards. At the end of all three counting periods, the three pulse rate scores were totaled by the recorders. In like manner, each subject was tested by following the directions of the tape recorder. Number twos became the subjects and subjects one and three acted as pulse counters and recorders. Likewise, number threes became the subjects and subjects one and two acted as the pulse counters and recorders. Should any subject fail to finish the five minutes, this was noted on his card and his pulse was counted for one minute after stopping along with the two succeeding counts. This was done with the use of a Minerva stop-watch and an extra helper provided for such an emergency.

Treadmill Test

The second test to be administered to all subjects was the Treadmill Run Test. The treadmill employed in this study was a Quinton Electric, Model 18-49-C, located on the ground floor of the gymnasium at Kansas State Teachers College. This instrument was large enough for a subject to walk or run upon and constructed so that the speed of the belt and the incline could be adjusted. Prior to testing, all subjects were orientated to the procedures involved in the treadmill test and were instructed on how to mount and dismount from the running treadmill followed by a thirty second trial run.

Prior to the first day of testing, the investigator met with each respective class and divided the subjects in each class into groups of three; group A, group B, and group C, and notified each group as to what day they were to report for testing. All subjects involved were requested to report to the gymnasium in which the treadmill was housed during their respective class periods with their respective groups at their perscribed time for testing. As each group reported on their respective days they were numbered off into groups of three and were given their two four-by-six inch cards with their names, the pulse rate scores of the Harvard Step Test, and available space for the pulse rate scores of the Treadmill Test. Subjects number two and three acted as pulse counters and recorders while subject number one took the test.

The Treadmill Test consisted of running at seven miles per hour, fifteen percent grade (miles per hour and percent grade were selected at random) for as long as possible, but not in excess of three minutes. Individually, each subject was instructed to stand on the mounting platform of the treadmill and on the command "ready begin," given by the investigator, the subject stepped onto the moving belt and began running. Each subject ran as though he was running on an outdoor track, but was instructed to hold onto the hand-rail assembly of the treadmill. At the end of the three minute test run, the investigator gave the command "dismount," to which the subject then stepped from the moving belt onto the dismounting platform. The subject was immediately seated between his two partners, subjects two and three. The investigator then instructed subjects two and three to prepare to count the pulse of subject number one by checking the pulsation of the radial artery on the thumb-side of the inside portion of the right and left wrist respectively. They had sixty seconds to find the pulse and make necessary adjustments. At the end of the sixty seconds, the command "count" was given and was counted for thirty seconds. The pulse rates were taken for three periods, each period lasting for thirty seconds. The first pulse counting period was from one minute to one minute and thirty seconds after the exercise; the second pulse counting period was from two minutes to two minutes and thirty seconds after the exercise; and the third pulse counting period was from three minutes to three minutes and thirty seconds after the exercise. The running time on the treadmill was determined by a Minerva Stop Watch operated by the investigator. The duration of the three pulse counting periods was determined by two Minerva Stop Watches operated by an assistant. At the end of each counting period the pulse counters recorded the number of pulsations on subject number ones' cards. At the end of all three counting periods, the three pulse rate scores were totaled by the recorders and given to the investigator's assistant. In like manner, each subject number one in each group of three was tested by following the directions and commands of the investigator and his assistant. Likewise, number twos became the subjects and subjects one and three acted as pulse counters and recorders, followed by number threes becoming the subjects and subjects one and two acting as the pulse counters and recorders. Should any subject fail to finish the three minute run test, this was noted on his card and his pulse was counted for one minute after stopping along with the two succeeding counts. A total of three class periods was required to complete all testing.

CHAPTER IV

ANALYSIS OF DATA

The computation employed for this study was the Person Product Moment coefficient of correlation. The mean scores of the Harvard Step Test and the Treadmill Run were the data used for this correlation.

I. CORRELATION FOR THE TOTAL GROUP

Since this study was to establish the degree of relationship between the two tests, correlations were computed for the total scores as well as the three recovery pulse counts which can be noted in Table I, page 45. On the Harvard Step Test, the total group of sixty subjects had a mean score of 164.63, with a range of 110 as low to 204 as the high, and a standard deviation of 18.12. On the Treadmill Run, the sixty subjects had a mean score of 182.78, with a range of 135 as low to 216 for the high, and a standard deviation of 18.23. The data yielded a positive correlation of +.33 for the total group, which indicates a significant relationship exists at the .01 level of significance. With 58 degrees of freedom, a .325 was necessary for significance at the .01 level of significance. This positive correlation does demonstrate the relationship between the performance on the Harvard Step Test and the Treadmill Run for the total group.

TABLE I

CORRELATION OF THE HARVARD STEP TEST TO THE TREADMILL RUN FOR ALL GROUPS

Group	N	Harvard Step Test Mean	Harvard Step Test S.D.	Treadmill Run Mean	Treadmill Run S.D.	r	P
Totals	60	164.63	18.12	182.78	18.23	.33	.01
Physical Fitness	27	167.85	18.20	181.11	16.48	.29	—
Tennis	17	170.29	15.72	182.41	17.74	.58	.05
Weight Lifting	16	153.18	16.09	186.00	22.02	.44	—

With 58 df, a .250 was needed at the .05 level.
With 58 df, a .325 was needed at the .01 level.
With 25 df, a .381 was needed at the .05 level.
With 25 df, a .487 was needed at the .01 level.
With 15 df, a .482 was needed at the .05 level.
With 15 df, a .606 was needed at the .01 level.
With 14 df, a .497 was needed at the .05 level.
With 14 df, a .623 was needed at the .01 level.

II. COEFFICIENT OF CORRELATION FOR EACH EXPERIMENTAL GROUP

The tennis group, on the Harvard Step Test, had a mean score of 170.29, with a range of 153 as the low to 202 as the high, and a standard deviation of 15.72. The Treadmill Run performance had a mean score of 182.41, with a range of 148 as the low to 216 for the high, and a standard deviation of 17.74. The data yielded a positive correlation of +.58 for the tennis group, which indicates a significant relationship does exist at the .05 level of significance and that there is a positive correlation between the performance on the Harvard Step Test and the Treadmill Run for this group. With 15 degrees of freedom, a .482 was necessary for significance at the .05 level of significance.

The weight lifting group, tested on the Harvard Step Test, showed a mean score of 153.18, with a range of 117 for the low to 181 as the high, and a standard deviation of 16.09. On the Treadmill Run Test, the weight lifting group had a mean score of 186.00, with a range of 137 as the low to 211 for the high, and a standard deviation of 22.02. The data yielded a positive correlation of +.44 for the group, which indicates a non-significant relationship exists at the .05 level of significance. With 14 degrees of freedom, a .497 was necessary for significance at the .05 level of significance. This positive correlation indicates that there is a definite relationship between the performance on the Harvard Step Test and the Treadmill Run for the weight lifting group.

The physical fitness group when tested on the Harvard Step Test showed a mean score of 167.85, with a range of 110 as the low to 204 for the high, and a standard deviation of 18.20. When tested on the Treadmill, the physical fitness group showed a mean score of 181.11, with a range of 135 for the low to 208 as the high, and a standard deviation of 16.48. The data yielded a positive correlation of .29 for the group, which indicates a non-significant relationship and that there is a low correlation between the performance on the Harvard Step Test and the Treadmill Run for the physical fitness group. With 25 degrees of freedom, a .487 was necessary for significance at the .01 level of significance, and a .381 was necessary for significance at the .05 level of significance.

Due to error on the part of the investigator, and because of administrative requirements of the physical education department, the physical fitness group was administered a cardiovascular training program for a total of eight days following the Harvard Step Test and prior to the Treadmill Run. Because of the training program, a low correlation might have resulted between the performance on the two tests for the group.

III. CORRELATION FOR ALL GROUPS ON THE RECOVERY PULSE COUNTS FOR THE TWO CARDIOVASCULAR EFFICIENCY TESTS

The total group which was composed of all subjects recorded highly significant correlations when the recovery pulse counts were correlated to one another. The lowest correlation was .71 which was between recovery period one and recovery period three of the Harvard Step Test, while a highly significant correlation of .96 resulted in recovery period two and the total pulse count of the same test. Table II, page 49, lists all correlations of recovery pulse counts for the total group.

The physical fitness group and the tennis group both recorded highly significant correlations when the recovery pulse counts were correlated to one another. The lowest correlation was .72 which was between recovery period one and recovery period three on the Treadmill Run of the physical fitness group. A high correlation of .97 resulted in recovery period two and the total pulse count on the Harvard Step Test of the physical fitness group, and in recovery period three and the total pulse count on the Treadmill Run of the tennis group. Table III, page 50, lists all correlations of recovery pulse counts for the physical fitness group, and Table IV, page 51, lists all correlations of recovery pulse counts for the tennis group.

TABLE II

CORRELATION OF THE THREE RECOVERY PULSE COUNTS FOR ALL SIXTY SUBJECTS ON THE TWO CARDIOVASCULAR EFFICIENCY TESTS

HARVARD STEP TEST

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.79	.71	.87
Recovery 2			.91	.96
Recovery 3				.93

TREADMILL RUN

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.83	.78	.91
Recovery 2			.90	.95
Recovery 3				.95

With 58 df needed at .05 level, .250;
at .01 level, .325.

TABLE III

CORRELATION OF THE THREE RECOVERY PULSE COUNTS FOR THE TWENTY-SEVEN SUBJECTS IN THE PHYSICAL FITNESS GROUP ON THE TWO CARDIOVASCULAR EFFICIENCY TESTS

HARVARD STEP TEST

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.90	.88	.96
Recovery 2			.90	.97
Recovery 3				.95

TREADMILL RUN

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.82	.72	.90
Recovery 2			.89	.96
Recovery 3				.92

With 25 df needed at .05 level, .381;
at .01 level, .487.

TABLE IV

CORRELATION OF THE THREE RECOVERY PULSE COUNTS FOR THE SEVENTEEN SUBJECTS IN THE TENNIS GROUP ON THE TWO CARDIOVASCULAR EFFICIENCY TESTS

HARVARD STEP TEST

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.74	.75	.89
Recovery 2			.84	.89
Recovery 3				.94

TREADMILL RUN

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.86	.82	.91
Recovery 2			.89	.93
Recovery 3				.97

With 15 df needed at .05 level, .482;
at .01 level, .606.

The weight lifting group recorded the lowest correlation of the three groups when the recovery pulse counts were correlated to one another. The lowest correlation for the group was .29 which was between recovery period one and recovery period three of the Harvard Step Test. A significantly high correlation of .96 resulted in recovery period two and the total pulse count of the Treadmill Run, recovery period three and the total pulse count of the Treadmill Run, and recovery period two and the total pulse count of the Harvard Step Test. Table V, page 53, lists all correlations of recovery pulse counts for the weight lifting group.

TABLE V

CORRELATION OF THE THREE RECOVERY PULSE COUNTS FOR THE SIXTEEN SUBJECTS IN THE WEIGHT LIFTING GROUP ON THE TWO CARDIOVASCULAR EFFICIENCY TESTS

HARVARD STEP TEST

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.56	.29	.66
Recovery 2			.91	.96
Recovery 3				.88

TREADMILL RUN

	Recovery 1	Recovery 2	Recovery 3	Total
Recovery 1		.84	.86	.94
Recovery 2			.94	.96
Recovery 3				.96

With 14 df needed at .05 level, .497;
at .01 level, .623.

CHAPTER V

SUMMARY AND CONCLUSIONS

It was the purpose of this study to investigate the degree of relationship which exists between the Harvard Step Test and a three minute Treadmill Test upon the cardiovascular efficiency of college males.

This study involved sixty full-time male students who were enrolled at Kansas State Teachers College of Emporia, during the spring semester of 1969. The students were selected from three physical education activity classes specifically designed for the development of physical fitness: intermediate tennis, weight lifting, and physical fitness.

All subjects were administered the modified Harvard Step Test mid-way through the spring semester, followed in two to three days by the Treadmill Test, with exception of the physical fitness group. Due to error, the physical fitness group was administered a cardiovascular training program for a total of eight days prior to their Treadmill Test.

The computation employed for this study was the Person Product Moment coefficient of correlation. The mean scores of the Harvard Step Test and the Treadmill Run were the data used for correlation.

I. FINDINGS

The findings for this study were as follows:

1. A positive correlation of +.33 was found for the total group, which demonstrates the relationship between the performance on the Harvard Step Test and the Treadmill Run.

2. The tennis group yielded a positive correlation of +.58, and the weight lifting group yielded a +.44, which indicates there is a positive correlation between the performance on the Harvard Step Test and the Treadmill Run for both groups.

3. The physical fitness group yielded a positive correlations of .29, which indicated a non-significant relationship and a low correlation between the performance on the Harvard Step Test and the Treadmill Run.

II. CONCLUSIONS

Within the limitations of this study, the following conclusions are justified.

1. When the two tests are compared the results indicate a comparable amount of cardiovascular efficiency of college males is required.

2. A degree of relationship does exist between the Harvard Step Test and the Treadmill Run upon the cardiovascular efficiency of college males.

III. RECOMMENDATIONS FOR FURTHER STUDY

As a result of the findings from this study the following recommendations are made for further study:

1. A study employing similar experimental design but using college age females as subjects.

2. A similar study should be made involving greater numbers of college age males who are not enrolled in physical education activity courses to investigate the effects of non-physical activity.

3. A study employing similar experimental design but involving an initial and final testing period separated by a six weeks cardiovascular training program.

4. A study employing similar experimental design involving college age males who are active in interscholastic athletics.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Clarke, H. Harrison. Application of Measurement to Health and Physical Education. Third edition. New Jersey: Prentice-Hall, Inc., 1959.

_______. Application of Measurement to Health and Physical Education. Fourth edition. New Jersey: Prentice-Hall, Inc., 1967.

Consolazio, C. Frank, Robert E. Johnson, and Evelyn Marek. Metabolic Methods. St. Louis: C. V. Mosby Company, 1951.

Consolazio, C. Frank, Robert E. Johnson, and Louis J. Pecora. Physiological Measurements of Metabolic Functions in Man. New York: McGraw-Hill Book Company, Inc., 1963.

Karpovich, Peter V. Physiology of Muscular Activity. Sixth edition. Philadelphia: W. B. Saunders Company, 1965.

de Vries, Herbert A. Physiology of Exercise. Iowa: Wm. C. Brown Publishing Company, 1966.

B. PERIODICALS

Alderman, Richard B. "Interindividual Differences in Heart Rate Responses to Bicycle Ergometer Work," Research Quarterly, 38:323-29, October, 1967.

Baker, John A. "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Males," Research Quarterly, 39:240-43, May, 1968.

Brouha, Lucien. "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, 14:31-36, March, 1943.

Bowles, Charles J., and Peter O. Sigerseth. "Telemetered Heart Rate Responses to Pace Patterns in the One-Mile Run," Research Quarterly, 39:36-46, March, 1968.

Cureton, Thomas K. "Comparison of Various Factor Analyses of Cardiovascular-Respiratory Test Variables," Research Quarterly, 37:317-25, October, 1966.

Day, James A. P. "A Statistical Investigation of the Ryhming Step Test," Research Quarterly, 38:539-43, December, 1967.

Falls, Harold B. and Jacob E. Weibers. "The Effects of Pre-Exercise Conditions on Heart Rate and Oxygen Uptake During Exercise and Recovery," Research Quarterly, 36: 243-52, October, 1965.

Gallagher, J. Roswell, and Lucien Brouha. "A Simple Method of Testing the Physical Fitness of Boys," Research Quarterly, 14:23-7, March, 1943.

Garrett, Leon, Mohammed Sabie, and Roy Pangle. "Four Approaches to Increasing Cardiovascular Fitness during Volleyball Instruction," Research Quarterly, 36:496-99, December, 1965.

Hodgkins, Jean, and Vera Skubic. "Cardiovascular Efficiency Test Scores for College Women in the United States," Research Quarterly, 34:454-61, December, 1963.

Holmgren, Gary L., and George S. Harker. "Characteristic Pace as Determined by the Use of a Tracking Treadmill," Journal of Applied Psychology, 51:278-83, 1967.

Homola, Samuel. "Testing Athletic Fitness," Athletic Journal, 46:56-59, 67, January, 1966.

Howard, Gorden E. "Effects of Warm-up on the Heart Rate During Exercise," Research Quarterly, 37:360-67, October, 1966.

Howell, Maxwell L., A. P. Bakogeorge, and B. A. Kerr. "Progressive Treadmill Test Norms for College Males," Research Quarterly, 35:322-25, October, 1964.

Howell, Maxwell L., and Ken Coupe. "Effect of Blood Loss Upon Performance in the Balke-Ware Treadmill Test," Research Quarterly, 35:156-65, May, 1964.

Koff, Arnold, Robert A. Bruce, Kenneth Fernandes, David Ovenell, and Russell K. Cutler. "Cardiorespiratory Responses to Strenuous Exercise in Physically Trained and Untrained Normal Men," Research Quarterly, 34:41-9, March, 1963.

Michael, Ernest D. Jr., and Arthur J. Gallon. "Pulse Wave and Blood Pressure Changes Occurring During a Physical Training Program," Research Quarterly, 31:43-59, March, 1960.

Montoye, Henry J., William Mack, and John Cook. "Brachial Pulse Wave as a Measure of Cross-Country Running Performance," Research Quarterly, 31:174-80, May, 1960.

Murphy, Mary Agnes. "A Study of the Primary Components of Cardiovascular Tests," Research Quarterly, 11:57-9, 1940. (Microcard.)

Skubic, Vera, and Jean Hodgkins. "Cardiovascular Efficiency Test Scores for Junior and Senior High School Girls in the United States," Research Quarterly, 35:184-92, May, 1964.

Vanderbie, Jan H. "Metabolic Cost of Simulated Sled Pulling on the Treadmill," Research Quarterly, 27:111-16, March, 1956.

C. UNPUBLISHED MATERIALS

Hunter, J. G. "The Nature of the Response of the Heart to Stool Stepping and Bicycle Riding." Unpublished Master's thesis, State University of Iowa, Iowa City, June, 1968. (Microcard.)

Smith, Sidney L. "A Study to Determine the Effects of Six Weeks of Calisthenics Upon Cardiovascular Efficiency of College Males." Unpublished Master's thesis, Kansas State Teachers College, Emporia, August, 1968.

Wykert, C. Robert. "The Effects of Three Maximal Effort Running Programs on the Cardiovascular Efficiency of Junior High School Boys." Unpublished Master's thesis, Kansas State Teachers College, Emporia, January, 1969.

APPENDIX

HARVARD STEP TEST AND TREADMILL RUN RECORD CARD

NAME: ______________________________ GROUP NO. __________
(Last) (First) (Mid. Int.)

Name of Tester: ______________________________

HARVARD STEP TEST	TREADMILL RUN
1st. pulse count: __________	1st. pulse count: __________
2nd. pulse count: __________	2nd. pulse count: __________
3rd. pulse count: __________	3rd. pulse count: __________
ADD—TOTAL COUNT: __________	ADD—TOTAL COUNT: __________