

THE EFFECTS OF VARIOUS PHYSICAL EDUCATION PROGRAMS  
ON CARDIOVASCULAR EFFICIENCY

---

A Thesis

Presented to

the Division of Physical Education  
Kansas State Teachers College of Emporia

---

In Partial Fulfillment  
of the Requirements for the Degree  
Master of Science

---

by

Dennis M. Woolf

August 1969

TE  
VI

Cope Miller  
Approved for the Major Department

Truman Hayes  
Approved for the Graduate Council

3

288335

## ACKNOWLEDGMENTS

I extend my deep appreciation to Dr. George Milton for his assistance in making this study possible.

## TABLE OF CONTENTS

CHAPTER	PAGE
I. THE PROBLEM AND DEFINITIONS OF TERMS USED . . . . .	1
The Problem . . . . .	1
Statement of the problem . . . . .	1
Statement of the hypotheses . . . . .	1
Importance of the study . . . . .	2
Definitions of Terms Used . . . . .	2
Step test . . . . .	2
Physical fitness . . . . .	2
Resting pulse rate . . . . .	3
Post-exercise pulse rate . . . . .	3
Heart rate recovery time . . . . .	3
Palpation method . . . . .	3
Cadence . . . . .	3
Delimitations of the Study . . . . .	3
Limitations of the Study . . . . .	4
II. REVIEW OF THE LITERATURE . . . . .	5
The Development of the Cardiovascular	
System as Indicated by Step Tests . . . . .	5
The Development of Cardiovascular Efficiency	
as Indicated by Various Types of Tests . . . . .	16

CHAPTER	PAGE
III. TESTING PROCEDURE . . . . .	24
Subjects . . . . .	24
Organization of Groups . . . . .	25
Equipment Used . . . . .	26
Laboratory Assistants . . . . .	27
Training Groups . . . . .	27
IV. ANALYSIS OF DATA . . . . .	32
Significance of the Mean Gain for the Four	
Groups in the Harvard Step Test Performance . . . . .	32
Analysis of Variance of Cardiovascular Improvement	
for the Subjects in the Four Groups Tested . . . . .	34
V. SUMMARY, FINDINGS, CONCLUSIONS, AND	
RECOMMENDATIONS . . . . .	37
Summary . . . . .	37
Findings . . . . .	37
Conclusions . . . . .	38
Recommendations . . . . .	39
BIBLIOGRAPHY . . . . .	41
APPENDIX . . . . .	45

## LIST OF TABLES

TABLE	PAGE
I. The Significance of the Difference Between the Initial and Final Cardiovascular Efficiency Score for All Training Groups . . . . .	35
II. Analysis of Variance of Cardiovascular Improvement for the Subjects in the Four Groups . . . . .	36

## CHAPTER I

### THE PROBLEM AND DEFINITIONS OF TERMS USED

One of the basic objectives in every physical education program is to develop physical fitness in those who participate. If this objective is to be realized, then some method of judging the effects of the program on the physical fitness of the student should be employed. This study has used a modified step test in order to determine the relative physical fitness of high school boys as indicated by their cardiovascular efficiency.

#### I. THE PROBLEM

Statement of the problem. The purpose of this study was to investigate the differences in the effects of various physical activities on the cardiovascular efficiency of high school males. Specifically, this study ascertained the effects of (1) physical education class activities; (2) interscholastic football; (3) a combination of physical education class activities and interscholastic football; (4) no organized physical activity at any time during the twelve week training period, on the cardiovascular efficiency of high school males.

Statement of the hypotheses. There was no difference in the cardiovascular efficiency of high school males participating in various physical activities.

Importance of the study. The modified Harvard Step Test uses a pulse rate to measure the efficiency of the cardiovascular system. Using the pulse rate as a reliable index of cardiovascular efficiency, the physical educator can note improvements in the physical fitness development of the students in the physical education program.

## II. DEFINITION OF TERMS USED

Cardiovascular efficiency. Cardiovascular efficiency, as defined by Brouha, is the ability of the cardiovascular system to adapt itself to hard work and to recover from what it has done.<sup>1</sup>

Step test. The step test is an activity which requires the participant to step, one foot at a time, up on to and down from a bench, stool, chair, etc. This activity was done at a pace of thirty steps per minute for a period of four minutes.

Physical fitness. Physical fitness is the physical or physiological efficiency of a subject exemplified by his ability to perform work and recuperate.<sup>2</sup>

---

<sup>1</sup>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), p. 31.

<sup>2</sup>Frederick W. Kasch, "A Comparative Study of the Pulse Rate and Respiratory Metabolism of Cardiac and Normal Boys During Standard Exercise," (unpublished Masters Thesis, New York University, New York, August, 1956), p. 4.



Resting pulse rate. The resting pulse rate was the number of heart beats per minute while the subject was lying down, relaxed, and awake. The resting pulse was taken the final thirty seconds of a two minute resting period.

Post exercise pulse rate. The post exercise pulse rate was the heart beat rates determined during the one, two, and three minute pulse counts following the step test exercise. The one minute count began five seconds after exercise had stopped.

Heart rate recovery time. The heart rate recovery time was the time it took the post exercise pulse rate to reach an at rest rate following the step test exercise.

Palpation method. The palpation method was a means of detecting the pulse rate by placing the tester's first two fingers on the ventral side of the wrist just proximal to the base of the subject's thumb.

Cadence. Cadence, as used in the step test, was a pace denoting the number of steps per minute during the testing exercise. The cadence used in this study was at a rate of thirty steps per minute. The cadence was kept constant by using a tape recorder during exercise time.

### III. DELIMITATIONS OF THIS STUDY

This study used cardiovascular recovery from a step test exercise as a device to indicate the development of cardiovascular efficiency in

high school males. The study compared the efficiency levels achieved by members of four separate groups participating in four separate programs of physical activity. Each of the eighty-four subjects was administered a modified Harvard Step Test before and after a twelve week training period.

#### V. LIMITATIONS OF THE STUDY

Three of the four groups studied in this cardiovascular experiment had participated in supervised physical activity. The activities themselves varied in their intensities. One of the factors that could not be controlled in these three groups was the amount of effort put forth by each individual during his particular activity. Effort would differ from individual to individual within each specific group. This being the case, the results of the study would be affected. The fourth group, control group, was to have no organized activity. However, their participation in vigorous physical activity may still have taken place. This factor was also uncontrollable. Other limitations which affected the results, but were not controllable, were weight and height of the subject, amount of sleep, diet, emotional reactions, smoking, agility, and amount of previous experience with similar tests.

## CHAPTER II

### REVIEW OF THE LITERATURE

Cardiovascular efficiency has been used quite extensively as an index to relate the fitness of groups or individuals to their participation in various intensities of exercise. The text of this chapter has dealt with many of the tests and experiments designed to show the relationships between cardiovascular efficiency and exercise.

The studies reviewed in this chapter have been arranged into two sections. The first section considers the development of cardiovascular efficiency and the results of such development as determined by step tests. The second section deals with cardiovascular development as indicated by various other types of tests.

#### I. THE DEVELOPMENT OF THE CARDIOVASCULAR SYSTEM

##### AS INDICATED BY STEP TESTS

Experiments in cardiovascular response to exercise were conducted by Tuttle in which a thirteen inch stool was the testing vehicle for high school boys. In this test, Tuttle varied the amount of steps per minute from fifteen to sixty steps per minute. The height of the stool remained constant throughout the test. The results showed that the maximum rate at which most subjects could function in the test is at about a sixty step per minute pace. Anything beyond sixty steps per minute generally resulted in an inefficiency due to a coordination factor. Since this coordination ability was not the object of the step

test, it should be kept to a minimum and not allowed to interfere with the cardiovascular test. By varying the number of steps per minute, Tuttle changed the impact of the exercise. The exercise time intervals were also changed from one minute to three minutes. Tuttle's major objective was to increase the heart beat rate by increasing the work output of the subjects.<sup>3</sup>

In another series of tests, Tuttle and Walker tested fourteen college varsity track athletes and their recovery rates after exercise. The results of this study showed that no significant difference existed in the resting pulse rate before, during, and after a season of track competition. The mean resting heart rate for thirty seconds in pre-season, mid-season, and post-season testings were 33-34-33 respectively. Tuttle and Walker did find, however, a significant difference between pre-season, mid-season, and post-season recovery rates after exercise. The difference here was in the number of heart beat counts it took before the subject went from the immediate post-exercise rate to the resting pulse rate. This study showed that the mean pre-season number of counts to recover was 355. During the mid-season, the total number of heart beats to achieve the normal at rest pulse was 349. This is a difference of six heart beats and is considered by Tuttle and Walker to be significant. The mean number of heart beats to reach a resting rate

---

<sup>3</sup>W. W. Tuttle, "Use of Pulse Ratio Test for Rating Physical Efficiency," Research Quarterly, II (May, 1931), p. 5.

in post-season readings was 228. This was 127 beats less than the mean count taken during the pre-season tests. Tuttle and Walker concluded that athletic training would have a significant affect on the recovery rate, but not on the resting rate of the individual.<sup>4</sup>

A study of twenty college males by Morehouse and Tuttle revealed that there was a direct relationship between the post-exercise pulse rate and the intensity of the step test exercise. The exercises in this study ranged from twenty to fifty steps per minute. The post-exercise pulse rate was taken for thirty seconds starting five seconds after the exercise ended. Also, the greater the increase in beats per minute due to mild exercise of the individual with a low resting pulse rate, the faster the fall in beats per minute after exercise. The relationship between low resting pulse rate and recovery after mild exercise did not exist as the exercise approached the strenuous level. Tuttle and Morehouse found that the reliability of the test was best if the procedure called for a forty to fifty step per minute cadence. The actual indicator of fitness was the recovery rate time that it took the individual to reach the resting rate.<sup>5</sup>

Some very definite effects of training on heart beat rate recovery was indicated in a 1959 study by Michael and Gallon. The study was

---

<sup>4</sup>W. W. Tuttle and F. H. Walker, "Effects of a Season of Training and Competition on the Response of the Hearts of High School Boys," Research Quarterly, XI (December, 1940), pp. 78-81.

<sup>5</sup>Laurence E. Morehouse and Waid W. Tuttle, "A Study of Post Exercise Heart Rate," Research Quarterly, XIII (March, 1942), p. 3.

a one minute step test at a thirty-six step per minute pace. The experiment used a seventeen inch bench. Seventeen college basketball players were tested every three weeks for a period of sixteen weeks. After three weeks of basketball practice for one and one-half hours a day, five days a week, the subjects showed a significant improvement in their recovery time after exercise. The significance was at the .05 level. After six weeks of basketball training, the significance of the recovery rate was at the .01 level. This high level was maintained throughout the remainder of the training program. After the season of basketball training, a test was given at two periods during the detraining time. The first test was given after ten weeks of detraining. There was a significant reversal of the recovery rate from what it had been during the training period. The second test was given twenty weeks after training stopped, and the recovery rate speed had shown a marked decline from the ten week detraining test.<sup>6</sup>

Ruffer conducted a study in which fifty highly active males were compared to fifty inactive males. The active males were determined by their participation in sports, games and recreational activities as shown by a questionnaire and interviews. The inactive group was determined by its lack of participation in such activities. The subjects

---

<sup>6</sup>Ernst D. Michael and Arthur Gallon, "Periodic Changes in the Circulation During Athletic Training as Reflected by a Step Test," Research Quarterly, XIX (October, 1959), pp. 303-311.

were of junior and senior high school age. All of the subjects tested were from the same school system. The subjects were given a step test. The test included an eight inch bench and a cadence of thirty steps per minute for five minutes. The heart rates in this step test were obtained by pulse counts. The pulse counts for the recovery data started sixty seconds after exercise had stopped, and was taken for thirty seconds.

The results of the study showed that the highly active group had significantly lower heart beat rates immediately following exercise than did the inactive group. The highly active group also showed significantly lower heart beat rates after a one minute recovery period than was shown by the inactive group.<sup>7</sup>

Elbel found that during a step test the relationship between the pulse rate increase and body weight was insignificant. Elbel also reported in his study that there was a positive correlation, but not a significant one, between pre-exercise pulse rate and the increase, due to the step test exercise, at a rate of eighteen steps per minute, for periods of thirty and sixty seconds. He also stated that there was a negative correlation between pre-exercise pulse rate and the increase during a thirty-six step per minute test that lasts for four sixty second periods.<sup>8</sup>

---

<sup>7</sup>William A. Ruffer, "Study of Extreme Physical Activity Groups of Young Men," Research Quarterly, XXVI (May, 1965), pp. 188-196.

<sup>8</sup>Edwin R. Elbel, "Relationship Between Pre-Exercise and Post-Exercise Pulse Rate," Research Quarterly, XIX (October, 1948), p. 222.

Bogard tested 120 college males with an initial Harvard Step Test. The initial test was administered the first week of a six and one-half week training program. The study was devised to determine the effects of long distance running on the cardiovascular efficiency of the subjects. The study by Bogard was such that four groups of students were formed. One group trained by running for a period of two minutes; a second group trained by running for a period of four minutes; the third group's training consisted of running for a six minute period of time; the fourth group ran eight minutes during each training session. At the end of six and one-half weeks, the subjects were given a second Harvard Step Test.

Bogard concluded that cardiovascular efficiency may be improved by participation in a running program. The study also revealed that an increased amount of running does not bring about a proportionate increase in the cardiovascular efficiency of the individual. The reason for this conclusion was that the two minute running group made the greater gain by having a higher degree of significance in the improvement of cardiovascular efficiency.<sup>9</sup>

Kasch conducted a study in which twenty-seven noncardiac males were tested against twenty-seven cardiac males. The subjects were from eight to thirteen years of age. Kasch tested the subjects with a step

---

<sup>9</sup>Gale Wayne Bogard, "The Effects of Four Running Programs on the Development of Cardiovascular Efficiency," (unpublished Specialists Thesis, Kansas State Teachers College, Emporia, Kansas, June, 1967), pp. 35-36.



test using a twelve inch bench at a pace of twenty-four steps per minute for three minutes. The results obtained by Kasch showed that the non-cardiac subjects were significantly lower in their total pulse rates during recovery than the cardiac group. The recovery pulse was taken at fifteen second intervals for five minutes.<sup>10</sup>

In a study by Davis, thirty college athletes were trained in a strenuous swimming program. Prior to the training program, a Schneider Test was given as a basis for comparing the group's cardiovascular efficiency improvement at the end of a nine week training period. The initial test was correlated with the post-training test and showed no significance in the improvement of the subjects' cardiovascular conditions at the .05 level of confidence.<sup>11</sup>

Jackson, Sharkey, and Johnston used twenty college male students in a study to determine the difference between one, two, three, and five days a week activity programs on the development of cardiovascular efficiency. The activity consisted of a treadmill session of ten minutes at a speed of seven miles per hour. To compare the groups, a pre-training and a post-training step test was administered. The step

---

<sup>10</sup>Fredrick W. Kasch, "A Comparative Study of the Pulse Rate and Respiration Metabolism of Cardiac and Normal Boys During Standardized Exercise," (unpublished Ed.D. dissertation, New York University, New York, July, 1956).

<sup>11</sup>Jack Farr Davis, "Effects of Training and Conditioning for Middle Distance Swimming Upon Measures of Cardiovascular Fitness, and Strength of Involved Muscles," (unpublished Ed.D. dissertation, University of Oregon, Eugene, Oregon, June, 1955).

test was a twenty-two step per minute exercise using a forty centimeter bench. Also given to these groups was a pre-training and a post-training oxygen consumption test. The results indicated that the three day activity schedule group showed as much improvement in cardiovascular efficiency as did the five day a week activity group. The oxygen and step tests correlated in the results with a coefficient of correlation of .72.<sup>12</sup>

In a study of the effects of football training on the cardiovascular system, Hammer studied twenty college varsity football players. The study consisted of step tests administered during pre-training, training, and de-training periods. The step test used, in this study, was a seventeen inch bench at a pace of thirty-six steps per minute for one minute. The resting pulse was taken before each step test while the subjects were in a sitting position. In post-exercise, the recovery pulse was determined for the final thirty seconds of each recovery minute for three minutes.

Hammer concluded that the pulse recovery for three minutes was lower during the training step test than it was in both the pre-training and post-training step tests. Hammer believed that the pulse rate measured after a standard exercise, such as the step test, became

---

<sup>12</sup>Jay H. Jackson, Brian J. Sharkey, and Pat Johnston, "Cardio-respiratory Adaptations to Training at Specified Frequency," Research Quarterly, LXXIX (May, 1968), pp. 295-300.

lower as an athlete continued to engage in a systematic football training program. As the training program stopped, and the de-training period continued, the pulse recovery totals increased until they reached the pre-training level.<sup>13</sup>

Milton employed the Harvard Step Test in a study of 463 college males. The subjects were tested to determine the effects of four different training programs on their cardiovascular efficiency as shown by the Harvard Step Test. The subjects were arranged into four groups. Each group was administered a pre-training Harvard Step Test. The training sessions lasted for a total of seven weeks. One of the four groups ran for ten minutes in each training session, one group ran for twenty minutes, and the third group ran for thirty minutes. The fourth group trained with isometric exercises for approximately five or six minutes each training session.

After the seven week training period, the four groups were administered the second Harvard Step Test. Milton concluded:

(1) Within the high scoring subjects on the first Harvard Step Test, the greatest improvement in cardiovascular efficiency was found in the ten minute and twenty minute running groups; (2) the running exercise improved the cardiovascular efficiency more than the isometric

---

<sup>13</sup>Willard M. Hammer, "Physiological Changes During Periods of Football Training and Detraining," (unpublished Ed.D. dissertation, University of Oregon, Eugene, Oregon, August, 1963).

exercises; (3) the increased running time of the three running groups did not show a significant proportional increase in the improvement of cardiovascular efficiency as was determined by the comparison of the pre-training Harvard Step Test to the post-training Harvard Step Test.<sup>14</sup>

In a study employing 125 children between seven and twelve years of age, Faine and Mathews checked the reliability of counting recovery pulse rates after a step test exercise. Random selections of subjects' pulse rates were counted by two testers simultaneously. The two pulse counts, in order to be valid, were to agree within two pulse beats of one another. This made the outside error in counts approximately three per cent. The procedure was followed at the pre-exercise reading, when the at rest pulse rate was taken, and during the post-exercise pulse rate recordings. In this experiment, it was found that the pulse rate declined rapidly toward the resting rate between twenty-five and forty-five seconds after the exercise had stopped. Faine and Mathews believed that the first thirty seconds immediately following exercise gave a valid maximum pulse rate obtained during exercise. In almost every case, the pulse was back to the resting rate within two minutes after the exercise

---

<sup>14</sup>George C. Milton, "The Effects of Three Programs of Long Distance Running and an Isometric Exercise Program on the Development of Cardiovascular Efficiency," (unpublished Ph.D. dissertation, Louisiana State University, Baton Rouge, August, 1966), pp. 57-60.

had stopped. For this reason it was concluded that it was useless to record the heart beat rate every thirty seconds for more than three minutes.<sup>15</sup>

In an experiment testing seventeen college basketball players, Michael and Gallon found that recovery from a step test exercise to the resting heart beat rate took from two to three minutes.<sup>16</sup>

Faulkner conducted a study in which the peak post-exercise heart rates of subjects were determined. Faulkner concluded that every individual contributed a different level of effort during testing exercise. In order to eliminate the variations in effort, the Harvard Step Test proved to be the most adequate testing device to insure proximal efforts by each subject tested. The reason for this conclusion was that the Harvard Step Test required a given amount of work output within a given period of time for the exercise.<sup>17</sup>

---

<sup>15</sup>S. Faine and D.T. Mathews, "Heart Rate as a Measure of Physical Fitness," Research Quarterly, XXII (December, 1951), p. 399.

<sup>16</sup>Michael and Gallon, loc. cit.

<sup>17</sup>John Faulkner, "Heart Rate During Physical Exercise," Research Quarterly, XXIV (December, 1953), pp. 453-458.

## II. THE DEVELOPMENT OF CARDIOVASCULAR EFFICIENCY AS INDICATED BY VARIOUS TYPES OF TESTS

In an experiment by Montoye, twenty-one varsity college oarsmen were tested on a treadmill. There were two tests given to the athletes. One of the tests was administered before and one after twelve weeks of rowing competition. Montoye concluded that the post-exercise recovery pulse rate was altered by the training program. Montoye's data indicated that the maximum post-exercise recovery pulse rate decreased with an increased training program.<sup>18</sup>

Alderman tested forty college male students on a bicycle ergometer. The test was designed to show the correlation between two work loads of the same task and their effects on heart rate increase after exercise. The work loads were incorporated into four bicycle exercises. Two of the bicycle exercises were performed at 45.45 revolutions per minute. The other two exercise periods were conducted at a speed of 54.54 revolutions per minute. The study indicated that when the individuals did two different work loads, of the same task, the heart beat increase correlated in both cases to the other subjects and their response to the work loads. The heart rate scores of different individuals did not correlate when the work loads were done

---

<sup>18</sup>H. J. Montoye, "Interrelation of Maximum Pulse Rate During Moderate Exercise, Recovery Pulse Rate, and Post Exercise Blood Lactates," Research Quarterly, XXIV (December, 1953), pp. 453-458.

through two different tasks. This indicated that a performance on one given type of test was not a true measure of an individual's cardiovascular efficiency. Some individuals ranked differently on two different types of tests when compared to the other subjects in the same study.<sup>19</sup>

In a study using twenty male and forty female college students, Salit and Tuttle disclosed that work done on a bicycle ergometer in a period of two minutes could be used as an indicator of cardiovascular efficiency. The study compared a predicted work output to the actual output during exercise. It was found that the weight of the male subjects correlated with their work output. The coefficient of correlation was .606. The formula,  $(17 \times \text{subject's weight in Kg.} + 448)$  was used to compute the amount of work a man should do on the basis of how much he weighs. Those subjects who did more work than was predicted were believed to be in better physical condition than those who equaled their prediction or were under the predicted amount of work. Salit and Tuttle concluded that the difference between actual and predicted work output was a better indicator of cardiovascular efficiency and physical fitness than merely work output achieved. The formula of work predictability was good for men only. Women showed no

---

<sup>19</sup>R. B. Alderman, "Individual Differences in Heart Rate Response to Bicycle Ergometer," Research Quarterly, XXXVIII (October, 1967), p. 323.

significant correlation between weight and work output.<sup>20</sup>

Rothacker compared forty athletes to forty non-athletes in a knee raise test before and after a fall season of activity. The forty athletes were tested before and after seasons of football, basketball, swimming, and track. Pulse recovery rates were determined for both the athletes and the non-athletes following the knee raise tests that required twenty raises in five seconds. A summary of Rothacker's conclusions is as follows:

1. Heart rate at rest was lower in the athletes than in the non-athletes.
2. The difference between heart rate while standing at rest and lying at rest varied only slightly between the athletes and the non-athletes.
3. Heart rate immediately following exercise was lower in athletes than in non-athletes.
4. Heart rate returned to normal in the first half of the second minute in eighty per cent of both the athletes and non-athletes.
5. In the last half of the second minute, all subjects returned to the resting pulse rate.
6. Pulse rate following exercise was lower for athletes than for non-athletes.<sup>21</sup>

Butler found that when the palpation method of taking pulse rates was compared to the plethysmograph, the pulse rate counts were

---

<sup>20</sup>Elizabeth Salit and W. W. Tuttle, "The Validity of Heart Rate and Blood Pressure Determination as Measures of Physical Fitness," Research Quarterly, XV (October, 1944), p. 252.

<sup>21</sup>J. L. Rothacker, "A Study of Athletic Condition in Relation to Circulation and Weight," Research Quarterly, XI (May, 1935), p. 62.



from a minus twelve to a plus four counts different. These readings were taken for a thirty second period while the subjects were at rest. When the readings were extended for a continuous two minutes before exercise, the range of palpation counts was from thirty-three less than the plethysmograph score to as much as thirty-six counts more than the plethysmograph.<sup>22</sup>

In a study by Campbell, seven college basketball players were tested to determine the effects of a season of basketball competition on their heart rates. A treadmill exercise was employed in pre-season and post-season testings. The post exercise pulse recoveries were established for thirty seconds, sixty seconds and ninety seconds.

Campbell's study showed no significant difference between the pre-season and the post-season resting pulse rates. The results did show that the mean recovery heart rates were significantly lower in post-season than they were in the pre-season tests.<sup>23</sup>

Bartels and Fox tested twenty college males in a ten second isometric exercise to determine its effects on the heart rate. The exercise included an isometric effort of up to sixty per cent of a

---

<sup>22</sup>L. K. Butler, "Accuracy in Securing Pulse by Palpation," Research Quarterly, XI (May, 1940), p. 18.

<sup>23</sup>Donald E. Campbell, "Heart Rates of Selected Male College Freshmen During a Season of Basketball," Research Quarterly, XXXIX (December, 1968), pp. 880-887.

previously determined maximum pull. The results of the test showed that the heart rate increased only slightly during the exercise, but raised sharply in the few seconds following the ten second exercise. The rapid increase in heart rate was then followed by a drop to the resting level within a thirty second recovery period.

The isometric study by Bartels and Fox also showed that the subjects' resting heart rate increased prior to the isometric test for the first two or three test sessions. After the third test session, no significant change was noted in the resting heart rate before the exercise.<sup>24</sup>

In a study by Michael, heart beat recovery rate was compared to the amount of metabolites (metabolic waste products) present and the effects of blood pressure on heart beat rate recovery after exercise. During the experiment, occlusions (devices used to restrict circulation) were put on the subjects' extremities. The results showed that when the recovery rate was below 140 beats per minute and occlusions applied, the heart beat rate always decreased. However, when occlusions were placed on a subject with a post-exercise heart beat rate of over 140 beats per minute, the heart beat rate did not show a rapid decline. Michael also found that if the occlusions were released when the heart rate was less than 110 beats per minute, there was a sudden increase in the rate of heart beats. If the heart beat rate was above the 110 beats per minute

---

<sup>24</sup>Robert L. Bartels and Edward Fox, "Effects of Isometric Work on Heart Rate, Blood Pressure, and Net Oxygen Cost," Research Quarterly, XXXIX (October, 1968), pp. 437-442.

level, and the occlusions released, there was no change noted.<sup>25</sup>

Herbert de Vries discussed six variables that have had effects on cardiovascular experiments. de Vries contended that some of these variables could not be fully controlled since they had their influence outside the laboratory. The six variables discussed by de Vries were:

- (1) Age- The age of the subjects will dictate what the tester can generally expect during the study. To illustrate this, the range of heart beat rates at rest for twelve to eighteen year old males was between seventy-nine and ninety beats per minute. For males over eighteen years, there was no correlation between age and heart rate at rest;
- (2) Sex- most studies revealed that the resting female heart rate was from five to ten beats per minute faster than the resting male heart beat at a given age;
- (3) Size- the range of sizes of the subjects had an influence on the construction and use of testing apparatus;
- (4) Posture- de Vries stated that subjects in his studies showed an increase of ten to twelve beats per minute difference in the standing at rest pulse rate and the lying at rest pulse rate;
- (5) Food- the resting pulse will be affected by the presence of food within the digestive system. The studies by de Vries indicated that the resting pulse increased significantly following food intake;
- (6) Body Temperature- the body temperature fluctuation had a significant affect

---

<sup>25</sup>E. D. Michael, "Local Metabolites and the Circulatory Adjustments to Exercise," Research Quarterly, XXXIV (March, 1963), pp. 64-69.

on the pulse rate at rest, during exercise, and in recovery.<sup>26</sup>

Tuttle reported that a variation in the position of the subject during a resting period had a significant effect on the resting pulse rate. Tuttle found that from five to ten beats per minute more would be recorded in the resting pulse on those subjects standing erect as compared to the same subjects when in a lying position. Also, Tuttle stated that the difference in resting pulse rates of individuals of different ages was not due to the age of the person, but could be attributed to the size and volume of the body.<sup>27</sup> In conjunction with the position and age of the subjects, the general metabolic activities of the body increased approximately thirteen per cent for every one degree increase of body temperature.<sup>28</sup>

Wright stated that when the temperature of the environment was lowered, little effect took place as far as the change in the pulse rate of the body was concerned. This was due primarily to a decrease in the area covered by the cardiovascular system. However, when the environmental temperature increased, the pulse rate of the individual also increased due to dilation of blood vessels.<sup>29</sup>

---

<sup>26</sup>Herbert de Vries, Physiology of Exercise (Dubuque, Iowa: Wm. C. Brown and Co., 1966), p. 71.

<sup>27</sup>W. W. Tuttle and William Zoethout, Textbook of Physiology (St. Louis, Mo.: The C. V. Mosby Co., 1940), p. 219.

<sup>28</sup>Ibid., p. 461.

<sup>29</sup>Samson Wright, Applied Physiology (New York, N.Y.: University Press, 1940), pp. 423-424.

In a study by Jokl, it was determined that body size and composition were the main factors involved in the ability of an individual to endure strenuous activity. Limitations on the cardiovascular efficiency and performance of the heart were: size of the heart, body form, quality of the skeleto-muscular tissues, and adiposity. Also, previous dietary practices had ultimately limited the ability to do well in muscular exercises.<sup>30</sup>

The purpose of the review of the literature was to obtain a collection of ideas from those who have previously dealt with the problems involved in studies of the relationships between cardiovascular efficiency and the physical fitness of various groups of students. These studies were designed to relate physical activities to the development of cardiovascular efficiency. It was the purpose of this study to continue the investigation of the effects of physical activity on the cardiovascular efficiency in hopes that it would lead to better physical education programs.

---

<sup>30</sup>Ernst Jokl, "Advances in Physiology of Exercise - The Heart of the Athlete," Journal of Health Physical Education and Recreation, XXVI (November, 1955), pp. 22-23.

## CHAPTER III

### TESTING PROCEDURE

The purpose of this study was to determine the development of cardiovascular efficiency in high school males as a result of a twelve week training program of physical education class activities, or interscholastic football, or no organized physical activity. A modified Harvard Step Test was administered before and after the twelve week training period.

#### I. SUBJECTS

The subjects employed in this study were tenth, eleventh, and twelfth grade males, and ranged from fourteen to seventeen years in age. To become eligible for the study, each student must have been participating in only one of the three physical education activity programs or not participating in any type of organized physical activity. Prior to being tested, each subject was in an academic classroom situation. The academic classes involved were physiology, English, biology, art, and general math. The classrooms from which the subjects were acquired, were all located on the same floor, and with the exception of one, they were all located in the same end of the high school building. The purpose for selecting the students in these classrooms was to facilitate the reliability of the resting pulse rate which was

taken after the subjects had left the classroom and prior to the step test exercise.

Of the ninety-eight students involved in the pre-training step test, eighty-four students completed the study and were used for the final analysis. Four of the subjects had begun basketball practice two weeks prior to the final step test, seven students were either absent from school or were recovering from illness, and three students had dropped from school.

## II. ORGANIZATION OF GROUPS

The selection of subjects for this study was based on their participation in various organized physical education activities. All male students in each of the five academic sections were administered a questionnaire (see Appendix) to determine the extent of their physical education activities. With the information obtained from the questionnaire, the students were either eliminated due to participation in other physical activities, or placed in one of the following four groups:

Group I. Group I was composed of those students who were in one of the regularly scheduled physical education classes, but no other organized physical activity.

Group II. Group II consisted of students who participated only in interscholastic football.

Group III. Group III was formed from students in one of the physical education classes and who also participated in interscholastic football.

Group IV. Group IV was composed of students who had not participated in any type of physical activity during the twelve week training period. This group served as the control group.

The decision to organize the four test groups as such, was based on the idea that all groups had started the 1968 fall term at Emporia High School under relatively the same conditions. Each group had completed a three months absence from organized school activities. They were all tested during the second week of school, and each group was re-tested twelve weeks after the initial test. Uncontrollably, some of the individuals in the groups were more active during the summer months than others. This factor would effect the results of the test, and was recognized as a delimitation factor.

### III. EQUIPMENT USED

The equipment used was kept to a minimum due to the nature of the step test. A bench sixteen inches in height, two feet long, and eighteen inches wide was used as the exercise device. The room in which the test was administered was a combination physiology-biology laboratory. This room was kept at a relatively constant temperature and was relatively isolated from outside interference. A tape



recorder was used to pace the subjects during the step exercise. The times for the recovery counts were kept by a stop watch. During the resting period, the subjects rested on a padded table. Results of the tests were kept on three by five cards (see Appendix). One card was used for both the initial and final step tests.

#### IV. LABORATORY ASSISTANTS

The assistants used to collect the data were male physiology and biology laboratory assistants. The week prior to the initial test was used as an orientation period for the assistants. For two days during this week, the assistants recorded the cadence and practiced the palpation pulse count method. The writer of the study supervised the testing and the transport of students to and from the testing site.

#### V. TRAINING OF GROUPS

Group I, the physical education class group, trained five sessions a week for fifty minutes each session. Each session began with ten minutes of calisthenics. In the first four weeks of the twelve week training period, volleyball and tumbling were the activities for the physical education classes. During the second four weeks, gymnastics made up the bulk of the group's activity. The final four weeks were devoted primarily to wrestling activities.

Group II, the football players, participated in football practice sessions for approximately one and one-half hours each session for six sessions a week, the first three weeks of training. During the last nine weeks of training, there were four practice sessions a week and one game per week. Each of the practice sessions consisted of agility drills, sprints, and scrimmages.

Group III, the combination physical education-football group participated in the activities described for groups I and II. The subjects in this group were in two sessions of activity each day for the twelve week training period.

The control group, Group IV, had no organized activity during the regularly scheduled school day. This condition was true for the entire twelve weeks of training.

## VI. TESTING PROCEDURE

All subjects were administered the pre-training modified Harvard Step Test during the second week of the fall term of the 1968-69 school year. The groups were tested on successive days beginning with Group I, then Group II, Group III, and Group IV respectively.

As stated previously the subjects were removed from an academic classroom situation prior to testing. Each subject reported to the testing site while the previous subject completed his recovery counts after exercise. Upon reaching the testing site, the subjects

were asked to lie down for a timed period of two minutes. At the end of one and one-half minutes, the subject's resting pulse rate was determined by the assistants using the palpation method. The resting pulse rates were taken by two assistants simultaneously, with one assistant on each of the subject's wrists. This resting pulse rate was determined during the final thirty seconds of the two minute resting period.

The two minute resting time was selected as a result of a study by Faine and Mathews in which they concluded that the resting pulse of individuals was reached within a two minute resting period.<sup>31</sup>

As a validity check, the resting pulse rates taken by the two assistants were not to differ more than five counts. If the resting pulse rates differed more than five counts, the subjects were returned to the classroom and re-tested later that same day.

After the resting pulse had been determined, the subjects stood before a sixteen inch bench. Upon hearing the tape recorded signal "up", the subjects placed their left foot onto the bench. As the word "two" was sounded, the subjects placed their right foot onto the bench and stood erect. The word "three" was the signal for the subjects to place their left foot back down onto the floor. The word "four" was

---

<sup>31</sup>Solomon Faine and D. T. Mathews, "Heart Rate as a Measure of Physical Fitness," Research Quarterly, XXII (December, 1951), p. 399.

the signal to place the right foot onto the floor. This series of movements constituted one step in the exercise. The cadence used to complete one full step was recorded on the tape player at a rate of thirty steps per minute. The exercise continued at this rate for a maximum of four minutes. The total time of the exercise was recorded on the tape player at a rate of thirty steps per minute. The exercise continued at this rate for a maximum of four minutes. The total time of the exercise was recorded on the subjects' identification cards in minutes and also in total number of seconds.

Immediately following the exercise, the subjects sat down on a stool and their post-exercise recovery rates were determined by the two assistants simultaneously. The post-exercise pulse rates were taken for the first thirty seconds of each minute for three minutes. The pulse count in recovery was started five seconds after the exercise stopped. To keep the pulse count reliable, the assistants were to differ no more than ten counts. If the counts were beyond the limited ten difference, the subjects were taken back to the classroom and re-tested the following day.

The following formula was used to calculate the test scores for both the pre-season and post-season tests.<sup>32</sup>

---

<sup>32</sup>C. H. McCloy and Norma D. Young, Test and Measurements in Health and Physical Education (New York, N.Y.: Appleton-Century-Crofts, Inc., 1954), p. 304.

$$\frac{\text{Length of Exercise in Sec. X 100}}{2 \text{ X Sum of Pulse Counts in Recovery}}$$

The identical testing procedure was followed for the post-training test at the completion of the football season.

## CHAPTER IV

### ANALYSIS OF DATA

In this study of the cardiovascular efficiency development in high school males, data were obtained from the results of a pre-training and a post-training step test. The data established, included the significance of the mean gain for each group in recovery during the Harvard Step Test, and the significance of the mean gain in cardiovascular improvement among all subjects as shown by the analysis of variance.

#### I. SIGNIFICANCE OF THE MEAN GAIN FOR THE FOUR GROUPS IN THE HARVARD STEP TEST PERFORMANCE

In order to establish a significance of the difference between the mean gain for the physical education class group, a  $t$  was computed in which the initial step test recovery results were compared to the final step test recovery results. The  $t$  was computed after a difference between the total group mean recovery score in the initial test and the total group mean score in the final test had been established. To show a significant gain, the data for Group I, or the physical education group, had to have a  $t$  greater than 2.07 at the .05 level of significance. The computed  $t$  for Group I, or the physical education group, was 1.93. It can be seen that there was no significant gain in cardiovascular efficiency for Group I, or the physical education group, at the .05 level of confidence.

Group II, or the football group, participating in the twelve week football program had 170.05 as a mean total in the three minutes of recovery during the pre-training step test. A 156.55 mean total was acquired during the post-training step test. The difference between the means was 13.15 pulse counts. A  $t$  of 2.09 was needed at the .05 level of confidence to prove a significant difference in the development of the cardiovascular system.

The mean total of the one, two, and three minute recovery rates for the combination physical education-football group was 179.20 in the initial step test and 155.30 in the final step test. The difference between the mean totals was 23.90. The  $t$  for the difference in mean total pulse counts during recovery was 4.19. To establish significance, the  $t$  needed to be 2.09 at the .05 level of probability and 2.86 at the .01 level of probability. With a  $t$  of 4.19, the athletic team membership plus the physical education class activities, did significantly improve cardiovascular efficiency.

During the initial step test, the inactive group showed a mean recovery total of 202.24. The final mean recovery total was 191.33. A difference of 10.91 pulse counts was noted between the two mean total counts in recovery. A  $t$  was computed for the difference between the two mean recovery totals for Group IV, or the non-organized activity group; the  $t$  test score was 1.42. To be significant, the  $t$  must have been 2.09 at the .05 level of confidence.

A summarization of the data collected during cardiovascular recovery after the initial and final step tests can be seen in Table I.

## II. ANALYSIS OF VARIANCE OF CARDIOVASCULAR IMPROVEMENT FOR THE SUBJECTS IN THE FOUR GROUPS TESTED

An analysis of variance was employed to determine if there were significant differences in the gains achieved among the four tested groups in their performances during the Harvard Step Tests. Analyses were made in relation to the gains acquired between the initial and final Harvard Step Tests. The results of the analyses for the four groups are shown in Table II.

An  $F$  of 1.88 was obtained in the analysis of the differences in the gains made between the performances on the initial and final Harvard Step Tests. As noted from Table II, an  $F$  of 2.72 was needed to show a significant difference in cardiovascular improvement at the .05 level of significance. The non-significant  $F$  indicated that there was no significance in the increase of the cardiovascular efficiency performance when the physical education, football, physical education-football, and non-activity groups were compared.

Although all groups did improve, the physical education-football group made the largest amount of improvement in cardiovascular efficiency of all four groups.



TABLE I  
THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE INITIAL  
AND FINAL CARDIOVASCULAR EFFICIENCY  
SCORE FOR ALL TRAINING GROUPS

Group	N	Initial Mean	Final Mean	Mean Diff.	t	P
Physical edu- cation class	22	182.87	170.70	12.17	1.93	.05
Football	19	170.05	156.55	13.15	1.97	.05
Physical educa- tion-football	19	179.20	155.30	23.90	4.19	.05
No organized activity	20	202.24	191.33	10.91	1.42	.05

t needed:

With 22 df 2.07 for .05 level of probability  
With 19 df 2.09 for .05 level of probability  
With 19 df 2.09 for .05 level of probability  
2.86 for .01 level of probability  
With 20 df 2.09 for .05 level of probability

TABLE II  
ANALYSIS OF VARIANCE OF CARDIOVASCULAR  
IMPROVEMENT FOR THE SUBJECTS IN  
THE FOUR GROUPS

Source of Variance	Sum of Squares	df	Mean Square	F
Among groups	2210	3	736	1.88
Within groups	31292	80	391	
Total	33502	83		

F needed: 2.72 for .05 level of probability  
4.04 for .01 level of probability

## CHAPTER V

### SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

#### I. SUMMARY

This study dealt with the development of cardiovascular efficiency in high school males. Four groups were tested before and after a twelve week period of training in physical education class activities, or interscholastic football, or both physical education class and interscholastic football, or no organized physical activity. A step test was administered to determine the level of cardiovascular efficiency in both a pre-training and a post-training step test. The step test exercise was conducted at a thirty step per minute pace and the recovery rates after exercise were determined for each of three minutes in recovery.

#### II. FINDINGS

The findings in this study were based on the significance of the mean differences in total recovery pulse rates after exercise and the significance of the analysis of variance of cardiovascular improvement for the subjects in the four tested groups. The findings for this study were as follows.

1. Participation in physical education class and interscholastic football does significantly improve the cardiovascular efficiency of high school males as indicated at the .05 and .01 level of significance.

2. No significant improvement was noted in the cardiovascular efficiency of high school males having participated in regularly scheduled physical education class activities for a period of twelve weeks.

3. There was no significant improvement in the cardiovascular efficiency of high school interscholastic football players after a season of competition.

4. The control group, with no organized physical activity, showed no significant improvement in cardiovascular efficiency.

5. The significance of the analysis of variance indicated no significant differences in the improvement of cardiovascular efficiency among the four groups as shown by their performances in initial and final Harvard Step Tests.

### III. CONCLUSIONS

As a result of the data obtained from the initial and final step tests, the following conclusions have been drawn.

1. Participation in physical education activities and interscholastic football improves the cardiovascular efficiency of high school males. The improvement was significant at both the .05 and .01 levels of significance.

2. High school males having participated in regular physical education class activities, for a period of twelve weeks, will improve their cardiovascular efficiency, but not significantly.

3. Following a season of competition, football players will improve their cardiovascular efficiency, but the improvement will not be significant.

4. High school males having no organized physical activity will show no significant improvement in cardiovascular efficiency.

5. No significant differences are found among the four training programs in the effectiveness of improving cardiovascular efficiency.

#### IV. RECOMMENDATIONS

The purpose of this study was to investigate the effects of various types and intensities of physical education activities on the cardiovascular development of high school males. The prime variable in this study was the participation by the subjects in different physical activity programs for twelve weeks. Many studies of the same nature, but with different variables, can be done to further the investigation of cardiovascular efficiency development. Some recommendations of further studies are as follows:

1. Make a comparison between weight and the development of cardiovascular efficiency after a semester of high school physical education class activity.

2. Compare the differences in the effects of a season of varsity football competition and a season of tennis on the development and maintenance of the cardiovascular efficiency of high school boys.

3. Establish the level of cardiovascular efficiency and compare a physically active group of high school males to a group of physically inactive high school males.

4. Determine the pre-training level of cardiovascular efficiency, the amount of development of the cardiovascular system after a season of track competition, and the level of cardiovascular efficiency after ten weeks of de-training.

5. Determine the level of cardiovascular development of high school males at the beginning of the school year, and compare this to the level of cardiovascular efficiency at the end of the school year.

## **BIBLIOGRAPHY**

## BIBLIOGRAPHY

## A. BOOKS

- de Vries, Herbert A. Physiology of Exercise. Dubuque: Wm. C. Brown Company, 1966.
- McCloy, C.H. and N.D. Young. Test and Measurements in Health and Physical Education. New York: Appleton-Century-Crofts, Inc, 1954.
- Tuttle, W.W. and William Zoethout. Text Book of Physiology. St. Louis: The C.V. Mosby Company, 1940.
- Wright, Samson. Applied Physiology. New York: Oxford University Press, 1940.

## B. PERIODICALS

- Alderman, R.B. "Interindividual Differences in Heart Rate Response to Bicycle Ergometer," Research Quarterly, XXXVIII (October, 1967), p. 323.
- Bartels, Robert and Edward Fox. "Effects of Isometric Work on Heart Rate, Blood Pressure, and Net Oxygen Cost," Research Quarterly, XXXIV (October, 1968), pp. 437-442.
- Brouha, Lucien. "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, XIV (March, 1943), p. 31.
- Butler, L.K. and A.T. Hammel. "Accuracy of Measuring Heart Rate," Research Quarterly, XI (May, 1940), p. 18.
- Campbell, Donald E. "Heart Rates of Selected Male College Freshmen During a Season of Basketball," Research Quarterly, XXXIX (December, 1968), pp. 880-887.
- Elbel, E.R. "Relationship Between Pre-exercise and Post-exercise Pulse Rate," Research Quarterly, XIX (October, 1948), p. 222.
- Faine, S. and D.T. Mathews. "Heart Rate as a Measure of Physical Fitness," Research Quarterly, XXII (December, 1951), p. 399.



- Faulkner, John. "Heart Rate During Exercise," Research Quarterly, XXXIV (March, 1963), pp. 95-98.
- Jackson, Jay H., Brian Sharkey, and Pat Johnston. "Cardiorespiratory Adaptations to Training at Specified Frequency," Research Quarterly, XXXIX (May, 1968), pp. 295-300.
- Jokl, Ernst. "Advances in Physiology of Exercise - The Heart of the Athlete," Journal of Health, Physical Education and Recreation, XXVI (November, 1955), pp. 22-23.
- Michael, E.D. "Local Metabolites and the Circulatory Adjustments to Exercise," Research Quarterly, XXXIV (March, 1963), pp. 64-69.
- Michael, E.D. and A. Gallon. "Periodic Changes in the Circulation During Athletic Training as Reflected by a Step Test," Research Quarterly, XXX (October, 1959), pp. 303-311.
- Montoye, H.J. "Inter-relation of Maximum Pulse Rate During Moderate Exercise, Recovery Pulse Rate, and Post-Exercise Blood Lactate," Research Quarterly, XXIV (December, 1953), pp. 453-458.
- Morehouse, L.E. and W.W. Tuttle. "A Study of Post Exercise Heart Rate," Research Quarterly, XIII (March, 1942), p. 3.
- Rothacker, J.L. "A Study of Athletic Condition in Relation to Circulation and Weight," Research Quarterly, VI (May, 1935), p. 62.
- Ruffer, William A. "Study of Extreme Physical Activity Groups of Young Men," Research Quarterly, XXXVI (May, 1965), pp. 183-196.
- Salit, Elizabeth and W.W. Tuttle. "The Validity of Heart Rate and Blood Pressure Determination as Measures of Physical Fitness," Research Quarterly, XV (October, 1944), p. 252.
- Tuttle, W.W. "Use of Pulse Ratio Test for Rating Physical Efficiency," Research Quarterly, II (May, 1931), p. 5.
- Tuttle, W.W. and F.H. Walker. "Effects of a Season of Training and Competition on the Response of the Hearts of High School Boys," Research Quarterly, XI (December, 1940), pp. 78-81.

### C. UNPUBLISHED MATERIALS

Bogard, Gale Wayne. "The Effects of Four Running Programs on the Development of Cardiovascular Efficiency." Unpublished Specialists thesis, Kansas State Teachers College, Emporia, Kansas, 1967.

Davis, Jack Farr. "Effects of Training and Conditioning for Middle Distance Swimming Upon Measures of Cardiovascular Fitness and Strength of Involved Muscles." Unpublished Ed.D. dissertation, The University of Oregon, Eugene, Oregon, 1955.

Hammer, William M. "Physiological Changes During Periods of Football Training and Detraining." Unpublished Ed.D. dissertation, The University of Oregon, Eugene, Oregon, 1963.

Kasch, F.W. "A Comparative Study of the Pulse Rate and Respiratory Metabolism of Cardiac and Normal Boys During Standard Exercise." Unpublished Ed.D. dissertation, New York University, New York, New York, 1956.

Milton, George Cohle. "The Effects of Three Programs of Long Distance Running and an Isometric Exercise Program on the Development of Cardiovascular Efficiency." Unpublished Ph.D. dissertation, Louisiana State University, Baton Rouge, 1966.

## **APPENDIX**

GROUP PLACEMENT QUESTIONNAIRE

NAME \_\_\_\_\_ AGE \_\_\_\_\_

Check one of the following:

I am participating in

- I. Physical education class only \_\_\_\_\_
- II. Interscholastic football only \_\_\_\_\_
- III. Physical education and football \_\_\_\_\_
- IV. No organized physical activity \_\_\_\_\_

SUBJECT IDENTIFICATION CARD

NAME _____		ID. NO. _____	
First H.S.T.		Second H.S.T.	
Resting Pulse _____		Resting Pulse _____	
1 min. _____		1 min. _____	
2 min. _____		2 min. _____	
3 min. _____		3 min. _____	
Total _____		Total _____	

## HARVARD STEP TEST FORMULA

$$\frac{\text{Length of exercise in sec. X 100}}{2 \text{ X Sum of pulse counts in recovery}}$$