The Effects of Isometric and Isotonic Endurance Exercises on the Development of Cardiovascular Efficiency of Eighth Grade Girls Classified according to Initial Cardiovascular Efficiency and Weight.

Xandra L. Hamilton
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HAMILTON, Xandra L., 1936—
THE EFFECTS OF ISOMETRIC AND ISOTONIC
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MENT OF CARDIOVASCULAR EFFICIENCY
OF EIGHTH GRADE GIRLS CLASSIFIED ACCORD-
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AND WEIGHT.

Louisiana State University, Ed.D., 1966
Education, physical

University Microfilms, Inc., Ann Arbor, Michigan
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OF EIGHTH GRADE GIRLS CLASSIFIED ACCORDING
TO INITIAL CARDIOVASCULAR
EFFICIENCY AND WEIGHT

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Education

in

The Department of Health, Physical and Recreation Education

by

Xandra L. Hamilton
B.S., Butler University, 1958
M.S., Butler University, 1960
January, 1966
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ACKNOWLEDGMENTS

The author wishes to express her appreciation to Dr. Jack K. Nelson for his suggestions, assistance, and patience in serving as major professor for the experiment and the students and faculty at Westlane Junior High School for their cooperation and assistance.
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ABSTRACT

The purpose of this study was to determine the effectiveness of isometric exercises and isotonic endurance exercises in improving cardiovascular efficiency of eighth grade girls who were rated from high to low in initial cardiovascular efficiency. A secondary purpose was to determine the relative effects of isometric exercises and isotonic endurance exercises in improving cardiovascular efficiency of the subjects when classified as being underweight, average weight, or overweight.

The subjects in this study were 120 eighth grade girls enrolled in physical education classes. At the beginning of the experiment each girl was classified as being underweight, average weight, or overweight in accordance with the Pryor Width-Weight Chart. All subjects were then administered the modified Harvard Step Test. Based upon the results of the initial step test, the subjects were divided into five equal groups with the twenty-four subjects having the lowest cardiovascular efficiency scores in one group, the next lowest twenty-four scores in the second group, and on up to the twenty-four subjects having the highest step test scores comprising the fifth group. Each of these groups was then randomly divided into an isometric exercise group and an isotonic exercise group.
The subjects in the isotonic group performed a series of isotonic exercises, and the girls in the isometric group performed a battery of isometric exercises three days per week for six weeks in addition to their regular physical education activity. At the end of the training program, the modified Harvard Step Test was readministered.

The data were analyzed by means of the t-test for correlated means to establish the significance of the mean gains in cardiovascular efficiency scores from the initial to the final tests for each group. Where significant t-scores were found, analysis of covariance was used to compare the effects of the two exercise programs. Product-moment coefficients of correlation were employed to analyze the relationship of the type of exercise program with cardiovascular efficiency performance of the subjects when classified by initial cardiovascular fitness and also when classified by body weight.

The main findings in this study were:

1. For the general population of eighth grade girls, the isometric exercises performed in this study will produce significant improvement in cardiovascular efficiency.

2. The subjects with lowest initial cardiovascular efficiency improved more with isotonic exercises than with isometric exercises.
3. The subjects of highest initial cardiovascular efficiency in the isotonic exercise program had significantly poorer scores at the end of the study, whereas the subjects of similar initial status in the isometric program showed no significant change in scores.

4. For all subjects there was a significant negative correlation between initial status in cardiovascular efficiency and gains made from initial to final test.

5. The relationship between body weight and initial cardiovascular efficiency, although negative, was not significant, nor was the correlation between type of exercise and step test improvement in subjects when classified by body weight.

6. The average weight subjects in both exercise programs showed significant improvement in cardiovascular efficiency performance.

Within the limitations of this study, the following conclusions were drawn:

1. Isometric exercises are beneficial in improving cardiovascular efficiency for girls of all levels of initial cardiovascular fitness, while the benefits of isotonic exercises appear to be more specific according to initial level of fitness.

2. Isotonic exercises are better for subjects having low initial cardiovascular efficiency than are isometric exercises.
3. In order to improve cardiovascular efficiency, more strenuous exercises should be provided for subjects of high initial cardiovascular fitness.

4. Average weight girls show more improvement in cardiovascular efficiency than either underweight or overweight girls in both programs of exercise.
CHAPTER I

STATEMENT OF THE PROBLEM

I. INTRODUCTION

During the past several years there has been widespread concern for the physical condition of the American public. Not infrequently, achievement in sports and successful performance in emergencies demand a high level of respiratory and cardiovascular fitness. It is not surprising, therefore, that physical educators and athletic coaches have been vitally concerned with the development of these physiological systems. It follows that techniques for measuring the effectiveness of recreational and training programs in developing these physical factors are indispensable.¹

Because of this concern by physical educators, the United States public is becoming cognizant of what needs to be done, which is to provide our youth with more effective physical activities and professional guidance in body development and to determine one's present state of physical fitness

and improve it.²

Today, mechanical devices do a large portion of the hard labor, and it has been stated that most individuals do not regularly exercise enough to maintain an adequate level of physical fitness. As a result, the normal daily activity must be supplemented with some form of vigorous exercise for individuals to be physically fit.³

Muscular strength is the basis for physical fitness.⁴ This aspect, plus that of muscular endurance, is of primary concern to those attempting to improve their fitness. It has been said that one aspect of fitness which has received relatively little attention is that of cardiovascular endurance or efficiency.⁵

Cardiovascular efficiency has been defined as the ability of the heart and circulatory system to adjust to the stress of activity.⁶ In other words, it is the ability of the heart and its blood supply system to meet the body's

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³U.S. Department of the Navy, Shape-Up, p. 11.

⁴Ibid., p. 6.


oxygen requirements, commonly referred to as "wind." Improvement in cardiovascular efficiency appears to result mostly from participation in activities of speed and endurance.

Authorities on cardio-respiratory endurance have concluded that it is practically impossible to damage the normal heart through exercise. In fact, it has been quite well established that the normal cardiovascular system gradually, but effectively, adjusts itself to increased amounts of strenuous muscular activity. The immediate response to exercise of the cardiovascular system in the well-conditioned person differs from that of individuals who are not accustomed to strenuous muscular work. Likewise, the circulatory system of the trained individual shows a more rapid return to the pre-exercise level than that of the person who does not regularly engage in vigorous activities. Basing his opinion on a number of studies on cardiovascular improvement, Cureton concurred with this belief and stated that exercise is decidedly beneficial.

7 U.S. Department of the Navy, op. cit., p. 6.
Marsh wrote that through physical activity a wonderful metamorphosis takes place in the human body. The heart increases in working capacity; muscles become stronger and react more rapidly; the resting circulation of blood is accomplished with relative ease; and the total efficiency of the organism is immensely enhanced.11

On the basis of research done in this area, it has been concluded that a three-minute step-test is a valid test for measuring cardiovascular efficiency.12,13,14 However, there has been no consensus as to the best type of exercise to improve cardiovascular efficiency. Most of the literature on this subject has recommended vigorous, isotonic exercises, particularly those using a large number of repetitions, as being most effective in improving cardiovascular efficiency. However, recent evidence has indicated that isometric exercises will improve cardiovascular efficiency as well as


13Skubic and Hodgkins, "Cardiovascular Efficiency Test Scores for College Women in the United States, loc. cit.

improving other constituents of physical fitness.¹⁵,¹⁶

The comparison of isometric exercises with the more conventional isotonic exercises has been the subject of numerous studies in recent years. Because of the very nature of isometric exercise in terms of time actually spent exercising, there has been reluctance on the part of some physical educators to accept this method; in fact, it has been contended that isometric exercise is limited solely to strength development and is therefore deficient as an adequate approach to physical fitness.¹⁷ A controversy has thus ensued and has yet to be resolved.

In their zeal to defend their respective positions, writers on both sides of the issue have employed empirical reasoning and at times have summarized in part from research findings and in part from hypotheses.¹⁸ As a result, persons have been misled into concluding that one type of exercise is superior to the other in all situations. Much more information is needed. Is it not possible that isometric exercises


¹⁸Ibid.
are better for some individuals and isotonic exercises are better for others? Does the person's level of physical ability, such as in the area of cardiovascular efficiency, which a person possesses prior to the onset of any concentrated program of exercise have any bearing on the amount of improvement obtained by a particular method of exercise? Is body weight a factor in determining which type of exercise program is better? Before deciding the relative merits of isometric exercises and isotonic endurance exercises, these questions need to be answered. This study was designed to help provide answers to these questions.

II. PURPOSE OF THE STUDY

The purpose of this study was twofold: (1) it was to determine the effectiveness of isometric exercises and isotonic endurance exercises in improving cardiovascular efficiency of eighth grade girls who had been classified from high to low in cardiovascular efficiency as measured by the modified Harvard Step Test, and (2) it was to determine whether isometric exercises or isotonic endurance exercises were more beneficial in improving cardiovascular efficiency of eighth grade girls who had been classified as underweight, average weight, or overweight by means of the Pryor Width-Weight Chart.19

III. NEED FOR THE STUDY

Physical educators are often critical of the small amount of time allotted for physical education in the public and private schools. The laws of each state stipulate the minimum amount of time which must be devoted to physical education. However, many physical educators do not believe that this is sufficient. The problem is compounded by large classes and a lack of facilities and equipment. It is imperative then, to do the best job possible in the time allotted. This can be best accomplished through a thorough appraisal of the students by testing and then selecting activities which are the most beneficial for the students in light of their needs.

One of the primary objectives of physical education concerns physical fitness, a component of which is cardiovascular efficiency. This often presents a problem in terms of class time available. Many of the games and activities that are taught in physical education classes are not of a strenuous nature which results in the necessity to supplement the class activity with exercises designed to develop physical fitness. Therefore, the most expedient method is sought. Furthermore, in order to select the best methods, one needs to know whether the students' initial ability and physical status have a bearing on the efficiency of a particular method of exercise. This aspect of isometric versus isotonic exercises has not been previously investigated in scientific
studies. Consequently, there is a need for this study to help physical educators select the most effective and economical activities in order to satisfy the objectives of the program.

IV. DELIMITATIONS OF THE STUDY

The subjects in this study were eighth grade girls at Westlane Junior High School in Indianapolis, Indiana.

The duration of the experiment was eight weeks, of which the first and last weeks were used for testing. Only one method, the modified Harvard Step Test, was used to measure cardiovascular efficiency.

The investigator attempted to urge the girls to do the exercises as vigorously and conscientiously as possible, but undoubtedly, not all the girls were equally motivated.

V. DEFINITION OF TERMS

The terms basic to this study were defined as follows:

Isotonic Exercises. Isotonic exercises were defined as those exercises in which the distance between the muscle origin and insertion alters during the development of muscular tension.20

Isotonic Endurance Exercises. This type of exercise was defined as work being done against gravity in terms of the load and the distance through which the load is moved. A series of repeated efforts is involved.\textsuperscript{21}

Isometric Exercises. The term isometric exercises were exercises in which the distance between muscle origin and insertion remains constant for the period of tension.\textsuperscript{22}

Isometric Endurance Exercises. This term was used to designate isometric contraction whereby the muscle group attempts to maintain maximum tension for a relatively long period of time, beyond that necessary for just developing strength.

Bi-iliac Diameter. The bi-iliac diameter was defined to be the width of the pelvic crest measured at the widest flare of the iliac crest.\textsuperscript{23}

Lateral Thoracic Diameter. This term was described as the width of the chest measured at nipple level.\textsuperscript{24}

\textsuperscript{21}Ibid. \hspace{2cm} \textsuperscript{22}Ibid.  
\textsuperscript{23}Helen B. Pryor, \textit{loc. cit.}  
\textsuperscript{24}Loc. cit.
A review of the literature revealed numerous studies concerning the effect of various activities on physical fitness in general, and on cardiovascular efficiency in particular. The majority of the studies indicated that cardiovascular efficiency is improved through a variety of activities. There has been some controversy through the years as to the effects of strength building activities on cardiovascular efficiency.

Steinhaus\textsuperscript{1} implied that weight training decreases circulorespiratory endurance because the increase in skeletal muscle bulk which occurs is not accompanied by a commensurate increase in the size and efficiency of certain circulorespiratory mechanisms. In effect, the increased skeletal muscle would place a greater load on the circulorespiratory system and ultimately decrease circulorespiratory endurance.

A different view was expressed by McCloy\textsuperscript{2} when he

\begin{itemize}
  \item[\textsuperscript{1}]Arthur H. Steinhaus, cited in George Gillesley, "The Physiologists Speak on Weight Lifting," \textit{Journal of Physical Education}, 35:16-17, September-October, 1938.
\end{itemize}
pointed to muscle strength as one of three factors necessary in the development of circulorespiratory endurance, since an increase in strength would necessitate fewer muscle fibers being used by an individual during a given bout of exercise. This being the case, the onset of fatigue in muscles should be delayed, thereby decreasing the demand on circulorespiratory mechanisms and prolonging the period over which physical activity could be continued.

A number of the studies have utilized a step test as a means of measuring cardiovascular fitness. According to Brouha, a satisfactory estimate of a man's fitness can be obtained by exposing him to a standard exercise that no one can perform at a "steady state" for more than a few minutes and taking into account two factors: the length of time he can sustain it and the deceleration of his heart rate after exercise. He stated that this test purports to measure the general capacity of the body, in particular the cardiovascular system, to adapt itself to hard work and to recover from what it has done.

A study by Elbel and Holmer was conducted in an attempt to determine the relationship between the


pre-exercise pulse rate and the amount of time required for the pulse to return to the pre-exercise level following two minutes of exercise. The study also sought to determine the relationship between body weight and the amount of time required for the pulse rate to return to the pre-exercise level. The subjects were forty-five male students at the University of Kansas. All were considered to be above average in physical fitness. They performed the step-up exercise at a cadence of thirty-six steps per minute for two minutes. Pulse rates, with the subject in a recumbent position, were secured prior to exercise and at uniform intervals following exercise until the pulse rate had returned to the pre-exercise level. The conclusions were that (1) recovery time is not related to the pre-exercise pulse rate; (2) body weight is not related to the amount of time required for the return of the pulse to the pre-exercise rate; and (3) pre-exercise pulse rate and the increase due to a two-minute period of exercise are not related. An earlier study by Elbel\textsuperscript{5} had also indicated that the correlation between body weight and increased pulse rate due to exercise was insignificant.

Cullumbine\textsuperscript{6} made an attempt to compare the resting


cardiovascular state with several different aspects of physical fitness. The subjects were normally active and healthy persons aged ten to twenty-five years. The tests used were: (1) the Harvard Step-up Test; (2) the Endurance Step Test; (3) the Harvard Step Test performed to exhaustion; (4) strength; and (5) speed. He found that the slower the resting pulse or the lower the resting systolic blood pressure, the slower was the post-exercise pulse rate or the lower was the post-exercise systolic blood pressure, respectively.

Speed of movement, strength, and ability to sustain moderate exercises were positively correlated with the resting systolic blood pressure.

In a study conducted with 122 New Zealand school children with a mean age of 12.75 years, Faine and Mathews employed a modified Tuttle Pulse Ratio Test and concluded, as had Morehouse and Tuttle, that the pulse rate in the thirty seconds immediately after exercise is a valid measure of the maximum pulse rate attained during the exercise. It was further concluded that the pulse ratio covering the period two minutes after exercise also provides a measure of deceleration rate because the total number of beats will clearly decrease with rapid deceleration and increase if deceleration is delayed.7

Howell, Hodgson, and Sorenson\textsuperscript{8} equated two groups of seventeen subjects enrolled in required physical education on the basis of the modified Harvard Step Test. The experimental group participated in circuit training twice a week for four weeks. The control group took part in the regular service program consisting of badminton and volleyball. At the conclusion of the experimental period, all subjects were retested on the modified Harvard Step Test. The experimental group showed a statistically significant improvement over the four-week period whereas the control group did not; however, comparison of the mean gains between groups showed no significant difference.

Another study using a step test was reported by Michael and Gallon.\textsuperscript{9} A one-minute step test at thirty-six steps per minute on a seventeen-inch bench was given to seventeen varsity basketball players every three weeks during sixteen weeks of training and also after ten and twenty weeks of detraining. The results showed that recovery pulse rates made significant changes in three weeks and highly significant changes in six weeks. After six weeks of training, a plateau


was reached, and although no significant changes occurred when training was continued an additional ten weeks, the maximum changes were recorded at the end of the sixteen weeks of training. Three weeks of lay-off, due to vacation, after ten weeks of training caused a reversal of the recovery pulse rates, but the change was not statistically significant. It was then found that after three additional weeks of training the fitness level was again brought up to maximum. In ten weeks of detraining, the circulatory changes had reversed significantly so that conditioning was not maintained after daily workouts had stopped.

Marsh\textsuperscript{10} used the Brouha Five-Minute Step Test as one of several measures of physical fitness in investigating the effects of a long term (thirteen weeks) bicycle and general conditioning program on cardiovascular-respiratory and endurance fitness of four pre-pubescent boys. Each subject was pre-tested to determine individual fitness; then retested at the end. The boys improved in all areas of fitness; respiratory force, vital capacity, breath holding, Brouha Five-Minute Step Test, treadmill run, Four Item All-Around Muscular Endurance Test, Larson Composite, and motor ability.

In a study by Abdo,\textsuperscript{11} 198 women students were given a


\textsuperscript{11}Samia Hanem Ahmed Abdo, "Leg Strength and Height-Weight Factors in Relation to Cardiovascular Efficiency of
leg strength test and a three-minute cardiovascular efficiency test. Height, weight, chest width, and pelvic width were also measured. The purpose of the study was to investigate the influence of leg strength on the performance of the three-minute cardiovascular efficiency test and to study the relationship between three "weight" classifications and cardiovascular efficiency and between girls' ponderal indices and cardiovascular efficiency. The conclusions were that cardiovascular efficiency is related positively to leg strength for normal weight women, cardiovascular efficiency is related significantly to ponderal index, and cardiovascular efficiency is inversely related to weight. Cardiovascular efficiency was not found to be related to height.

Alost\textsuperscript{12} conducted an investigation in which he attempted to determine the effect of initial cardiovascular condition, type of conditioning program, and frequency of training upon the gain in Harvard Step Test scores of college men. An effort was also made to determine the effect of the various training programs upon proficiency in the activity engaged in during the study. Subjects were 240 college men at Louisiana State University. Two basic groups were formed, 

\textsuperscript{12}Robert A. Alost, "A Study of the Effect of Initial Cardiovascular Condition, Type of Training Program, and Frequency of Practice Periods Upon the Cardiovascular Development of College Men" (unpublished Ed.D. dissertation, Louisiana State University, 1963).
one doing isometric exercises and the other engaged in running activities. The subjects were given a battery of tests at the beginning and end of a seven-week period. All subjects were given the Harvard Step Test. Additional tests were given the isometric group, and a running test was given the isotonic group. Twelve groups of twenty subjects each were established according to activity, initial condition, and frequency of training. The isometric subjects participated in golf, and the isotonic subjects participated in tennis.

The findings indicated no significant difference in the effectiveness of an isometric exercise program and a running program of training in developing cardiovascular condition. Individuals in below average cardiovascular condition tended to gain more than those in above average condition, but below average subjects did not obtain the physical condition of the above average subjects. Improvement in cardiovascular condition increased as frequency of practice periods increased. Strength and running performances were directly related to frequency of practice periods.

In a study by Life, the effects of supplementary isometric exercises with swimming and golf on muscular strength, physical fitness and cardiovascular efficiency of college women were investigated. The subjects were ninety-six college women enrolled in physical education basic skills classes at Louisiana State University. The total group was

13Life, loc. cit.
divided into four smaller groups. Group 1 was enrolled in intermediate swimming and participated in isometric exercises. Group 2 engaged in beginning golf and isometric exercises. Group 3 had intermediate swimming with no supplementary exercises, and Group 4 participated in golf with no supplementary exercises. The subjects were given Roger's Physical Fitness Index Test and the Cardiovascular Efficiency Test for Girls and Women at the beginning and end of an eight-week period. All groups showed significant improvement in the Physical Fitness Index. Cardiovascular efficiency was improved by Groups 1, 2, and 3. All groups showed a significant increase in pull ups, arm strength, leg lifts, and lung capacity. Swimming and isometrics were better than golf and isometrics, and golf alone was better than swimming alone on the Physical Fitness Index. Isometric exercises were significantly superior to the non-isometric programs, and swimming was superior to golf in development of cardiovascular efficiency.

Bell\(^4\) conducted a study to show the effects of a gymnastics training program on the cardiovascular efficiency of young boys as reflected by the Schneider Index Test. The subjects were twelve boys ranging in age from five to eleven who participated in a gymnastics program for eight months.

Although several individuals made significant improvement in various factors measured, the gains made by the entire group were not significant as a result of the training program.

Another investigation using the Schneider Index Test was conducted by Warner. She assigned fifty-one female campers between the ages of nine and thirty to one of two groups. One group performed strenuous activities while the other participated in quiet activities in order for the investigator to study the effects of training on cardiovascular condition. She found that the subjects were favorably affected by vigorous training and that the training was beneficial.

Wilson, using an all-out treadmill run as a measure of circulorespiratory endurance, found that a group of college students who trained with weights for a period of twelve weeks showed an average decrease in treadmill running time of 11.15 per cent. A parallel group of control subjects who participated in volleyball classes following the initial test experienced a decrease in running time of 1.0 per cent. Wilson concluded that weight training had a detrimental effect on circulorespiratory condition.

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In a study similar in design to that of Wilson, Capen\textsuperscript{17} found conflicting results. The time of a 300-yard run was used as a measure of circulorespiratory endurance. Capen found that a group that trained with weights improved in the 300-yard run by 6.2 per cent. The control group with emphasis placed upon endurance elements in the training improved 6.5 per cent. Capen concluded that weight training was as effective in the development of circulorespiratory endurance as was a program of activity which especially emphasized endurance.

Brodt\textsuperscript{18} conducted an experiment in which six active adult males participated in a weight-lifting program. Ten adult males acted as a control group and did not participate in the program. The function of the experiment was to determine the effect of a weight-lifting program on cardiovascular efficiency. The results indicated that the effects of weight-lifting on cardiovascular condition were questionable and inconclusive.

Harrison\textsuperscript{19} studied the effects of a swimming endurance


program on the physical status of eight adult men and reported that, in general, there was an improvement in cardiovascular condition from participating in this program.

In a study of the effects of volleyball and calisthenics on the physical fitness of adult men, Hopkins concluded that the program (1) improved the resting cardiovascular condition; (2) did not increase cardiovascular endurance; and (3) lowered the resting pulse rate.

Tuttle and Walker studied the effects of a season of training and competition on the response of the circulatory system of high school boys. The following findings were reported: (1) there was no significant change in the resting heart rate, pulse rate immediately following exercise, rate above the resting rate after exercise, or primary recovery time; (2) the recovery pulse was less after the season, indicating that there was an improvement in physical condition as shown by the fact that fewer heart beats were required in reaching the resting level; and (3) whenever the data showed trends toward altered cardiac response, it was always in favor of more efficient heart action.


Boas investigated the effect of exhaustive exercise upon the individual. He studied the heart rates of twenty-seven boys, nine to fifteen years of age, who were told to run back and forth in a long corridor until they were nearly exhausted and then climb up and down a flight of stairs. The investigator found that the maximum heart rate during exercise was 190 beats per minute, and that the rate remained higher than the starting rate for almost an hour after the test.

Kruzic used thirty-nine college women, nine of whom were swimmers, ten who were volleyball players, and twenty who were basketball players, between the ages of eighteen and twenty-five and found training in these activities over a five- to eight-week period contributed to the improvement of cardiovascular condition.

The effects of various methods of training on running endurance tests and on a parallel battery of cardiovascular tests were investigated by Holmes. He attempted to find the most effective training method for improving fitness.


The subjects were seventy-six boys from six to fifteen years of age. The boys were tested before and after a six weeks interval of endurance training. The battery of cardiovascular tests showed decreases in cardiovascular fitness for all methods of training except muscular endurance training.

In an investigation by Nagle and Irwin,25 two experimental groups and one control group of twenty college freshmen in each group were tested on moderate and all-out exercise on a bicycle ergometer. Selected physiological responses and the circulorespiratory endurance times were measured. An eight-week training period followed during which the experimental groups participated in weight training programs, and the control subjects in archery or bait-casting. After training, the tests were again administered. Though there was an indication of improved circulorespiratory responses by the weight training groups following training, statistical treatment of the data revealed no significant differences among the three groups in their responses to exercise.

Wilson26 studied circulatory reactions of normal children to graduated exercise. It was shown that normal


children improved their circulatory reactions through strenuous competitive running.

Thompson\textsuperscript{27} studied some physiological effects of isometric and isotonic work in adult males. The isometric work consisted of squeezing the grip dynamometer for one minute at maximum effort; isotonic work was a one-minute bout of exercise on a bicycle ergometer. It was found that the effects of the two types of exercise are different relative to their effects on blood pressure. The isometric work caused a sharp rise in both systolic and diastolic blood pressure but both returned quickly, or less than a minute, to the resting level. On the other hand, isotonic work caused a sharp rise in the systolic blood pressure which lasted longer than one minute and no significant rise was observed in diastolic blood pressure. The author suggested that the chief cause of blood pressure changes in isotonic work is chemical in nature while those involved in isometric work are reflexive.

Hupé\textsuperscript{28} investigated both training and diet on cardiovascular condition. The study was to determine which form of training (circuit training, muscular endurance exercise, circuit training, muscular endurance exercise,


\textsuperscript{28}André Siméon Hupé, "The Effects of Training and Supplementary Diet on the Cardiovacular Condition of Young Boys" (unpublished Master's thesis, University of Illinois, 1958)
internal training, steeplechase running) and which supplementary diet (wheat germ, wheat germ oil, wheat germ oil crystals, placebo) would produce more changes in the cardiovascular fitness of young boys. All the boys showed improvement in cardiovascular fitness, but steeplechase running had the highest gain and thus, seemed to have improved the condition of the boys more than did the other three forms of training.

I. SUMMARY OF RELATED LITERATURE

The majority of the studies reviewed indicated cardiovascular efficiency was improved through a variety of exercise programs, mostly involving strenuous large-muscle activity. There were a few studies which did not find any change as a result of exercise programs and two which reported that the effects of relatively mild activity, such as archery and bait casting did as well as the more vigorous types of training. There were contradictory results reported in regard to the value of strength-building exercises in cardiovascular efficiency development although one study found a significant relationship between strength and step test performance. The research which investigated the relationship of body weight to cardiovascular fitness also produced conflicting results. Two recent investigations showed isometric exercises to be of value in improving cardiovascular efficiency. Most of the studies utilized a step test as a means of measuring cardiovascular efficiency.
CHAPTER III

PROCEDURE FOR THE STUDY

I. INTRODUCTION

This study was conducted during the fourth six-weeks grading period of the 1964-1965 school year at Westlane Junior High School, Indianapolis, Indiana. The subjects were 120 eighth grade girls enrolled in required physical education. At the beginning of the experiment, the subjects were classified as being overweight, average weight, or underweight in accordance with the Pryor Width-Weight Chart. In addition, all subjects were administered the modified Harvard Step Test. Based upon the results of the Step Test, the girls were given a cardiovascular efficiency score, ranked from high to low, and then divided into five groups of twenty-four subjects in each group. Each of these groups was randomly divided into an isometric and an isotonic group. In addition to the regular physical education activities, the isotonic groups performed a series of isotonic exercises each day of class, and the isometric groups performed a battery of isometric exercises. This procedure was followed three days per week for six weeks. At the end of this period, the Step Test was readministered. A statistical comparison of the
initial and final cardiovascular efficiency scores was used to establish the significance of the mean gains. The relative effect that each exercise program had on cardiovascular efficiency gains was then determined.

II. SUBJECTS

All of the girls were either thirteen or fourteen years of age at the time of the investigation. The age in years was recorded at the nearest birthday.

At the beginning of the study there were 140 girls involved. Due to excessive absences, nine of the girls were eliminated from the study. Since the statistical procedure necessitated that all groups be equal in number, eleven other girls were randomly eliminated, leaving a total of 120 subjects.

All of the subjects in the study were enrolled in a physical education class. As a result, their participation in the experiment was also part of the class requirement. It was planned that if any girl or her parents had objected to taking part in the study, the girl would have been excused. However, this did not occur.

The girls were nearly equally divided among four physical education classes. Each class met on Monday, Wednesday, and Friday. The class periods were fifty minutes in length. Allowing time to dress and take attendance, each class had twenty-five to thirty minutes of activity.
III. TIME SCHEDULE

The actual training program for the study was conducted during one six-weeks grading period. The testing was done the week before and the week after this period. The entire experiment, including testing, ran from February 12, 1965, until April 9, 1965. The girls were measured with the calipers Friday, February 12, 1965. Those absent on that day were measured the following Monday. The Step Test was administered Monday, February 15, 1965, to all girls in attendance. Those not present on that date took the Step Test either Wednesday or Friday of that week. At the conclusion of the experiment, the Step Test was readministered on Monday, April 5, 1965. Make-ups and retests were completed during the next two class periods.

The actual exercise program began on February 22, 1965, and ended April 2, 1965. The subjects participated in the exercise program every Monday, Wednesday, and Friday during this period with the exception of one day when school was dismissed because of heavy snow.

IV. TEST USED

There is considerable agreement among authorities on physiology of exercise that the pulse rate is a reliable
criterion for determining physical fitness. The test used in this investigation to determine cardiovascular efficiency was the modified Harvard Step Test devised by Skubic and Hodgkins. It was their purpose to find a test of cardiovascular fitness for girls and women which could be quickly and easily administered. The Harvard Step Test was modified from a five-minute test to a three-minute test. An eighteen-inch bench was used instead of the twenty-inch bench for boys and men, and the cadence was reduced to twenty-four steps per minute for girls and women. The research done by the authors involved trained and untrained girls, and active and sedentary women. The test was found to be both reliable and valid, and it clearly differentiated among females who were highly trained, those moderately active and those who were sedentary.


V. TESTING PROCEDURE

Prior to any test being administered, each girl was weighed and measured for height. The weighing and height measurement was done by selected students who had been previously trained. Following this, the bi-iliac diameter and the lateral thoracic diameter were measured for each girl by this investigator. These measurements were done with wooden, straight-arm, sliding calipers in the manner described by Pryor.⁵ (See Figures 1 and 2.)

In order to establish reliability in using the calipers, forty-six of the girls involved in the study were selected at random and measured during the week preceding the actual initial testing for the study. These measurements were then correlated with measurements taken at the beginning of the experiment. The reliability coefficients for both the bi-iliac diameter and the lateral thoracic diameter measurements were .94, which demonstrated satisfactory reliability.

For several days before the Step Test was administered, the subjects practiced counting the heart beats on each other at the carotid artery. During testing, each girl had two other girls count her pulse. The two counts were later compared to check reliability. Each girl also practiced the Step Test for short periods in order to thoroughly understand

⁵Pryor, loc. cit.
Figure 1. Measurement of the Bi-iliac Diameter

Figure 2. Measurement of the Lateral Thoracic Diameter
the manner of doing it and to become accustomed to the rhythm of the stepping.

On the day the Step Test was administered, the girls in each class were placed in groups of three and assigned to a bench. There were twelve or thirteen groups in each class; hence, twelve or thirteen girls taking the Step Test at the same time. The benches were taken from the locker rooms and measured exactly eighteen inches in height.

One girl in each group of three stood in front of her bench ready to begin taking the test. The other two girls sat on the floor on either end of the bench and steadied it. On the signal to begin, each girl began stepping up and down on her bench. The rhythm of twenty-four steps per minute was maintained by means of an electric metronome. After the first minute of stepping had passed, the investigator began counting aloud each second while watching a large wall clock with a sweep second hand. The girls who were to count the pulse also watched the clock in case a girl was not able to complete the full three minutes. In these instances the girl's "counter" wrote down the position of the second hand when the subject stopped. The subject remained seated for one minute, then her pulse was counted for thirty seconds. The procedure was the same for those completing the full three minutes except that the investigator announced when stepping should cease, and when the pulse counting should begin and end. The pulse count taken by each girl was
recorded independently. The second girl in each group of three then prepared to take the test. This procedure was followed until each girl had been tested.

In cases where the pulse rates recorded by the two counters for any subject were not the same, the investigator averaged the two counts if they varied five beats or less. If the variance was more than five, the girl repeated the test two days later. At the conclusion of the experiment, all girls were retested in the same manner.

VI. THE EXPERIMENTAL GROUPS

Using the formula and the table of recovery pulse rates devised by Skubic and Hodgkins, each girl received a cardiovascular efficiency score and rating. The cardiovascular efficiency scores were then ranked from high to low. The total number of girls was divided into five equal groups of twenty-four girls each.

Group 1 consisted of the girls with the lowest (and thus poorest) cardiovascular efficiency scores; Group 2 had the next to lowest scores; Group 3 had the middle scores; Group 4 consisted of the next to highest cardiovascular efficiency scores; and Group 5 had the highest scores.

Each of these five groups was then divided at random.

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into an isometric group and an isotonic group. Therefore, for each of the five groups assigned according to initial cardiovascular efficiency scores, half of the subjects were given isometric exercises and half received isotonic exercises.

The exercise program lasted for a period of six weeks. The girls met three times a week during this period. With one day missed because of snow, there were seventeen days of exercises. At the beginning of each class period, each girl reported to her assigned group of either isometric exercises or isotonic endurance exercises.

VII. ISOMETRIC EXERCISE PROGRAM

The isometric group performed seven exercises, six of them using the "isometric desk exerciser." These exercises, all done from a sitting position, were performed as follows:

1. **Isometric Exercise for abdominal and chest muscles.** The strap was placed across the middle of the back, and the subject pushed forward with the hands. The abdominal muscles were contracted as hard as possible while the subject pushed on the bars (Figure 3).

2. **Isometric Exercise for leg extensor muscles.** The feet were placed on one bar with the other bar on the front of the hips. The knees were bent at a 45 degree

"Isometric Desk Exerciser," Trim Line Products, Marion, Indiana.
Figure 3. Isometric Exercise for the Abdominal and Chest Muscles

Figure 4. Isometric Exercise for Leg Extensor Muscles
angle with the feet raised about one inch off the floor. The subject then pushed with her legs and pulled with her hands as hard as possible (Figure 4).

3. **Isometric Exercise for chest and shoulder muscles.** The strap was folded so that it was about one-half the maximum length. The arms were crossed in front of the chest, and the girls attempted to push the hands apart (Figure 5).

4. **Isometric Exercise for upper back and shoulder muscles.** The straps were folded to about one-half the maximum length with bars held in front of the chest. The girl attempted to pull the hands apart keeping the arms perpendicular to the floor (Figure 6).

5. **Isometric Exercise for arm flexor muscles.** The feet were placed on one bar. The hands grasped the other bar with the palms up and pulled upward as hard as possible (Figure 7).

6. **Isometric Exercise for arm and shoulder muscles.** One bar was placed across the upper part of the back. The straps passed under the shoulders to the front of the body where the subject held the other bar. The girl then pushed upward and forward as in the press exercise with weights (Figure 8).

The seventh exercise was the "dead lift" which was done with another piece of equipment. This exercise was done with two bars and a belt, called an "Iso-Kit," a gauge, and
Figure 5. Isometric Exercise for the Chest and Shoulder Muscles

Figure 6. Isometric Exercise for the Upper Back and Shoulder Muscles
Figure 7. Isometric Exercise for Arm Flexor Muscles

Figure 8. Isometric Exercise for the Arm and Shoulder Muscles
a platform. The equipment is shown in Figure 9. One bar was inserted in a loop of the belt under the platform and secured in grooves on the sides of the platform. The belt ran upward through a hole in the top of the platform. The subject stood on the platform and inserted the other bar in the loop best suited for her height. The elbows were kept straight and the back was inclined forward at about a 45 degree angle with the floor. The knees were also bent at approximately a 135 degree angle. The subject then pulled upward as hard as possible using the arms, back, and leg muscles (Figure 10).

Four of these platforms were built by this investigator. A belt, gauge, and bars were attached to each platform, making a permanent testing station. The platforms were numbered, and each girl was assigned to exercise at a specific station. The only adjustment needed was to insert the top bar in a numbered loop of the belt for each individual in accordance with her height. Since the initial assignment of subjects to the platforms was done according to the subjects' height, the number of adjustments was kept to a minimum. Each girl recorded her loop number for the exercise, which further reduced any unnecessary time needed for finding the proper height for each individual each exercise session.

One reason for using these platforms was the stability it provided, making it easier for the girls to exercise and
Figure 9. Platform and Belt, Bars and Gauge Comprising the Iso-Kit

Figure 10. Isometric Dead Lift Exercise and Testing Position Using Iso-Kit
to be tested, rather than having them stand on the bottom bar. In addition, it was felt that this would act as motivation. In previous studies it has been shown that knowledge of results has great motivating value, especially for isometric exercises. The gauge on the belt made it possible for each girl to record her total pounds of pull each day, and thus, each girl could tell if she were improving.

There was an isometric desk exerciser assigned for every two girls. Thus one girl assisted the other while she exercised and then they would exchange places. For all seven exercises the girls used a ten-second contraction. In the first three or four seconds, the subject began a gradual but steady pull or push until she reached the maximum exertion which she attempted to hold for the remaining seconds. The seconds were counted aloud by the girl's partner who shared the equipment with her.

VIII. ISOTONIC EXERCISE PROGRAM

For the isotonic group there were three exercises. The first was to do as many squat thrusts as possible in fifteen seconds. The squat thrust exercise was done in the following manner: from a standing position with arms hanging down at the sides, on the first count the subject assumed the

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7Norman A. Marcel, "The Effect of Knowledge of Results as Motivation on Physical Performance" (unpublished Research Study Conducted at Louisiana State University, December, 1961).
squat position with hands on the floor outside of, and slightly ahead of the feet; on the count of two the legs were thrust backwards and fully extended while supporting the upper body's weight on the hands, thus assuming the front--leaning-rest position; on the third count the subject moved quickly back to the squat position; and on the fourth count stood erect. This series of moves was done as fast as possible, yet it was stressed to the subject that each movement was distinct, and that none of the positions were bypassed. Each series of the four positions were counted as one, and each specific position as one quarter. Therefore the subject's score might be ten and one-half or eleven and three-quarters, etc.

For the second exercise, the girls ran in place as rapidly as possible for ten seconds, rested ten seconds, ran again for ten seconds, rested for ten seconds, then ran the third time for ten seconds. In this exercise the subjects barely raised the feet off the floor, thereby equalizing the height of the strides and also allowing maximum speed of movement. The third exercise was a form of the "jump and reach." Each girl stood with one side to the wall and reached upward with one hand as far as possible. A line ten inches above each girl's reach was drawn on the wall. The girls jumped fifty times in succession touching this line ten inches above their standing reach.

The totals for the first two exercises were recorded
once each week for each girl in order to show improvement and serve as motivation. For all three exercises the girls worked in pairs, one counting for the other.

Each day after the girls finished their exercises, they participated in the regular physical education activities. In order to make the investigation more reliable, the girls did not engage in any running, jumping, or otherwise strenuous activities while in class. Their class activity for the six weeks consisted of learning the basic skills needed for tennis, archery, and softball in preparation for outside activity in the spring.

IX. CLASSIFICATION BY WEIGHT

After the initial measurements of height, weight, bi-iliac diameter and lateral thoracic diameter were taken, and age recorded, each girl was classified according to the Pryor Width-Weight Chart. A reproduction of the tables is shown in the Appendix. The tables were used as follows:

1. For each girl, the investigator decided whether the subject's chest was narrow, medium, or wide by consulting the chest measurements shown at the top of the table for that age and sex.

2. After determining the proper chest-width table, the appropriate weight in pounds for the girl was found under the bi-iliac diameter measurement and opposite the height measurement for that individual. In this way, body build is taken into consideration.
For example: a thirteen-year-old girl with a thoracic lateral width measurement of 25.6 centimeters is considered to have a broad chest (according to the table). If the subject is 59 inches tall and her bi-iliac diameter measurement is 24.7, by consulting the "Broad Chest" table and locating the girl's height and bi-iliac diameter, the correct weight for this girl is found to be 92 pounds. If the same girl had had a narrow chest, for example, 20.9 centimeters, the appropriate weight would be only 78 pounds.\(^8\)

It was decided that girls who were within five pounds either way of their appropriate weight would be classified as being average weight. Those more than five pounds over the normal weight for their body size were designated as overweight and conversely, those girls weighing more than five pounds below were classified as being underweight.

For purposes of the statistical analysis, the amount of deviation from recommended weight was converted to percentage of overweight or underweight.

X. STATISTICAL ANALYSIS

The following statistical computations were made in analyzing the data:

1. The mean gains on cardiovascular efficiency scores were computed and tested for significance using the formula

\(^8\)Pryor, op. cit., p. 2.
for t-test for correlated groups as presented in Garrett.\(^9\)
This was done for each exercise group and for each subgroup
classified according to initial cardiovascular efficiency
scores and by body weight classifications.

2. In cases where significant gains were found,
analysis of covariance was employed to determine whether
there was a significant difference between the effects of the
two exercise programs.

3. The coefficients of correlation were also computed
using the product-moment method to further determine the
effects of each exercise program on cardiovascular efficiency
and the relationship of body weight to step test performance.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

I. COMPARISON OF THE EFFECTS OF ISOMETRIC WITH ISOTONIC EXERCISES

In establishing the significance of the mean gains in cardiovascular efficiency scores for the isometric exercise group and for the isotonic exercise group, t-tests were computed. The results of these comparisons are presented in Table I.

**TABLE I**

DIFFERENCES BETWEEN MEANS OF INITIAL AND FINAL CARDIOVASCULAR EFFICIENCY SCORES OF JUNIOR HIGH SCHOOL GIRLS FOR THE ISOMETRIC AND ISOTONIC EXERCISE GROUPS

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Initial Mean</th>
<th>Final Mean</th>
<th>Mean Diff.</th>
<th>SE Diff.</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric</td>
<td>60</td>
<td>52.7</td>
<td>54.7</td>
<td>2.0</td>
<td>.83</td>
<td>2.41</td>
<td>.05</td>
</tr>
<tr>
<td>Isotonic</td>
<td>60</td>
<td>53.5</td>
<td>55.3</td>
<td>1.8</td>
<td>1.19</td>
<td>1.51</td>
<td>NS</td>
</tr>
</tbody>
</table>

* t needed at .05 level, 2.00
* t needed at .01 level, 2.66
It can be seen that the t-ratio resulting from the comparison of the initial and final cardiovascular efficiency scores for the isometric group was 2.41. The t-ratios needed for significance were 2.00 at the .05 level of probability and 2.66 at the .01 level. Since the t-score of 2.41 was above that needed for the .05 level, it may be said that isometric exercises were effective in improving cardiovascular efficiency of the sixty girls comprising the isometric exercise group.

The computed t-ratio for the isotonic group was 1.51 which was below that needed for the .05 level of probability. Thus, when considering the total group of subjects who were in the isotonic exercise program, it was found that isotonic exercises were not effective in improving cardiovascular efficiency as measured by the Step Test.

**Comparison of Isometric Exercises with Isotonic Exercises by Covariance**

An analysis of covariance was used to determine if there was a significant difference in the mean scores between the two groups on the cardiovascular efficiency test. The analysis of covariance is an extension of the analysis of variance and is a means of matching groups statistically. It is used when there is a definite correlation between initial status and gain. It makes an adjustment for the effects that the initial scores may have had on the final scores. With two groups only, as in this study, the F-test
in the analysis of covariance may be interpreted the same as the t-test. The difference between the two statistical methods is that the t-test does not take into account the effect of initial status on the final scores.

The results of the analysis of covariance are shown in Table II.

### TABLE II

ANALYSIS OF COVARIANCE FOR THE ISOMETRIC AND ISOTONIC TEST SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td>NS</td>
</tr>
<tr>
<td>Within</td>
<td>5,939</td>
<td>117</td>
<td>50.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,939</td>
<td>118</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-ratio needed at .05 level, 3.93  
F-ratio needed at .01 level, 6.86

To reach significance an F-ratio of 3.93 was required for the .05 level of probability and an F-ratio of 6.86 was needed for the .01 level. In Table I it is shown that the isometric group's gain was higher than that of the isotonic group. However, when the final scores were corrected by covariance, it was found that there was no real difference between the groups; thus, the between sum of squares was
zero and obviously not significant. Therefore, even though the isometric exercise group gained significantly, the gain was not enough to show a significant difference between the subjects given the isometric exercises and the subjects of the isotonic group.

II. ANALYSIS OF GAINS IN CARDIOVASCULAR EFFICIENCY SCORES FOR SUBJECTS CLASSIFIED ACCORDING TO INITIAL CARDIOVASCULAR EFFICIENCY

Based upon initial cardiovascular efficiency scores, the total group of 120 subjects was divided into five equal groups. Group 1 consisted of the twenty-four girls with the lowest initial cardiovascular efficiency scores; the subjects in Group 2 had the next to lowest initial scores; Group 3 was composed of the middle twenty-four initial scores; Group 4 had the next to highest twenty-four initial cardiovascular efficiency scores; and Group 5 was comprised of the twenty-four subjects having the highest initial step test scores.

Each of these five groups was then divided at random into an isometric group and an isotonic group. Thus, for each of the five groups, assigned according to initial cardiovascular efficiency scores, half, or twelve of the subjects were assigned to the isometric exercise group and half, or twelve, were assigned to the isotonic exercise group.

In order to establish the significance of the mean differences in cardiovascular efficiency scores for each of these ten groups, t-tests were computed to compare their
initial and final cardiovascular efficiency scores. These data are shown in Table III.

Three of the groups had t-ratios high enough to be significant. All three groups were composed of subjects participating in isotonic exercises. The subjects lowest in initial cardiovascular efficiency assigned to the isotonic exercise group had a t-ratio of 3.07, which exceeded the t of 2.20 needed for significance at the .05 level. From this, it can be stated that isotonic exercises significantly improved the Step Test performance of those subjects of lowest initial cardiovascular efficiency.

The isotonic group composed of the subjects classified as next to lowest cardiovascular efficiency had a t-ratio of 3.74, which was significant at the .01 level of probability. Again, this indicated that isotonic exercises significantly improved performance in subjects of low initial cardiovascular efficiency.

A t-ratio of -2.49 was found for the isotonic group having the highest initial cardiovascular efficiency. Although this t-ratio was significant at the .05 level, it was a negative gain indicating that the subjects in this group experienced a significant loss in cardiovascular efficiency as measured by the modified Harvard Step Test.
TABLE III

DIFFERENCES BETWEEN MEANS OF INITIAL TEST AND FINAL TEST CARDIOVASCULAR EFFICIENCY SCORES FOR ISOTONIC AND ISOMETRIC EXERCISE GROUPS OF VARYING INITIAL CARDIOVASCULAR EFFICIENCY

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Initial Mean</th>
<th>Final Mean</th>
<th>Mean Diff.</th>
<th>SE Diff.</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotonic Lowest CVE</td>
<td>12</td>
<td>43.4</td>
<td>50.7</td>
<td>7.3</td>
<td>2.38</td>
<td>3.07</td>
<td>.05</td>
</tr>
<tr>
<td>Isotonic Next to Lowest CVE</td>
<td>12</td>
<td>47.8</td>
<td>52.4</td>
<td>4.6</td>
<td>1.23</td>
<td>3.74</td>
<td>.01</td>
</tr>
<tr>
<td>Isotonic Middle CVE</td>
<td>12</td>
<td>52.0</td>
<td>56.4</td>
<td>4.4</td>
<td>2.01</td>
<td>2.19</td>
<td>NS</td>
</tr>
<tr>
<td>Isotonic Next to Highest CVE</td>
<td>12</td>
<td>55.5</td>
<td>56.3</td>
<td>.8</td>
<td>1.81</td>
<td>.44</td>
<td>NS</td>
</tr>
<tr>
<td>Isotonic Highest CVE</td>
<td>12</td>
<td>68.9</td>
<td>60.9</td>
<td>-8.0</td>
<td>3.21</td>
<td>-2.49</td>
<td>.05</td>
</tr>
<tr>
<td>Isometric Lowest CVE</td>
<td>12</td>
<td>42.4</td>
<td>46.6</td>
<td>4.2</td>
<td>1.98</td>
<td>2.12</td>
<td>NS</td>
</tr>
<tr>
<td>Isometric Next to Lowest CVE</td>
<td>12</td>
<td>47.8</td>
<td>50.1</td>
<td>2.3</td>
<td>1.35</td>
<td>1.70</td>
<td>NS</td>
</tr>
<tr>
<td>Isometric Middle CVE</td>
<td>12</td>
<td>52.1</td>
<td>54.8</td>
<td>2.7</td>
<td>1.52</td>
<td>1.78</td>
<td>NS</td>
</tr>
<tr>
<td>Isometric Next to Highest CVE</td>
<td>12</td>
<td>55.8</td>
<td>58.1</td>
<td>2.3</td>
<td>1.76</td>
<td>1.31</td>
<td>NS</td>
</tr>
<tr>
<td>Isometric Highest CVE</td>
<td>12</td>
<td>65.2</td>
<td>63.7</td>
<td>-1.5</td>
<td>2.39</td>
<td>.64</td>
<td>NS</td>
</tr>
</tbody>
</table>

* t needed at .05 level, 2.20
* t needed at .01 level, 3.11
Comparison of the Effects of the Two Exercise Programs for Subjects Having the Lowest Initial Cardiovascular Efficiency Scores

In order to provide greater insight into the comparative effects of isometric and isotonic exercises, analysis of covariance was utilized to determine if there were significant differences between the two exercise programs in the development of cardiovascular efficiency in those cases where significant gains were found.

The results of the analysis of covariance for the twenty-four subjects having the lowest initial cardiovascular efficiency is shown in Table IV.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>271</td>
<td>1</td>
<td>271.00</td>
<td>5.38</td>
<td>.05</td>
</tr>
<tr>
<td>Within</td>
<td>1,057</td>
<td>21</td>
<td>50.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,328</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Corrected Means

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric Group</td>
<td>.................. 46.9</td>
</tr>
<tr>
<td>Isotonic Group</td>
<td>.................. 50.3</td>
</tr>
</tbody>
</table>

F-ratio needed at .05 level, 4.32
F-ratio needed at .01 level, 8.02
F-ratios of 4.32 and 8.02 were required for significance at the .05 and .01 levels of confidence respectively. The F-ratio of 5.38 revealed significance at the .05 level. Continuing with the analysis to determine which of the forms of exercise was better, the adjusted means were determined for each group. These are also shown in Table IV. The corrected mean for the isometric group was 46.9; for the isotonic group, the corrected mean was 50.3. Consequently, isotonic exercises were superior to isometric exercises in developing cardiovascular efficiency for the subjects of lowest initial status.

Comparison of the Effects of the Two Exercise Programs for Subjects Having the Next to Lowest Cardiovascular Efficiency Scores

Since a significant improvement was found for the isotonic exercise group, comprised of subjects of next to lowest initial cardiovascular fitness, analysis of covariance was again employed to compare the effects of the two exercise programs. This is shown in Table V. The resulting F-ratio of 1.50 was below the F of 4.32 needed to be significant at the .05 level of probability. Therefore, no significant difference was indicated between the effects of the isometric and isotonic exercises for these subjects, even though the isotonic group had shown significant improvement and the group of isometric subjects had not.
TABLE V

ANALYSIS OF COVARIANCE FOR THE CARDIOVASCULAR EFFICIENCY SCORES OF THE TWENTY-FOUR SUBJECTS HAVING THE NEXT TO LOWEST INITIAL CARDIOVASCULAR EFFICIENCY

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>33.00</td>
<td>1</td>
<td>33</td>
<td>1.50</td>
<td>NS</td>
</tr>
<tr>
<td>Within</td>
<td>461.89</td>
<td>21</td>
<td>21.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>494.89</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-ratio needed at .05 level, 4.32
F-ratio needed at .01 level, 8.02

Comparison of the Effects of the Two Exercise Programs for the Forty-Eight Subjects Having Lowest Cardiovascular Efficiency Scores

In the preceding two tables, comparisons were made between the two programs of exercise for subjects of lowest (Table IV) and next to lowest (Table V) cardiovascular fitness. The first comparison indicated isotonic exercises to be superior to an isometric program, whereas the second comparison failed to reveal a significant difference. Since both of the isotonic groups had shown significant improvement and the isometric groups had not, it was decided to combine the groups and compare the exercise programs. This was done to see if any generalization could be made concerning the
benefits of isotonic exercises over that of isometric exercises for subjects of low initial cardiovascular efficiency. Table VI shows the F-ratio of 2.54 which did not reach significance at the .05 level of probability. Therefore, it is evident that although isotonic exercises produced significant gains in subjects of low initial cardiovascular fitness, when the two lowest classifications were combined, the improvement was not of sufficient magnitude to be significantly better than the performance of the twenty-four subjects of similar initial status who trained isometrically.

### TABLE VI

ANALYSIS OF COVARIANCE OF CARDIOVASCULAR EFFICIENCY SCORES OF THE FORTY-EIGHT JUNIOR HIGH SCHOOL GIRLS HAVING LOWEST INITIAL CARDIOVASCULAR EFFICIENCY

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>99</td>
<td>1</td>
<td>99</td>
<td>2.54</td>
<td>NS</td>
</tr>
<tr>
<td>Within</td>
<td>1,753</td>
<td>45</td>
<td>38.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,852</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-ratio needed at .05 level, 4.06
F-ratio needed at .01 level, 7.23
Comparison of the Effects of the Two Exercise Programs for Subjects Having the Highest Cardiovascular Efficiency Scores

In the t-tests, the subjects in the isotonic group who possessed highest initial cardiovascular fitness scores had shown a significant decrease in performance. The two programs were thus compared by analysis of covariance and the results are shown in Table VII. The F-ratios required for significance were 4.32 and 8.02 for the .05 level of probability and the .01 level, respectively. The computed F-ratio of 7.54 was found to be significant beyond the .05 level of probability. When the final means were adjusted, the isometric group showed a mean of 65.13, and the corrected mean of the isotonic group was 59.44, which indicated that the isotonic group's scores were much below that of the isometric exercise group. It should be pointed out that the performance of the isometric subjects in this classification was slightly poorer at the end of the study than in the beginning (a negative gain of 1.5), but it was not significant.

Although there was no apparent explanation for this finding, the interpretation would be that the isotonic exercise program brought about significantly poorer cardiovascular efficiency performance for subjects of highest initial fitness than did the isometric exercise program; or, stated another way, the isometric program did not produce
any change in cardiovascular fitness for the person of high initial status, whereas, the isotonic program had a detrimental effect on the subjects in this classification.

**TABLE VII**

ANALYSIS OF COVARIANCE OF CARDIOVASCULAR EFFICIENCY SCORES OF THE TWENTY-FOUR SUBJECTS HAVING HIGHEST INITIAL CARDIOVASCULAR EFFICIENCY SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>730</td>
<td>1</td>
<td>730</td>
<td>7.54</td>
<td>.05</td>
</tr>
<tr>
<td>Within</td>
<td>2,032</td>
<td>21</td>
<td>96.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,762</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Corrected Means**

Isometric Group ........................................ 65.13

Isotonic Group ......................................... 59.44

F-ratio needed at .05 level, 4.32
F-ratio needed at .01 level, 8.02
Comparison of the Effects of the Two Exercise Programs for the Forty-Eight Subjects Having the Two Highest Cardiovascular Efficiency Scores

As seen in Table III, neither exercise program produced any significant change in cardiovascular fitness for subjects in the next to highest initial score classification. However, the subjects in the isotonic exercise program in this category had an observed difference in initial and final mean scores of only .8 and the isometric group's gain was a positive 2.3. It was therefore decided to combine the subjects in the two highest classifications and compare the effects of the two programs to see if the isotonic exercises did result in significantly poorer performance for subjects of high initial cardiovascular efficiency. The comparison is shown in Table VIII.

It can be seen that even though a significant difference was found between the exercise programs for subjects of highest initial classification, when these subjects were combined with those in the next to highest category, no significant difference was obtained. The F-ratio of 1.89 was considerably below the F of 4.06 needed to demonstrate significance at the .05 level of probability. Therefore, it can be stated that there was no significant difference between the effects of isometric and isotonic exercises for the subjects in the two highest classifications of initial cardiovascular efficiency.
TABLE VIII
ANALYSIS OF COVARIANCE OF CARDIOVASCULAR EFFICIENCY SCORES FOR THE FORTY-EIGHT JUNIOR HIGH SCHOOL GIRLS OF HIGHEST INITIAL CARDIOVASCULAR EFFICIENCY

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>128</td>
<td>1</td>
<td>128</td>
<td>1.89</td>
<td>NS</td>
</tr>
<tr>
<td>Within</td>
<td>3,043</td>
<td>45</td>
<td>67.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3,171</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F-ratio needed at .05 level, 4.06
F-ratio needed at .01 level, 7.23

III. RELATIONSHIP OF INITIAL CARDIOVASCULAR FITNESS WITH CARDIOVASCULAR EFFICIENCY SCORE GAINS MADE IN THE TWO EXERCISE PROGRAMS

This analysis was to determine if there were any apparent, over-all trend, or regression line, which would show whether the type of exercise program had different effects on subjects in accordance with their initial cardiovascular efficiency. A coefficient of correlation between initial status and gain was computed first for the total group; then for the isometric group; and then for the isotonic group. The data are shown in Table IX.

For the total group, an r of -.48 was found, which was far beyond that needed for significance at the .01 level of confidence. This high correlation between status and
TABLE IX
COEFFICIENTS OF CORRELATION OF INITIAL CARDIOVASCULAR EFFICIENCY SCORES WITH GAINS IN CARDIOVASCULAR EFFICIENCY SCORES FOR THE TOTAL GROUP, THE ISOMETRIC GROUP, AND THE ISOTONIC GROUP

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean of Initial CVE Scores</th>
<th>Mean of Gains in CVE</th>
<th>df</th>
<th>r</th>
<th>P</th>
<th>Regression Coeff.</th>
<th>Variation Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Group</td>
<td>53.1</td>
<td>1.9</td>
<td>118</td>
<td>-.48</td>
<td>.01</td>
<td>-.44</td>
<td>.23</td>
</tr>
<tr>
<td>Isometric Group</td>
<td>52.7</td>
<td>2.0</td>
<td>58</td>
<td>-.26</td>
<td>.05</td>
<td>-.27</td>
<td>.07</td>
</tr>
<tr>
<td>Isotonic Group</td>
<td>53.5</td>
<td>1.8</td>
<td>58</td>
<td>-.54</td>
<td>.01</td>
<td>-.40</td>
<td>.29</td>
</tr>
</tbody>
</table>

For total group: r needed at .05 level for 118 df, .175
r needed at .01 level for 118 df, .230

For each exercise group: r needed at .05 level for 58 df, .253
r needed at .01 level for 58 df, .333
gain was the justification for using covariance in the analysis of the data. The regression coefficient of -.44 indicated that for a rise of one unit in cardiovascular efficiency initial score, there was a negative gain of -.44. The variation percentage means that twenty-three per cent of the gain made was attributed to the initial status in cardiovascular efficiency.

For the isometric group, the coefficient of correlation was -.26, which was significant at the .05 level. This group had a regression coefficient of -.27, indicating that for a rise of one unit in initial cardiovascular efficiency score, there was a corresponding decrease in performance at the end of the program of -.27. The variation percentage indicates that only seven per cent of the gain was due to initial level of cardiovascular efficiency.

The isotonic group had an $r$ of -.54 which far exceeded that needed for significance at the .01 level. The regression coefficient was -.40, and the variation percentage was .29. Thus, twenty-nine per cent of the gain for the isotonic group was due to initial status.

In all of the computed correlations, it was seen that a negative relationship existed between initial fitness and gains. This relationship was most pronounced in the isotonic group, where evidently the exercises were quite beneficial to initially low cardiovascular efficiency performers, and yet, not of any significant value, even deleterious, to the
subjects possessing a high degree of cardiovascular fitness at the onset of the investigation.

IV. RELATIONSHIP OF CARDIOVASCULAR EFFICIENCY PERFORMANCE WITH BODY WEIGHT CLASSIFICATIONS

In keeping with one of the purposes of the study, the relationship of body weight and cardiovascular efficiency was analyzed in an effort to determine the possible influence that each type of exercise might have on persons of different body build. Using the Pryor Width-Weight Tables, it was first determined how much each girl should weigh for her particular body build. If the girl deviated from her recommended weight, the amount of deviation was recorded in percentage of overweight or underweight.

The first correlation was between initial cardiovascular efficiency and body weight for all the subjects. This was done to see if the same relationship would exist as found in Abdo's¹ study in which she found a high negative correlation between step test performance and body weight in college women. The coefficient of correlation obtained in this study was -.16, which is shown in Table X. A correlation of .18 was needed for significance at the .05 level of probability; hence, the r of -.16 did not quite reach significance, although the direction of the correlation was

¹Abdo, loc. cit.
the same as in Abdo's study. This finding will be discussed in more detail in Chapter V.

### TABLE X

**COEFFICIENT OF CORRELATION OF INITIAL CARDIOVASCULAR EFFICIENCY AND BODY WEIGHT FOR THE TOTAL GROUP**

<table>
<thead>
<tr>
<th>Mean of Initial CVE Scores</th>
<th>Mean Weight Difference</th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.10</td>
<td>5.34</td>
<td>-.16</td>
<td>NS</td>
</tr>
</tbody>
</table>

* r needed at .05 level, .180
* r needed at .01 level, .246

A second correlation was computed between Step Test score gains and body weight for the sixty subjects in the isometric program. In Table XI, the resulting coefficient of correlation of -.19 is presented. To be significant, with fifty-eight degrees of freedom, an r of .255 was needed.

Also shown in Table XI is the correlation between gain in cardiovascular efficiency scores and body weight for the isotonic subjects. This correlation was found to be .04 which, obviously, was also not significant. Consequently, for all three correlations the null hypothesis was accepted.

From these results, it would appear that there is no relationship between the step test performance of junior high
school girls and body weight, nor is there any particular effect of a program of isometric exercises or a program of isotonic exercises on cardiovascular fitness development when considered in terms of body weight.

**TABLE XI**

**COEFFICIENT OF CORRELATION OF THE GAINS IN CARDIOVASCULAR EFFICIENCY SCORES AND BODY WEIGHT OF THE ISOTONIC AND ISOMETRIC SUBJECTS**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Mean of Gains in CVE Scores</th>
<th>Mean Weight Difference</th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric</td>
<td>1.98</td>
<td>5.80</td>
<td>-.19</td>
<td>NS</td>
</tr>
<tr>
<td>Isotonic</td>
<td>1.83</td>
<td>4.88</td>
<td>.04</td>
<td>NS</td>
</tr>
</tbody>
</table>

*r* needed at .05 level, .255
*r* needed at .01 level, .331

**Analysis of Gains Made in Cardiovascular Efficiency for Subjects Classified into Three Categories:**

**Underweight, Average Weight, and Overweight**

One further analysis of data was made in which the subjects were classified as being underweight, average weight, or overweight. The Pryor Width-Weight Chart was again used, with the criteria for average weight being the recommended weight plus or minus five pounds. Those subjects more than five pounds over the average weight for body size were classified as overweight, and those more than five
pounds below the average weight were classified as being underweight. Then, within each of the weight classifications, the subjects who had performed the isometric exercises were separated from those girls who had been in the isotonic exercise program for comparison of the exercise programs. For each of the six subgroups, t-tests were computed to compare initial and final cardiovascular efficiency scores to establish whether significant gains were made (Table XII).

Only two of the six groups had significant gains. One group was composed of subjects of average weight who had trained with isometric exercises, and the other group was comprised of subjects of average weight who had performed isotonic exercises.

The average weight isotonic group had a t-ratio of 2.39 which exceeded the 2.11 needed for significance at the .05 level; a t-ratio of 2.29 was found for the average weight isometric group, which also was significant at the .05 level. Therefore, both isometric and isotonic exercises significantly improved the cardiovascular efficiency of subjects classified as being of average weight.

**Comparison of the Effects of the Two Exercise Programs in the Development of Cardiovascular Efficiency for Average Weight Subjects**

An analysis of covariance was used to determine if there was a significant difference between the effectiveness of isotonic and isometric exercises for the average weight
TABLE XII
DIFFERENCES BETWEEN MEANS OF INITIAL TEST AND FINAL TEST CARDIOVASCULAR
EFFICIENCY SCORES FOR ISOTONIC AND ISOMETRIC EXERCISE
GROUPS OF VARYING WEIGHT CLASSIFICATIONS

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Initial Mean</th>
<th>Final Mean</th>
<th>Mean Diff.</th>
<th>SE</th>
<th>Diff.</th>
<th>t</th>
<th>p</th>
<th>t Needed</th>
<th>t Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>13</td>
<td>61.8</td>
<td>60.4</td>
<td>-1.4</td>
<td>3.18</td>
<td>-.44</td>
<td>NS</td>
<td>2.18</td>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>Isotonic</td>
<td>18</td>
<td>52.4</td>
<td>57.1</td>
<td>4.7</td>
<td>1.97</td>
<td>2.39</td>
<td>.05</td>
<td>2.11</td>
<td>2.90</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>29</td>
<td>50.5</td>
<td>52.0</td>
<td>1.5</td>
<td>1.51</td>
<td>.99</td>
<td>NS</td>
<td>2.05</td>
<td>2.76</td>
<td></td>
</tr>
<tr>
<td>Isotonic</td>
<td>9</td>
<td>56.7</td>
<td>57.7</td>
<td>1.0</td>
<td>3.02</td>
<td>.33</td>
<td>NS</td>
<td>2.31</td>
<td>3.36</td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>26</td>
<td>52.4</td>
<td>55.5</td>
<td>3.1</td>
<td>1.35</td>
<td>2.29</td>
<td>.05</td>
<td>2.06</td>
<td>2.79</td>
<td></td>
</tr>
<tr>
<td>Isometric</td>
<td>25</td>
<td>51.5</td>
<td>52.7</td>
<td>1.2</td>
<td>1.07</td>
<td>1.12</td>
<td>NS</td>
<td>2.06</td>
<td>2.80</td>
<td></td>
</tr>
</tbody>
</table>
subjects. In Table XIII, the F-ratio of .53 is seen to be considerably below that needed for significance at the .05 level of probability, indicating that there was no significant difference between the effectiveness of the two exercise programs.

**TABLE XIII**

**ANALYSIS OF COVARIANCE OF THE ISOTONIC AND ISOMETRIC EXERCISES OF THE AVERAGE WEIGHT SUBJECTS**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Corrected SS</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>28</td>
<td>1</td>
<td>28.00</td>
<td>.53</td>
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<td>41</td>
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F-ratio needed at .05 level, 4.08
F-ratio needed at .01 level, 7.29
CHAPTER V
SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The purposes of this study were to determine the comparative effectiveness of isometric exercises and isotonic endurance exercises in improving cardiovascular efficiency of eighth grade girls. The comparison of the two exercise programs was further analyzed on the basis of the girls' initial cardiovascular efficiency classifications; and finally, to determine whether isometric exercises or isotonic endurance exercises were more beneficial in improving cardiovascular efficiency of eighth grade girls when classified according to body weight.

The subjects involved in this study were 120 eighth grade girls enrolled at Westlane Junior High School, Indianapolis, Indiana.

At the beginning of the investigation, the subjects were measured for height, weight, chest width, and hip width as indicated in the Pryor Width-Weight Chart.

The modified Harvard Step Test was also administered to all subjects at the beginning of the investigation. Based upon their cardiovascular efficiency scores, the girls
were ranked from high to low, and then divided into five equal groups. Each of these groups was then divided at random into two subgroups: an isometric exercise group and an isotonic exercise group. Prior to the regular physical education activities each day of class, the isotonic exercise groups performed a series of isotonic exercises, and the isometric exercise groups performed selected isometric exercises. This procedure was followed three days per week for six weeks. At the end of the six-week period, the Step Test was readministered.

The data were analyzed by means of the t-test for correlated means to establish the significance of the mean gains in cardiovascular efficiency scores from the initial to the final tests for each exercise group and subgroup classified according to initial cardiovascular fitness status and body weight. Where significant t-scores were found, analysis of covariance was used to compare the effects of the two exercise programs.

The product-moment method of correlation was employed to analyze the relationships between initial cardiovascular fitness and amount of improvement made; the relationship between type of exercise program and step test performance of subjects when classified according to initial cardiovascular fitness; the correlation between body weight and step test performance and the relationship between type of exercise program and cardiovascular efficiency development of subjects classified in terms of body weight.
II. FINDINGS

The findings of this study were as follows:

1. In the analyses of the total group, the subjects performing isometric exercises improved significantly in cardiovascular efficiency, while the subjects having isotonic exercises did not. However, the isometric group's gains were not high enough to be significantly better than the gains of the isotonic exercise group.

2. The subjects in the two lowest categories of initial cardiovascular fitness improved significantly in step test performance as a result of an isotonic exercise program. The subjects of the same initial condition who were given isometric exercises did not show significant gains. When the two exercise programs were compared, only in the lowest classification was a significant difference found, in favor of isotonic exercises.

3. Isotonic exercises resulted in significantly poorer cardiovascular efficiency scores at the end of the training program for subjects of highest initial cardiovascular efficiency than did the subjects of the same initial status in the isometric program. The latter group showed no change from initial to final tests.

4. For all subjects, a significant negative correlation was found between initial cardiovascular condition and gain made from initial to final test. This negative relationship was much more pronounced in the isotonic exercise
group than in the group who exercised isometrically.

5. The relationship between body weight and step test performance was in a negative direction, although the coefficient of correlation was not significant. The relationship between the type of exercises employed and changes in cardiovascular efficiency of girls, when classified according to body weight, was not significant.

6. Both exercise programs produced significant gains in cardiovascular fitness for the eighth grade girls classified as being of average weight; no difference was found in the comparative effectiveness of the two types of exercises for these subjects.

**Discussion of Findings**

The results of this study did not show any distinct advantage for either isometric or isotonic exercises in the development of cardiovascular efficiency. However, there were certain implications, which may warrant further study. In this section, the writer has endeavored to go beyond the mere statement of findings and make inferences and suggest possible explanations for the results when deemed appropriate.

It was found that there was a significant gain in cardiovascular efficiency for the total isometric exercise group but not for the isotonic exercise group. However, the analysis of covariance indicated there was no significant difference between the two exercise groups. This finding
may be explained by the fact that the subjects of lowest
initial fitness gained significantly as a result of isotonic
exercises, and the subjects of highest initial status had a
significant drop in performance. This probably had a neutraliz­
ing effect resulting in no over-all gain. On the other
hand, the isometric exercise program did not produce signifi­
cant gains for any subgroup (formed on the basis of initial
fitness), but when combined and analyzed as one group, a
significant gain was noted. This could be interpreted as
indicating that isotonic exercises may be more specific in
their effects, their value being dependent upon the individ­
ual; whereas, the effects of isometric exercises may be more
general in nature, being applicable for all persons regard­
less of their initial status.

The finding which showed the subjects of highest
initial cardiovascular efficiency experiencing a decrease in
performance at the end of the training program cannot be
readily explained. Had they shown no change, it would be
understandable, indicating that the exercises were not
vigorous enough to cause significant improvement for persons
at this level of fitness. Perhaps the explanation might lie
in the area of motivation, time of the year, outside activi­
ties, or other extraneous variables. Nevertheless, there
was a very definite negative correlation between initial
status and gain which cannot be wholly attributed to amount
and intensity of the exercise program; nor by the contention
that the very good have less room for improvement.

The importance of motivation was recognized, and every effort was made to encourage the subjects to do their best in training and in their tests, and to provide the subjects with a knowledge of results, and a record of progress. The increase in strength of the isometric subjects as measured by the Iso-Kit for the "dead lift" exercise, indicated that these subjects were exerting maximum effort for the exercise provided. The isotonic exercise subjects also kept records of the number of squat thrusts completed and the number of steps taken in the running exercise. The increase in number of squat thrusts and steps for nearly all subjects gave evidence that they, too, exerted maximum effort during training.

A superficial examination of the initial and final means of cardiovascular efficiency scores for the three weight classifications indicated that being overweight was detrimental to cardiovascular efficiency performance. The overweight subjects had the lowest cardiovascular efficiency scores; whereas, the underweight subjects had the highest cardiovascular efficiency scores. However, the correlation between weight and cardiovascular efficiency, although negative, was not significant. One major point of contention in the classification of the subjects by body weight may be the Pryor Width-Weight Chart itself. There is some reason to believe that this chart is not as valid as it once was. Since the last copyright date was 1940, it would appear that
this chart is not up to date with the changes that have come about in the human physique. The literature gives evidence of the fact that the American youth today is taller and heavier than at any time in the past. From close personal observation of the subjects in this study, this investigator did not feel that all of the subjects classified by the chart as being underweight or overweight were actually underweight or overweight. This was particularly true of the girls classified as overweight. According to the chart, fifty-four, or nearly half of the subjects were classified as being overweight. In the opinion of this writer, the group was fairly homogeneous in terms of body size. There were a few noticeable overweight and underweight girls, but the majority of the subjects seemed to be about "average" in body build and weight.

Therefore, although neither isometric nor isotonic exercises caused significant gains for the overweight or underweight subjects, it was felt by this investigator that there were too few subjects who were actually markedly overweight or underweight.

III. CONCLUSIONS

Within the limitations of this study, the following conclusions appear to be justified:

1. For the general population of eighth grade girls, the isometric exercises performed in this study will produce significant improvement in cardiovascular efficiency.
2. Isotonic exercises are better for subjects having low initial cardiovascular efficiency than are isometric exercises.

3. In order to improve the cardiovascular efficiency of the high initial cardiovascular efficiency group, more strenuous exercises should be provided.

4. Being overweight is detrimental to cardiovascular efficiency performance, as measured by a step test.

5. Average weight girls show more improvement in cardiovascular efficiency than either underweight or overweight girls, regardless of the type of exercise program employed.

IV. RECOMMENDATIONS

In consideration of the results of this study, the writer makes the following recommendations:

1. An experiment lasting longer than six weeks to see if length of time of training is a contributing factor in improvement of cardiovascular efficiency.

2. A study providing increasingly more strenuous exercises as initial cardiovascular efficiency improves.

3. An investigation using a more up-to-date form of weight classification and a sizable number of subjects who are decidedly overweight and underweight.
SELECTED BIBLIOGRAPHY
SELECTED BIBLIOGRAPHY

A. BOOKS


B. PERIODICALS


C. UNPUBLISHED MATERIALS


D. PAMPHLETS


U. S. Department of the Navy. "Shape-Up."
APPENDIX
### Girls, Age 13 Years

#### For Narrow Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 21.3 cm. and below</th>
<th>Weight of breast diameter in centimeters</th>
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</thead>
<tbody>
<tr>
<td>21.3</td>
<td>22.3</td>
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<td>58</td>
<td>67</td>
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<td>59</td>
<td>68</td>
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</table>

#### For Medium Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 21.4 to 23.8 cm.</th>
<th>Weight of breast diameter in centimeters</th>
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<td>22.4</td>
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#### For Broad Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 23.9 cm. and above</th>
<th>Weight of breast diameter in centimeters</th>
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<td>23.9</td>
<td>24.9</td>
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### Girls, Age 14 Years

#### For Narrow Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 21.9 cm. and below</th>
<th>Weight of breast diameter in centimeters</th>
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<tbody>
<tr>
<td>21.9</td>
<td>22.9</td>
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<td>53</td>
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#### For Medium Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 21.9 to 24.8 cm.</th>
<th>Weight of breast diameter in centimeters</th>
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#### For Broad Chest

<table>
<thead>
<tr>
<th>Thoracic Lateral Width, 24.9 cm. and above</th>
<th>Weight of breast diameter in centimeters</th>
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</thead>
<tbody>
<tr>
<td>24.9</td>
<td>25.9</td>
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**Note:** The table above provides weight tables for Pryor width-weight charts. It includes data for both girls aged 13 and 14 years, detailing the thoracic lateral width and weight of the breast diameter in centimeters. The data is organized into three categories: for narrow chest, medium chest, and broad chest, with measurements ranging from 21.3 cm to 24.9 cm. The table is divided into subcategories for weight in centimeters ranging from 21.9 to 27.3, 22.9 to 27.9, and 23.9 to 28.9, respectively, for each chest width range.
The author was born in Greensburg, Indiana on June 5, 1936. She received her elementary and high school education in Greensburg, graduating from Greensburg High School in 1954.

In 1958 she received her Bachelor of Science degree from Butler University in Indianapolis, Indiana. Upon graduation, she was appointed an Instructor of Physical Education at Butler University where she remained for four years. Her Master of Science degree was acquired in 1960.

Work toward the Doctor of Education Degree was begun at Louisiana State University in 1962, with a major in physical education and a minor in education. While completing the classwork at Louisiana State University, she served as a graduate teaching assistant in the Women's Division of the Department of Health, Physical, and Recreation Education.

In addition to teaching at Butler University and Louisiana State University, the author also taught at Westlane Junior High School, Indianapolis, Indiana. She is presently an Assistant Professor of Physical Education at Butler University.

She is a member of the Indiana Association of Health, Physical Education and Recreation; the American Association of Health, Physical Education and Recreation; the Midwest Association of Physical Education for College Women; and Delta Psi Kappa.
Candidate: Xandra L. Hamilton

Major Field: Physical Education

Title of Thesis: The Effects of Isometric and Isotonic Endurance Exercises on the Development of Cardiovascular Efficiency of Eighth Grade Girls Classified According to Initial Cardiovascular Efficiency and Weight

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination: January 12, 1966