The Effects of Varying Training Time Periods on the Development of Cardiovascular Efficiency in College Women

Susan Anne Yeager

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THE EFFECTS OF VARYING TRAINING TIME PERIODS ON THE DEVELOPMENT OF CARDIOVASCULAR EFFICIENCY IN COLLEGE WOMEN

BY

SUSAN ANNE YEAGER

A thesis submitted in partial fulfillment of the requirements for degree Master of Science, Major in Physical Education, South Dakota State University

1969
THE EFFECTS OF VARYING TRAINING TIME PERIODS ON THE DEVELOPMENT OF CARDIOVASCULAR EFFICIENCY IN COLLEGE WOMEN

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor

Head, Health, Physical Education, and Recreation Department

Date
THE EFFECTS OF VARYING TRAINING TIME PERIODS ON THE DEVELOPMENT OF CARDIOVASCULAR EFFICIENCY IN COLLEGE WOMEN

Abstract

Susan A. Yeager

Under the supervision of Associate Professor Glenn E. Robinson

Eighteen volunteers were randomly divided into three groups, and the treatments were then randomly assigned. The study involved a six-week conditioning period followed by a three-week deconditioning period. The subjects were tested before and after the conditioning period to determine the effects of the conditioning programs on cardiovascular efficiency. A third test was administered three weeks after the second test to measure the level of retention of fitness of all subjects. The two tests administered each testing period were the Astrand Test of Predicted Maximal Oxygen Uptake and a test of physical work capacity. During the conditioning program all subjects rode the bicycle ergometer three times per week. Group A exercised ten minutes per session, group B exercised for twenty minutes each session, and group C exercised for thirty minutes each session.

The results indicated that all three groups significantly improved in cardiovascular efficiency between Test I and Test II, and retained this level throughout the deconditioning phase of the study. No significant differences were found to occur between the groups.
ACKNOWLEDGEMENTS

The investigator would like to express sincere thanks to Dr. Paul Brynteson for his guidance and assistance in developing and writing this thesis, and to Associate Professor Glenn E. Robinson for his help and moral support throughout the project.

The writer would also like to express her appreciation to the eighteen subjects whose cooperation made this study possible.

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CHAPTER I

INTRODUCTION
CHAPTER I

INTRODUCTION

Citizens caught up in the contemporary style of living need to be aware of the significance of cardiovascular efficiency. As the American way of life seems to have turned from one of physical activity to one of mostly mental activity, certain trends can be noted. Among these trends is the increased belief that physical exercise has a positive effect upon the condition and optimum functioning of one's body. Recent reports indicate that physical exercise has been prescribed in rehabilitation programs for post-myocardial infarction patients and former bedridden patients.¹ Other recent studies show the results of moderate-to-intense training programs upon subject; however, studies concerned with minimal amounts of training necessary for increased cardiovascular efficiency have yet to be dealt with in depth. As Skinner reports,

"More research . . . is definitely needed to fill the gaps in our knowledge concerning the optimal amount of exercise required to elicit a training response. What is also needed is information on the minimal amount of activity needed to induce and maintain an adequate level of cardiovascular fitness."²

This need of more meaningful research was the problem confronted in this study.


Statement of the Problem

The purpose of this study was to investigate the effects of three selected training time periods upon the development of cardiovascular efficiency of college freshmen women.

Significance of the Study

In today's busy world many people work according to precise schedules where every minute counts. Most people would enjoy some particular leisure-time physical activity, but they are too tired or too busy to carry out these ideas about physical activity. The warnings about the effects of a sedentary life are common knowledge, but the average person does not have time, means, or energy to improve his physical condition. Also, there is a misconception involved, because most people think they must become as well-conditioned as competing athletes in order to improve their physical conditions. Just how much exercise is needed to improve or maintain a good level of fitness? How strenuous must the activity be? As stated previously, the purpose of this study was to determine what effects three different lengths of exercise periods have upon individual fitness. Thus, it was also the purpose of this study to indicate what minimal time is required per week for an individual to improve and maintain his desired fitness level.

Limitations of the Study

1. The subjects involved were eighteen freshmen women volunteers from basic instruction courses in physical education for the
1969 spring semester at South Dakota State University. No physical education majors were allowed to participate.

2. No one participating in an intercollegiate activity could volunteer for participation in the study.

3. The training program lasted six weeks, with three training sessions per week for each subject.

4. The eighteen subjects were divided into three groups of six each. One group trained for ten minutes per session, another trained for twenty minutes per session, and the third trained for thirty minutes per session.

5. No attempt was made to regulate or limit the subject's diet, sleep, or other aspects of her personal life. Each subject, however, was asked not to change her living habits during the course of the study.

**Definition of the Terms**

**Cardiovascular efficiency.** Cardiovascular efficiency refers to the ability of the body to do work for a prolonged period of time. It is dependent upon the capability of the cardiovascular and respiratory systems to deliver oxygen and nutrients to the tissues and carry away their metabolites.

**Cardiovascular efficiency test.** The cardiovascular efficiency test used in this study was one in which each subject pedaled on a bicycle ergometer against an increasing workload until the heart rate reached 170 beats per minute.
Pre-test. The pre-test was given immediately prior to the training program to determine the level of fitness of each subject before the training program began.

Post-test. The post-test was given immediately after the training program ended in order to discover any changes in cardiovascular efficiency.

Retention test. The retention test was administered three weeks after the completion of the training program to determine the level of fitness of each subject after a period of little activity.

Training program. The training program was that part of the study which extended between the pre-tests and post-tests. It was an exercise program, or a conditioning phase, where the three treatments were administered. The subjects trained either ten, twenty, or thirty minutes a day, three days per week for six weeks.

Training rate. Training rate referred to the intensity of the workload. Each subject pedaled on the bicycle ergometer at a frequency of fifty revolutions per minute, and the heart rate was maintained at 144 beats per minute.

Hypotheses

1. There is an improvement in cardiovascular efficiency whether subjects train ten, twenty, or thirty minutes per day, three days per week.

2. There is no significant difference among the three groups in the development of cardiovascular efficiency.
CHAPTER II

REVIEW OF RELATED LITERATURE
CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter contains the related literature pertinent to this investigation, which is divided into the following sections:

1. Conditioning and Cardiovascular Efficiency
2. Testing of Cardiovascular Efficiency

Conditioning and Cardiovascular Efficiency

Roskamm reported that an increase of physical activity has been widely discussed as a means of preventing certain circulatory system diseases. Other studies appearing in this report have shown that active exercises such as bicycling, skiing long distances, skating, and running lower the pulse rate over a certain length of time and increase the heart volume. Exercises like weight lifting and gymnastics did not affect the cardiovascular system.3

In a study by Hermansen and Andersen, it was determined that maximal heart rates were related to fitness. Well-trained subjects had lower maximal heart rates than untrained subjects. The utilization of oxygen for athletes and nonathletes remained the same when the subjects pedaled a bicycle ergometer at submaximal workloads. In measuring aerobic capacity, however, both male and female athletes were able to consume larger amounts with greater efficiency than

sedyentary men and women. Male athletes consumed an average of 71 milliliters of oxygen per kilogram of body weight per minute (ml/kg/min), whereas sedentary men consumed an average of 44 ml/kg/min. Women athletes consumed an average of 55 ml/kg/min, while sedentary women consumed an average of 38 ml/kg/min of oxygen.4

Karvonen reported that heart rate was the key to determining the intensity of training. In training one-half hour daily for four weeks, the subject did not increase his working performance if his heart rate was less than 135 beats per minute, even though his resting rate decreased. However, if the heart rate was around 150 beats per minute, a significant increase in work performance was seen.5

Hollman and Vonrath reported slightly different figures when their subjects trained daily for five weeks on the bicycle ergometer. If the subjects' heart rates were above 130 beats per minute, their maximal oxygen uptakes increased.6

Concerning duration and repetition rates of training, a training program of one-half hour, five days a week was sufficient to definitely increase one's working capacity. Shorter times also produced some similar effects. One-half hour of training every third day did not lead to further gains in working capacity of persons

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5Roskamm, op. cit., p. 895.

6Ibid.
already trained, but it was enough to sustain their levels of working performance.\footnote{Ibid., p. 897.}

Sinning and Adrian studied cardiorespiratory changes in college women. Seven members of a women's basketball team and eight non-participants were tested before and after a basketball season. A maximal oxygen uptake test on the bicycle ergometer and a number of other cardiovascular and pulmonary measurements were given. The results showed a significant increase in maximal oxygen uptake among the participant group, but other pulmonary functions and cardiovascular measurements did not show concomitant improvement. It was decided that the training program was not strenuous enough to cause the participants to reach their capacity for physical conditioning.\footnote{Wayne E. Sinning and Marlene J. Adrian, "Cardiorespiratory Changes in College Women Due to a Season of Competitive Basketball," \textit{Journal of Applied Physiology}, 25:720-723, December, 1968.}

Twenty-three college women participating in Walters' study underwent eleven straight days of training. Results of a treadmill walking test and a bicycle ergometer test by Tuttle and Wendler showed that each subject increased her physical efficiency. After the eleven training days, a five-week deconditioning program ensued. The subjects maintained their higher levels of fitness for two weeks, but by the end of the five-week period, their efficiency decreased.\footnote{C. Etta Walters, "A Study of the Effects of Prescribed Strenuous Exercises on the Physical Efficiency of Women," \textit{Research Quarterly}, 24:103, 109-110, March, 1953.}
Gettman studied the effects of various amounts of training upon middle-aged men. The subjects were divided into three groups, and after five months of training, they were tested on selected cardiovascular, motor, and respiratory measures. The first group trained three days per week, the second group trained five days per week, and the third group, the control group, did not train at all. The only exercise the control group had was through normal activity. The two groups in training followed identical training programs, identical in type of running and calisthenics, and in length of time per workout, so that the only difference was in the actual number of training sessions per week. Before the training program began, there was no significant difference among the groups. After five months of training, however, the two exercise groups had significant changes in heart rate, before, during, and after a submaximal bicycle ergometer ride, and with heartograph measures of systolic amplitude. The training groups also enjoyed better motor fitness. When the author investigated the differences between the two training groups, he found that the five-day per week group had better times on the mile run, but there were no significant differences between the two groups in the areas of heart rate, heartograph measures, motor fitness, or respiratory fitness. Thus, in this study there was no significant difference between training three days per week or five days per week. 10

Stern's study compared the effects of two interval training programs which differed only in the frequency of application of the training stimuli. Fifteen male subjects, ages seventeen to twenty-one years, were selected from physical education basic instruction classes on the basis of interest. The subjects were matched by pairs for grouping purposes on the basis of performance of the mile run and a five minute step test. The two groups then worked on two different training programs for seven weeks. One group worked with a lighter workload three times per week (Monday, Wednesday, and Friday). The second group worked twice a day every four or five days. The results showed that both groups significantly lowered their mile run times. Group A, running three times per week, improved at a faster rate, but had a slightly higher regression rate than Group B. When cardiovascular tests were given after the training period, the investigator was not able to state any significant findings, because the differences between the two groups were not consistent. Thus, the training programs produced significant endurance gains for both groups, and there was no difference concerning performance between the two methods of training.\footnote{Barry Elroy Stern, "The Effects of Frequency of Exposure to Training on Endurance Performance and Selected Cardiovascular Fitness Tests" (unpublished Master's thesis, University of Illinois, Urbana, 1963), pp. 40-41, 48, 61, 87, 90-94.}

Knehr, Dill, and Neufeld completed a study of cardiovascular fitness on fourteen male subjects. For six months the subjects trained at middle-distance running and worked on the treadmill. The
Subjects were tested after two months of training, four months of training, and six months of training. Subjects made their greatest improvements within the first two months of training. The results showed that their resting heart rates were lower, their respiration rates and volumes were slightly lower, their plasma chloride contents were slightly higher, their capacities for supplying oxygen to the tissues of the body were higher, and their lactic acid capacities were higher. The subjects also increased their efficiency of grade walking on the treadmill.¹²

Cooper stated his two basic principles for training programs to increase cardiovascular efficiency as follows:

If the exercise is vigorous enough to produce a sustained heart rate of 150 beats per minute or more, the training-effect benefits begin about five minutes after the exercise starts and continue as long as the exercise is performed. If the exercise is not vigorous enough to produce or sustain a heart rate of 150 beats per minute, but is still demanding oxygen, the exercise must be continued considerably longer than five minutes, the total period of time depending on the oxygen consumed.¹³

In summation of training practices, Skinner noted, "Training programs are no longer purely empirical. Many relationships between intensity, duration, repetition rate, and other parameters and their effects on the body are not yet clear."¹⁴


¹⁴Roskamm, op. cit., p. 898.
Testing of Cardiovascular Efficiency

Davies found that prediction of maximal oxygen uptake from cardiac frequency caused problems due to errors in measurement. Errors due to intersubject variability in maximal heart rate may be small and insignificantly different from that to be expected from day-to-day variations of measurement of maximal heart rate and maximal oxygen uptake. He recommended, however, that if accuracy greater than plus or minus 15 percent is required, direct measurement should be used.\textsuperscript{15}

Taylor, in studying the differences between maximal and submaximal workloads, found that submaximal workloads left more room for error. Variations among test results on the same individuals were a prominent source of test unreliability. This unreliability, however, declined if the subjects worked to maximum capacity. At submaximal levels, heart-rate and blood-lactate measures were the most reliable sources of information.\textsuperscript{16}

Astrand and Ryhming compared direct and indirect methods of determining physical work capacity of individuals. Direct measurements were possible, but several problems accompanied this method of measurement. The process itself was intricate, and was possible only


in a well-equipped laboratory. Subjects themselves were known risks also, because maximal tests sometimes caused undesirable results with older subjects or subjects with respiratory and heart diseases. Problems also occurred with indirect measurements, because the results were not as accurate as direct measures. Because there were undesirable factors in both methods, it was decided that certain criteria must be established. Therefore, the work must be long enough for certain circulatory and ventilatory changes to occur, yet the subjects should not be pushed to a dangerous level which might jeopardize their health.17

Astrand reported that large muscle groups must be employed when oxygen uptake was analyzed. He further stated that if a subject exercised at submaximal workloads, the length of the exercise period should be at least four minutes, until respiratory and circulatory systems have time to adjust. The writer related that if a workload was too light, psychological factors could influence test results. Also, if the workload was too heavy, the subject would be less willing to cooperate, and certain physiological risks would become apparent.18

Rowell, Taylor, and Wang studied treadmill walking with four normal groups of men eighteen to twenty-four years of age. They predicted each subject's maximal oxygen uptake from his pulse rate and


oxygen uptake at a single submaximal workload, with an ambient temperature of 78 degrees Fahrenheit. They found that they underestimated their subjects' actual maximal oxygen uptake values. The authors concluded that at a submaximal workload the subject's pulse rate could vary independently of oxygen uptake, and could vary directly with his emotional state or degree of excitement. A submaximal load could also be affected by the subject's degree of conditioning, the amount of time passing between meals and testing, the amount of circulating hemoglobin, the degree of the subject's hydration, alterations in ambient temperature and hydrostatically induced changes resulting from prolonged erect posture.¹⁹

Glassford, et al., with the aid of twenty-four male subjects aged 17-33, tested three direct methods and one indirect method of measuring maximal oxygen uptake. The indirect test was the Astrand-Ryhming method; the direct measures were the Astrand bicycle ergometer test, the Mitchell, Sproule, and Chapman treadmill test, and the Taylor, Buskirk, and Henschel treadmill test. In addition, a physical fitness test devised by Johnson, Brouha, and Darling was given. The results of the tests showed no significant difference of mean values, but the direct treadmill tests, which employed more muscle mass, yielded higher maximal oxygen uptake values than Astrand's bicycle ergometer test.

It was concluded that the treadmill and bicycle ergometer results were probably not equivalent, due to local muscle fatigue. It appeared that the Astrand-Ryhming nomogram produced a good estimation of maximal oxygen uptake in a population unaccustomed to cycling.20

In a study directed by Astrand and Saltin, seven subjects performed maximal work of seven varying types. The first three categories employed the use of the bicycle ergometer. In the first type of exercise, the subject sat and pedaled the bicycle ergometer. In the second form of exercise he pedaled from a supine position. In the third type of work, the subject pedaled arm and leg ergometers simultaneously. The forth form of exercise was treadmill running, the fifth was snow skiing, the sixth was swimming, and the seventh was arm work (cranking) only. Maximal oxygen uptake increased a few percent in treadmill running, simultaneous arm and leg ergometry, skiing, and pedaling the bicycle ergometer from a sitting position. There was a 15 percent decrease in supine bicycle ergometer work over sitting bicycle ergometer work. Swimming also showed a decrease in maximal oxygen uptake, as did arm exercise only. It was concluded that aerobic capacity and maximal heart rate were the same for well-trained subjects in maximal running or cycling. It was noted further that the volume of oxygen consumed during physical exercise depends upon the load on

the muscle and the mass of the muscle at work. For this reason leg performance was better than arm performance alone, but both arm and leg performance together was better than leg performance alone. 21

Aerobic capacity of adolescents was the topic of a study by Knuttgen. He had ninety-five male and ninety-five female students, ages fifteen to eighteen, ride the bicycle ergometer until exhaustion. At rest, the males had higher values for oxygen consumption, ventilatory equivalent, and metabolism rate. Females had higher heart rates. When tested again at maximal work level, the males had higher values for oxygen consumption, metabolism rate, and heart rate. Females had higher values for ventilatory equivalent. It was noted that oxygen consumption increased with age only for males. Knuttgen concluded that body size was influential, because the males' means were higher than the females' means. It was also found that the emotional state of each subject, the relationship between eating and the time of testing, dehydration, loss of blood, and ambient temperature all had a detrimental effect upon the accuracy of the tests, and these factors should be controlled. 22

Wyndham, et al. tested four highly trained men on the bicycle ergometer. They concluded that maximal oxygen uptake and maximal


suddenly, and blood lactate levels increased. It was determined that such a test formed desirable results.25

Astrand noted that in youngsters just over twelve years of age, the maximum oxygen uptake for girls was 17 percent lower than the rates for boys. In the same study comparing adults, females were 29 percent lower than males. He further noted that maximal heart rates for men and women were nearly equal, but in submaximal work, women even trained subjects, had higher heart rates. Vital capacities of women were only 70 percent of men's vital capacities, but both sexes had the same ratio of residual volume to total capacity. The women had higher blood lactic acid values over the men subjects.26

Astrand also noted a study of aerobic activity. At fifty percent maximal oxygen uptake for six minutes of exercise, average heart rate for men was 128, while women's heart rates averaged 138. At seventy percent maximal oxygen uptake, men's heart rates were up to 154 and women's rose to 164. The mean maximal heart rate for men and women combined was 195, with a standard deviation of ten.27


26Per-Olof Astrand, "Human Physical Fitness with Special Reference to Sex and Age," Physiological Reviews, 36:312-313.

27Ibid., p. 326.
Metheny, et al. used male and female subjects for one study. The seventeen females were graduate students in health, physical education, and recreation, their ages ranging from twenty to twenty-seven. None were considered to be in training. There were thirty males ranging in age from nineteen to twenty-three. None of the men were athletes in training. All subjects were submitted to two different tests each day. First came a moderate exercise of walking on the treadmill for fifteen minutes at 3.5 miles per hour at an 8.6 percent grade. The strenuous exercise consisted of running on the treadmill at seven miles per hour at the same grade for five minutes or until exhaustion, whichever came first. Only nine subjects, all of whom were males, could complete the five-minute run. Heart rates were recorded on a Guillemin cardiotachometer. Blood pressure was determined with a sphygmomanometer and stethoscope. Oxygen consumption was measured by an open-circuit gasometer. Results of the walk showed that women had higher heart rates than the men, but their recovery rates were the same. Generally, the women were less fit. Results of the run showed that men and women had almost identical maximal heart rates, but women reached maximum sooner. Again, women were not as fit, and could last only half as long on the running test as men. 28

In another study by Astrand and Saltin, five subjects were tested during maximal work on the bicycle ergometer. After a ten-minute

warmup, each subject then rode for varying lengths of time between two and eight minutes, until exhaustion compelled him to stop. Maximal oxygen uptake, heart rate, ventilation, and blood lactic acid were all observed. Each subject's heart rate and maximal oxygen uptake peaked at nearly identical moments in the experiments. More rapid increases were noted when heavier workloads were set. It was determined that for studies of circulation and respiration during submaximal work, the exercise should last at least five minutes. 29

Thirty untrained young college women, ages seventeen to twenty-two, participated in a study of physical work capacity by Michael and Horvath. Each subject pedaled the bicycle ergometer at fifty revolutions per minute at a load of 300 kilogram meters per minute for one minute. The workload was increased 150 kilogram meters each succeeding minute until the subject could not maintain the cadence. Expired air was collected with a Tissot spirometer or a Douglas bag after the first minute of exercise. It was determined that the subjects who had lower heart rate levels had greater capacities for exercise. There was a lack of relationship between recovery heart rates and work capacity and work capacity following maximal work, however. The writers concluded that the subjects in the study were either more efficient at maximum

levels or else they were unable to push themselves to higher work levels.30

Ninety-five male athletes and thirty-eight female athletes from the Swedish national teams participated in a maximal oxygen uptake test conducted by Saltin and Astrand. The best score for males was 6.17 liters per minute, while the best female value was 3.6 liters per minute. The uptake scores were tabulated by sport or event in order to determine which athletes were able to utilize their cardiorespiratory systems to their utmost. All mean scores were recorded in ml/kg/min. The team order, from high to low, for the men's teams was as follows: cross country skiing, running 3000 meters, speed skating, orienteering, running 800 to 1500 meters, bicycling, biathlon, walking, canoeing, alpine skiing, running 400 meters, swimming, ski jumping, rowing, gymnastics, table tennis, fencing, wrestling, weight lifting, and untrained control group. Similar results were found with the members of the women's teams. The maximal oxygen uptake average for the men's ski team was 83 ml/kg/min. The average for the weight lifters was 56 ml/kg/min, and the average for the untrained group was 44 ml/kg/min. The women's ski team averaged 64 ml/kg/min, while the untrained women (housewives) averaged 39 ml/kg/min.31


In summary, numerous tests utilizing various types of apparatus and exercise have been devised to test cardiovascular efficiency. However, there seems to be no specific test which is universally accepted in experiments of cardiovascular efficiency. Both direct and indirect methods of testing, and maximal and submaximal workloads have favorable and unfavorable aspects. The literature also indicated that subjects themselves may influence test results. Thus, with numerous tests and their variations being reported, an investigator has a choice of measures available to fit a prescribed testing procedure.
CHAPTER III

METHODS AND PROCEDURES
Chapter III

Methods and Procedures

Source of the Data

Eighteen subjects were randomly selected from freshmen women volunteers from basic instruction classes in physical education for the 1969 spring semester at South Dakota State University. None of the subjects were involved in an intercollegiate sport or other conditioning program prior to or during the study. The subjects were randomly assigned to the three experimental groups by the "track pillbox" method. The treatments involved in the study were randomly assigned to each group. Table I, on the following page, summarizes the physical characteristics of the subjects and shows the groupings.

Organization of the Study

The study involved a six-week conditioning period, followed by a three-week deconditioning period. The subjects were tested before (Test I) and after (Test II) the six-week training period to determine the effects of the conditioning programs on cardiovascular efficiency. A third test (Test III) was administered nineteen to twenty-six days after Test II to measure the level of retention of fitness of all subjects.

For the conditioning program, the groups were randomly assigned to one of three treatments which differed only in length of time which each subject in the group exercised. Group A exercised on a
TABLE I
AGE, HEIGHT, AND WEIGHT OF THE SUBJECTS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>Group*</th>
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<td>J. B.</td>
<td>19</td>
<td>5'6&quot;</td>
<td>119</td>
<td>A</td>
</tr>
<tr>
<td>B. B.</td>
<td>19</td>
<td>5'3&quot;</td>
<td>120</td>
<td>C</td>
</tr>
<tr>
<td>D. H.</td>
<td>18</td>
<td>5'5&quot;</td>
<td>138</td>
<td>C</td>
</tr>
<tr>
<td>E. J.</td>
<td>18</td>
<td>5'4&quot;</td>
<td>120</td>
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<tr>
<td>M. P.</td>
<td>19</td>
<td>5'5&quot;</td>
<td>133</td>
<td>C</td>
</tr>
<tr>
<td>C. P.</td>
<td>19</td>
<td>5'8&quot;</td>
<td>129</td>
<td>A</td>
</tr>
<tr>
<td>S. R.</td>
<td>19</td>
<td>5'2&quot;</td>
<td>115</td>
<td>B</td>
</tr>
<tr>
<td>R. S.</td>
<td>19</td>
<td>5'6&quot;</td>
<td>142</td>
<td>A</td>
</tr>
<tr>
<td>J. W.</td>
<td>18</td>
<td>5'5&quot;</td>
<td>116</td>
<td>A</td>
</tr>
<tr>
<td>C. W.</td>
<td>19</td>
<td>5'3&quot;</td>
<td>115</td>
<td>C</td>
</tr>
</tbody>
</table>

Means 18.6 5'5" 125.3

* Group refers to the experimental group to which each subject was randomly assigned.
Monark bicycle ergometer for ten minutes each session, group B exercised on the bicycle ergometer for twenty minutes each session, and group C exercised on the bicycle ergometer for thirty minutes each session.

For the first minute of all exercise periods, the workload was set at three kilogram meters to cause a rapid increase in heart rate for all subjects. This was sufficient to cause the heart rate to rise to a rate which approximated the training rate. Subjects in each group then exercised at eighty percent maximal heart rate for the allotted time. It was assumed the maximal heart rate for all subjects was 180 beats per minute, thus making the assumed rate of eighty percent maximal heart rate that of 144 beats per minute.

The training period continued for six weeks with three sessions per week. At the end of the six-week period, the post-tests were administered.

Collection of the Data

Two tests served as the criterion measures. One of the tests was a measure of predicted maximal oxygen uptake, devised by Astrand. The second test was the measurement of physical work capacity.

Astrand Test of Predicted Maximal Oxygen Uptake. Each subject rode the bicycle ergometer for six minutes at a constant submaximal load of one and one-half kilograms and at a pedal frequency

---

of fifty revolutions per minute. Pedal frequency was maintained by using a metronome. Each subject's heart rate was checked with a stethoscope and recorded the last fifteen seconds of each minute. An average of the last two minutes was used to predict the subject's maximal oxygen uptake in liters per minute. The maximal oxygen uptake was then recorded in milliliters per kilogram of body weight per minute (ml/kg/min) on the basis of each subject's weight.

**Physical Work Capacity Test.** The cardiovascular test consisted of a bicycle ergometer test in which the subject initiated exercise at a workload of zero kilograms. This workload increased at the rate of one-half kilogram each minute thereafter until the heart rate reached 170 beats per minute. The subject maintained a pedaling rate of fifty revolutions per minute throughout the test.

A six channel physiograph, manufactured by the E and M Instrument Company, was used throughout the test to record the subject's heart rate. Three electrodes were placed on each subject for this purpose. Two were placed on the subject's rib cage, one on either side, and the third, placed on the back of the neck, acted as a ground. A cardiotachometer, part of the physiograph itself, was used to approximate the subject's heart rate throughout the test, but the actual measure was obtained by counting the distance between the recorded R waves for fifteen seconds.

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CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS
CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

The results of this study and their implications are found in this chapter.

Organization of the Data for Analysis

The data were organized so that physiological changes of the subjects as a group were of primary concern. The subjects were divided into three groups of six each for the study. Individual scores were not appraised per se, as this writer was concerned only with results between and within groups.

A t ratio was computed to determine the significance of the differences occurring within each group for Test I and Test II, and Test II and Test III.\(^3\) A one-tailed test of significance was used to test the directional hypothesis. The significance of the differences among the groups was studied by using the F test for completely randomized designs, as described by Bruning and Kintz.\(^3\) A two-tailed test of significance was used to test the null hypothesis. The .05 level was accepted as the minimal level of confidence needed in order


to have a significant difference.

Analysis of the Data

Table II shows the mean changes within each group for physical work capacity from Test I to Test II, the difference between the two means, the standard error of the difference, the degrees of freedom, and the $t$ ratio. The mean scores for group A increased 24 seconds from Test I to Test II. This increase was significant at the .05 level of confidence. The increase of 50 seconds in group B from Test I to Test II was significant beyond the .01 level of confidence. Finally, group C increased 35 seconds from Test I to Test II. This increase was significant at the .05 level of confidence.

### TABLE II

<table>
<thead>
<tr>
<th>GROUP*</th>
<th>MEANS (seconds)</th>
<th>$t$**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TEST I</td>
<td>TEST II</td>
</tr>
<tr>
<td>A</td>
<td>350</td>
<td>374</td>
</tr>
<tr>
<td>B</td>
<td>378</td>
<td>428</td>
</tr>
<tr>
<td>C</td>
<td>352</td>
<td>387</td>
</tr>
</tbody>
</table>

*Group A exercised for 10 minutes 3 days per week.
Group B exercised for 20 minutes 3 days per week.
Group C exercised for 30 minutes 3 days per week.

**For a one-tailed test, $t_{.05}^{(5)} = 2.02$, and $t_{.01}^{(5)} = 3.37$.
For a one-tailed test, $t_{.05}^{(4)} = 2.13$, and $t_{.01}^{(4)} = 3.75$.  

Table III shows the significance of the changes within groups from Test I to Test II in the predicted maximal oxygen uptake test. The mean scores for group A increased 5 milliliters per kilogram of body weight per minute (ml/kg/min) from Test I to Test II. This increase was significant at the .01 level of confidence. The increase of 5 ml/kg/min for group B was not significant at the .05 level. Group C had an increase of 8 ml/kg/min, which was significant beyond the .05 level of confidence.

**TABLE III**

CHANGES WITHIN GROUPS FOR PREDICTED MAXIMAL OXYGEN UPTAKE BETWEEN TEST I AND TEST II

<table>
<thead>
<tr>
<th>GROUP*</th>
<th>MEANS (ml/kg/min)</th>
<th>d</th>
<th>SEd</th>
<th>df</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TEST I</td>
<td>TEST II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>36</td>
<td>41</td>
<td>5</td>
<td>1.32</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>38</td>
<td>43</td>
<td>5</td>
<td>3.12</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>38</td>
<td>46</td>
<td>8</td>
<td>2.55</td>
<td>5</td>
</tr>
</tbody>
</table>

*Group A exercised for 10 minutes 3 days per week.
Group B exercised for 20 minutes 3 days per week.
Group C exercised for 30 minutes 3 days per week.

**For a one-tailed test, t .05 (5) = 2.02, and t .01 (5) = 3.37.
For a one-tailed test, t .05 (4) = 2.13, and t .01 (4) = 3.75.
Table IV indicates the results of the $t$ ratio within each group for the test of physical work capacity between Test II and Test III. Group A had a difference of one second between Test II and Test III, which was not a significant figure. Group B had a difference of 21 seconds, which also was not significant. Group C indicated a difference of 25 seconds. Again, this figure was not significant at the .05 level of confidence.

**TABLE IV**

CHANGES WITHIN GROUPS FOR PHYSICAL WORK CAPACITY BETWEEN TEST II AND TEST III

<table>
<thead>
<tr>
<th>GROUP*</th>
<th>MEANS (seconds)</th>
<th>$d$</th>
<th>$SE_d$</th>
<th>df</th>
<th>$t^{**}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TEST II</td>
<td>TEST III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>374</td>
<td>373</td>
<td>-1</td>
<td>4.72</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>428</td>
<td>407</td>
<td>-21</td>
<td>16.28</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>387</td>
<td>362</td>
<td>-25</td>
<td>14.29</td>
<td>5</td>
</tr>
</tbody>
</table>

*Group A exercised for 10 minutes 3 days per week.
Group B exercised for 20 minutes 3 days per week.
Group C exercised for 30 minutes 3 days per week.

**For a two-tailed test, $t_{.05}(5) = 2.57$, and $t_{.01}(5) = 4.03$.**

**For a two-tailed test, $t_{.05}(4) = 2.78$, and $t_{.01}(4) = 4.61$.**
Table V indicates the changes within groups from Test II to Test III in levels of predicted maximal oxygen uptake. Group A had a difference of 2 ml/kg/min, which was not sufficient to show any significance. Group B had a difference of 2 ml/kg/min, which, again, was not a significant figure at the .05 level of confidence. Group C showed a difference of 5 ml/kg/min. This was not a significant difference at the .05 level of confidence.

**TABLE V**

<table>
<thead>
<tr>
<th>GROUP*</th>
<th>MEANS (ml/kg/min)</th>
<th>d</th>
<th>SE$_d$</th>
<th>df</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TEST II</td>
<td>TEST III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>41</td>
<td>43</td>
<td>2</td>
<td>3.86</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>45</td>
<td>2</td>
<td>3.19</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>46</td>
<td>41</td>
<td>-5</td>
<td>3.10</td>
<td>5</td>
</tr>
</tbody>
</table>

*Group A exercised for 10 minutes 3 days per week.
Group B exercised for 20 minutes 3 days per week.
Group C exercised for 30 minutes 3 days per week.

**For a two-tailed test, t .05 (5) = 2.57, and t .01 (5) = 4.03.**
For a two-tailed test, t .05 (4) = 2.78, and t .01 (4) = 4.61.
The comparison of the changes among groups for the physical work capacity test from Test I to Test II are shown in Table VI. There was no significant difference among the group changes, as indicated by an F of 1.43.

**TABLE VI**

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>df</th>
<th>ms</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>11493</td>
<td>17</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>1837</td>
<td>2</td>
<td>918.5</td>
<td>1.43</td>
</tr>
<tr>
<td>Within Groups</td>
<td>9656</td>
<td>15</td>
<td>643.7</td>
<td></td>
</tr>
</tbody>
</table>

*F* (.05(2/15) = 3.68.

Table VII shows the comparison of the changes among groups for the predicted maximal oxygen uptake test from Test I to Test II. The F was equal to 1.07, which indicated no significant difference among the group changes.

**TABLE VII**

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>df</th>
<th>ms</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>480</td>
<td>17</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>60</td>
<td>2</td>
<td>30</td>
<td>1.07</td>
</tr>
<tr>
<td>Within Groups</td>
<td>420</td>
<td>15</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

*F* (.05(2/15) = 3.68.
Summary and Discussion of Results

All three groups showed significant gains in physical work capacity between Test I and Test II. Group A and group C showed significant improvements beyond the .05 level of confidence, whereas group B improved beyond the .01 level of confidence. Group A and group C also showed significant gains in predicted maximal oxygen uptake between Test I and Test II; however, group B did not show any significant improvement.

No significant differences were found to occur among the groups between Test II and Test III for either the physical work capacity test or the predicted maximal oxygen uptake test. This indicated that for at least three weeks all groups retained the cardiovascular efficiency improvements that resulted from the conditioning programs.

The results of the analysis of variance tests comparing the changes among the groups indicated that there was no significant difference among the groups for both the physical work capacity test and the predicted maximal oxygen uptake test from Test I to Test II. Therefore, no treatment was better than the other treatments.

The training period caused significant improvements in the subject's cardiovascular efficiency. This was consistent with most findings and reports, which indicate that cardiovascular efficiency
can be improved as a result of training.\textsuperscript{36, 37, 38, 39}

The investigator found that a three day per week training period was sufficient to increase the subject's cardiovascular efficiency, as did Gettman\textsuperscript{40} and Stern.\textsuperscript{41} The subjects did not lose a significant amount of cardiovascular efficiency between Test II and Test III. This corresponded with Walters' observations that it took between two and five weeks for the regression rate to be significant.\textsuperscript{42}

Subjects in this study trained at the pulse rate of 144 beats per minute. Test results indicated improvement in cardiovascular efficiency during this period. These results were in accordance with figures recorded by Hollman and Vonrath in a study by Roskamm, stating


\textsuperscript{42} Walters, \textit{op. cit.}, pp. 109-110.
that if the subjects' heart rates exceeded 130 beats per minute, there would be increases in cardiovascular efficiency for the subjects. Karvonen, however, trained subjects one-half hour daily at a heart rate of 135 beats per minute for four weeks, and the subjects showed no improvement. Subjects did improve when a constant heart rate of 150 was maintained.\textsuperscript{43} Cooper set a minimal figure of 150 beats per minute in order to improve cardiovascular efficiency.\textsuperscript{44} Sharkey and Holleman, in a study of training with various constant heart rates, found that the group maintaining 180 beats per minute significantly improved over all other groups in cardiovascular efficiency. The group maintaining 150 beats per minute was significantly different from the group maintaining 120 beats per minute.\textsuperscript{45}

All training times of ten, twenty, and thirty minutes were sufficient to increase the workload placed upon the human body. Astrand and Saltin\textsuperscript{46} recommended and Roskamm\textsuperscript{47} indicated through testing that submaximal exercises should last for thirty minutes.

\begin{itemize}
\item \textsuperscript{43}Roskamm, \textit{op. cit.}, p. 895.
\item \textsuperscript{44}Kenneth H. Cooper, \textit{Aerobics} (New York: M. Evans and Company, Inc., 1968), p. 23.
\item \textsuperscript{45}Brian J. Sharkey and John P. Holleman, "Cardiorespiratory Adaptations to Training at Specified Intensities," \textit{Research Quarterly}, 38:698-703, December, 1967.
\item \textsuperscript{46}Per-Olof Astrand and Bengt Saltin, "Oxygen Uptake During the First Minutes of Heavy Muscular Exercise," \textit{Journal of Applied Physiology}, 16:971, November, 1961.
\item \textsuperscript{47}Roskamm, \textit{op. cit.}, pp. 895, 897.
\end{itemize}
Brynteson found significant results in a study involving thirty-minute training sessions. On the other hand, Durnin, Brockway, and Whitcher found significant results with training periods of ten, twenty, and thirty minutes in duration. Sharkey and Holleman found that ten minutes of exercise three days per week would lead to significant improvements in cardiovascular efficiency.

Physiological factors, such as emotions, food intake, amount of sleep, and time of the test may have had effects upon the results of this study, as Davies, Taylor, and Rowell observed in their studies. The investigator felt that the test of predicted maximal oxygen uptake would have been more accurate if stricter control over the subjects had been possible, and perhaps the differences between Test II and Test III would have been more meaningful.


50 Sharkey and Holleman, op. cit., p. 968.


As a result of the findings of this study, both hypotheses were retained. The hypotheses are stated as follows:

1. There is an improvement in cardiovascular efficiency whether subjects train ten, twenty, or thirty minutes per day, three days per week.

2. There is no significant difference among the three groups in the development of cardiovascular efficiency.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the effects of three selected training time periods upon the development of cardiovascular efficiency of college women. Eighteen freshmen volunteers from the physical education basic instruction program for the 1969 spring semester at South Dakota State University were selected to participate in this study. The subjects were assigned to the three experimental groups by the track pillbox method. The treatments involved in the study were randomly assigned to each group.

The study involved a six-week conditioning period followed by a three-week deconditioning period. The subjects were tested before (Test I) and after (Test II) the six-week training period to determine the effects of the conditioning programs on cardiovascular efficiency. A third test (Test III) was administered nineteen to twenty-six days after Test II to measure the level of retention of fitness of all subjects.

For the conditioning program, the groups were randomly assigned to three treatments which differed only in the length of time which each subject in the group exercised. Group A exercised on the bicycle ergometer for ten minutes each session, group B exercised on the bicycle ergometer for twenty minutes each session, and group C exercised on the bicycle ergometer for thirty minutes each session.
For the first minute of all exercise periods, the workload was set at three kilograms to cause a rapid increase in heart rate for all subjects. This was sufficient to cause the heart rate to rise to a rate which approximated the training rate. Subjects in each group then exercised at eighty percent maximal heart rate for the allotted time. It was assumed that maximal heart rate for all subjects was 180 beats per minute; therefore, the training rate was established as 144 beats per minute.

The training period continued for six weeks at three sessions per week. At the end of the six-week period, the post-tests were administered.

Two bicycle ergometer tests served as the criterion measures. One of the tests was a measure of predicted maximal oxygen uptake, devised by Astrand. The second test was the measurement of physical work capacity and was measured by the time it took the subject's heart to reach 170 beats per minute while pedaling against increasing workloads.

A t ratio was computed to determine the significance of the differences occurring within each group for Test I and Test II, and Test II and Test III. A one-tailed test of significance was used to test the directional hypothesis. The significance of the differences among the groups was studied by using the F test for completely randomized designs. A two-tailed test of significance was used to test the null hypothesis. The .05 level was accepted as the minimal level of confidence needed in order to have a significant difference.
All three groups showed significant gains in physical work capacity between Test I and Test II. Group A and group C showed significant improvements beyond the .05 level of confidence, and group B improved beyond the .01 level of confidence. Group A and group C also showed significant gains in predicted maximal oxygen uptake between Test I and Test II; however, group B did not show any significant improvement.

No significant differences were found to occur among any of the groups between Test II and Test III for either the physical work capacity test or the predicted maximal oxygen uptake test. This indicated that for at least three weeks all groups retained the cardiovascular efficiency improvements that resulted from the conditioning programs.

The results of the analysis of variance tests comparing the changes among the groups indicated that there was no significant difference among the groups for both the physical work capacity test and the predicted maximal oxygen uptake test from Tests I to Test II. Therefore, no treatment was better than the other treatments.

Conclusions

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

1. Physical exercise significantly improved the subjects' cardiovascular efficiency.
2. There was no significant difference among training treatments of varying times.

3. Cardiovascular efficiency was retained at least three weeks after the training program ceased.

Recommendations

The following recommendations for further study are listed:

1. A similar study be undertaken in which the training period is extended for a longer period of time.

2. An identical study be pursued utilizing more subjects to validate these results.

3. A study, or studies, utilizing lower training heart rates and/or training fewer times or minutes each week be devised.

4. A similar study be undertaken employing running as the physical activity.
BIBLIOGRAPHY

A. BOOKS


B. PERIODICALS


C. UNPUBLISHED MATERIALS


APPENDIX
APPENDIX

RECORDINGS OF THE THREE TRIALS INDICATING PHYSICAL WORK CAPACITY LEVELS IN SECONDS

<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>JB</td>
<td>A</td>
<td>412</td>
<td>397</td>
<td>400</td>
</tr>
<tr>
<td>JLm</td>
<td>A</td>
<td>355</td>
<td>384</td>
<td>395</td>
</tr>
<tr>
<td>LM</td>
<td>A</td>
<td>288</td>
<td>332</td>
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<td>A</td>
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<td>RS</td>
<td>A</td>
<td>393</td>
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<td>JW</td>
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<td>315</td>
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<td>379</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>350</td>
<td>374</td>
<td>373</td>
</tr>
</tbody>
</table>

|        |       |      |      |      |
| EJ     | B     | 355  | 387  | 413  |
| AJ     | B     | 414  | 482  | 471  |
| KK     | B     | 357  | 401  | 362  |
| EL     | B     | 417  | 470  | 409  |
| JLi    | B     | 349  | 398  | 379  |
| SR     | B     | 312  | 359  | 409  |
| Mean   |       | 378  | 428  | 407  |

|        |       |      |      |      |
| BB     | C     | 418  | 456  | 437  |
| DH     | C     | 304  | 306  | 270  |
| RM     | C     | 327  | 386  | 365  |
| NN     | C     | 363  | 450  | 378  |
| MP     | C     | 328  | 332  | 368  |
| CW     | C     | 372  | 391  | 355  |
| Mean   |       | 352  | 387  | 362  |

Total Mean | 360   | 396.3 | 380.67 |
## Recordings of the Three Trials Indicating Predicted Maximal Oxygen Uptake Levels in ML/KG/Min

<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>JB</td>
<td>A</td>
<td>42</td>
<td>42</td>
<td>44</td>
</tr>
<tr>
<td>JLa</td>
<td>A</td>
<td>36</td>
<td>41</td>
<td>55</td>
</tr>
<tr>
<td>LM</td>
<td>A</td>
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<td>38</td>
<td>51</td>
</tr>
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<td>A</td>
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<td>31</td>
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<td>RS</td>
<td>A</td>
<td>34</td>
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<td>39</td>
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<tr>
<td>JW</td>
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<tr>
<td>NN</td>
<td>C</td>
<td>36</td>
<td>44</td>
<td>39</td>
</tr>
<tr>
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