AN INVESTIGATION OF THE EFFECTS OF

TWO TRAINING PROGRAMS ON SELECTED CARDIO-RESPIRATORY

VARIABLES OF COLLEGE WOMEN

by

Louise Chloe King

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Approved by

Rosemary McGee
Director

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at the Woman's College of the University of North Carolina, Greensboro, North Carolina.

Rosemary McGee
Thesis Adviser

Oral Examination Committee Members

Eileen Griffin

Gail M. Hennis

Anna Joyce Reardon

July 18, 1962
Date of Examination

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CHAPTER I

INTRODUCTION

The total fitness of an individual should be the aim of every physical educator. Physical fitness, in particular, has been emphasized as an accepted objective of physical education throughout its history[2]. Only through exercise and training can one's fitness level be raised.

Extensive research has been conducted using various types and methods of training to improve levels of fitness. According to Morehouse and Miller[15], the method of training should be related to the dominant feature of the event. The training in this study stressed endurance as the primary factor being developed. Endurance may be defined as "the ability to continue work."[16:26] In order to increase the capacity of the individual to continue work, the theory of overload was practiced. This advocates developing the individual by increasing the intensity of the activity. Morehouse and Rasch state that endurance is limited by two factors: "the willingness to work on in spite of the pain of fatigue, and the capacity of the homeostatic mechanism to make rapid and extensive adjustments within the functioning organism."[16:26] In light of the latter of these two limiting factors, the cardio-respiratory functions were studied to observe the effects of the training upon the body.

In order to clarify the measured variables, a brief definition of the functions of each of the two systems follows:

Cardiovascular: The function of the blood flow through a system of arteries, capillaries, and veins in order to provide fuel and oxygen and remove waste products, water, and carbon dioxide.[13:45]

Respiration: The function of the blood and lung tissues in the exchange of gases (oxygen and carbon dioxide) between the air in the alveoli and the capillary tissues, and the exchange between the tissue cells and the blood in the capillaries throughout the body. The oxygen-carrying power of the blood is determined by the number and size of the red blood corpuscles.[13:46]

In the college situation, many women propel themselves around the campus on bicycles; many women also have occasion to hurry by running across campus. The prevalence of students using bicycles is ever-increasing as the demands of college life leave less and less time between appointments for most college students. The number of each student's daily commitments necessitates hurrying around the campus most of the day. Whether one rides or runs, "hurry" is a common by-word on any campus. All students need to be fit in order to maintain this rapid pace of living. With these two activities in mind, this study was conducted to investigate the effects of training by bicycling and running on cardio-respiratory variables.

It has been said that in order to develop endurance, one must run[5]. This interested the experimenter sufficiently to cause her to want to compare the effects of bicycling and running as related to the cardiovascular and respiratory systems. Thus, this study was designed for the purpose of ascertaining the effects a training program would have on college women in regard to changes in pulse rate, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption at base level and post-exercise. The training program consisted either of running on a specific course five times a week for four weeks, or riding bicycles on a specific course five times a week for four weeks. The study also attempted to determine which of the two programs would bring about the greatest degree of change in these physiological variables.

CHAPTER II

STATEMENT OF PROBLEM

The primary purpose of this study was to determine what effects two different training programs had on the cardio-respiratory systems of college women. The programs were identical in duration and frequency of exercise, but the activities differed. The two activities were riding bicycles and running. Pulse rate, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption were recorded at base level and after exercise both before and after the four-week training program.

The statistical results obtained from the measures taken were used to indicate whether or not one type of training was more effective than the other in increasing the efficiency of the cardio-respiratory systems at base level and after exercise as measured by the Harvard Step Test.

The study also attempted to determine whether or not either or both of the training programs of four weeks was of sufficient duration to cause significant changes in the variables measured.

CHAPTER III

REVIEW OF LITERATURE

Training and conditioning programs are essential to achieving success in athletic performance as well as to improving one's total fitness. This study was concerned with cardio-respiratory fitness. Two training programs were conducted for four weeks in order to see the effects of these methods of conditioning upon the cardio-respiratory efficiency of college women. In order to establish a training program and to select the measurements and tests to be used, an investigation of the research in the following areas was made: total physical fitness, cardio-respiratory efficiency and endurance, cardiovascular tests, respiratory variables and measurements, work load, and training programs.

TOTAL PHYSICAL FITNESS

Cureton defines physical fitness as follows:

> Physical fitness is one phase of total fitness which is characterized by absence from disease, the ability to handle the body well, and the capacity to work hard over a long period of time without diminishing efficiency.[7:18]

Willgoose defines physical fitness as "the capacity for activity."[22:16] As Bainbridge[1] explains, regular physical exercise, or training, creates greater strength and efficiency of the body as a whole. He goes on to say, that the two largest developments are those of the muscular system as a whole, and more especially of those muscles employed in the form of exercise; the other is an increase in the range and delicacy of the adjustments of the circulatory and respiratory systems whereby the supply of oxygen to the body is assured.

CARDIO-RESPIRATORY EFFICIENCY AND ENDURANCE

Cardio-respiratory fitness, in particular, implies the optimum adaptability to do and recover rapidly and completely from hard work. When discussing cardio-respiratory efficiency, Willgoose[22] states that with training there is an increase in the total cardiac output, a slower rate of breathing is assumed and a corresponding economy of respiration. When both fit and unfit performers execute the same exhausting amount of work which neither can sustain in a steady state, the fit man shows the following: (1) longer duration of effort before exhaustion; (2) higher oxygen consumption; (3) slower maximal heart rate; (4) larger stroke volume; (5) higher blood lactate; (6) and faster return of blood pressure and heart rate to normal after work, according to Morehouse and Miller [15].

Morehouse and Rasch state that "endurance is the ability to continue work."[16:26] Those authors also report that endurance is limited by two factors: (1) the willingness to do work in spite of the pain of fatigue; (2) "the capacity of the homeostatic mechanism to make rapid and extensive adjustments with its functioning organism."[16:26] Fitness for endurance activities, according to Larson and Yocum, is largely determined by "the ratio of the amount of blood circulated per minute to the oxygen requirements of the body."[13:160]

Karpovitch states that endurance develops gradually and time is necessary for reaching a maximum efficiency[44]. The time depends upon three factors which are the type of exercise, its relative difficulty, and the frequency and duration of practice. The same author reports that the obvious reason why a capacity for endurance reflects the degree of physical fitness is that endurance depends upon "the ability to counteract the accumulation of fatigue products; an ample store of fuel; an adequate oxygen supply; and the stability of the physio-chemical state of the organs and tissues."[44:421]

The differences between an athlete and a person of poor endurance are most striking during vigorous exercise. Morehouse and Miller[15] explain that an athlete with greater endurance is able to withstand high levels of lactic acid, to use larger volumes of oxygen, to have a lower heart rate during prolonged work, to have the heart rate and lactic acid concentration return to normal more quickly.

Cureton defined endurance as:

> ...representing the integrated results of skillful coordination, will power, mechanical precision and durability of the neuro-muscular and circulatory mechanisms in the continuous performance of any motor stunt for the longest period or greatest number of times.[6:425]

Holmes defined endurance as "the capacity of the individual for long-continued sub-maximal contractions where a sufficient number of muscle groups are used with a sufficient duration and intensity to put a demand on circulatory and respiratory functions."[62:11] Cardio-respiratory endurance, according to Willgoose[22], is a kind of physiological fitness demonstrated through an adjustment of the heart and lungs to prolonged physical exertion.

In his weight training study, Capen[28] reported that cardio-respiratory endurance may be increased by increasing the strength and muscular endurance of the muscles concerned and by improving, by hypertrophy, the increased capillary supply, the strength and muscular endurance of the heart itself.

Sufficient evidence has shown that the fit individual possesses the following, in relation to circulatory-respiratory endurance: (a) a larger minute volume; (b) a slower pulse rate; (c) lower blood pressure; (d) a larger surface area in the lungs; (e) a larger supply of red blood corpuscles and hemoglobin.

Significance of Pulse Rate

According to Cureton[7], Bowen was the first physical educator to study the pulse rate systematically as related to exercise and physical fitness. According to Schneider and Crampton[55], Bowen concluded that "the pulse rate is due to: (1) the speed of the exercise, (2) the effort in the exercise, (3) the physiological condition of the subject, (4) the age, and (5) the postural and mental state of the subject."[55:579]

A slower resting pulse is characteristic of a well-conditioned athlete. It has been reported by Schneider[19], Carlson and Johnson[4], Sloan and Keen[58], Brassfield[24], Dawson[34], Knehr, Dill, and Neufeld[46], Gemmill, Booth, Detrick, Schiebel[40], Guyton[10], Larson[48], and Henry[43] that a lowered resting heart rate is one effect of conditioning on the cardiovascular system. Gould and Dye[9] state that the resting pulse of a trained individual may be from five to thirty beats slower than in untrained individuals.

Cureton gives the following physiological meaning of pulse rate:

> The pulse rate tests make the easiest and simplest way to check circulatory-respiratory fitness. Pulse rate does not represent a complete test of circulatory fitness but the pulse is the easiest to measure and is the most reliable of the physiological variables which reflect the internal bodily efficiency in response to exercise. Within modern limits of exercise the pulse rate response to exercise practically parallels the total oxygen cost of the work and the minute volume of the heart. The recuperation time of the pulse to return to normal approximately parallels the circulatory-respiratory efficiency to buffer the fatigue products in the blood after exercise and to restore normality.[7:162]

Although much research has revealed that the resting pulse rate is slower as a result of training, Tuttle and Walker[61] found that there was no significant change in resting heart rate in high school boys after a season of competition and training in track. Elbel, Reid, and Ormond[36] found the same to be true in their study.

Another fundamental difference between trained and untrained individuals is that, for a particular task, the heart of a trained man pumps more blood per minute with fewer strokes than does that of the untrained man[24]. Carlson and Johnson[4], Bainbridge[1], Gemmill, Booth, and Pocock[41], Gould and Dye[9], and Taylor[59] all reported that during physical exercise for which the individual is trained, the pulse rate is increased relatively less and returns to normal earlier after exercise than in an untrained individual. This also holds true, but to a smaller extent, in an activity for which the individual is not trained.[9]

The significance of the recovery of the pulse rate after exercise has been investigated extensively. Tuttle and Walker[61] reported that the recovery pulse was less after training, indicating that there was some improvement in physical condition, as shown by the fact that fewer heart beats were required in reaching the resting level. According to Cogswell, Henderson, and Berryman[31], in submaximal exercise the post-exercise pulse ratio showed a decrease with training, on the step test.

Elbel and Holmer[35] reported that there is no significant relationship between the resting pulse rate and recovery time at any intensity of exercise. However, Schneider[19] and Larson[48] found that the circulatory system of the trained individual shows a more rapid return to the pre-exercise level than does the one possessed by the person not regularly engaged in vigorous activity.

Knehr, Dill and Neufeld[46] reported that individuals in condition show a more rapid pulse recovery after exercise than individuals not so conditioned. However, they also found that "when complete exhaustion is reached in a given time, the rate of work varying, the pulse recovery curve remains unaffected by training."(46:155)

CARDIOVASCULAR TESTS

There are two methods of testing cardio-respiratory function. One method involves the use of laboratory tests such as oxygen consumption, minute volume of respiration, carbon dioxide determination, and blood composition. A second method is that using non-laboratory tests which can be administered to large numbers of individuals by examination. The latter requires no technical training in laboratory techniques and includes such tests as pulse rate, blood pressure, breath holding, and vital capacity(13). The non-laboratory, functional tests can be measured either by motor performance tests, such as running for a long distance, or by measuring the circulatory and respiratory systems at rest, during, and after exercise reactions. The latter is preferable if time permits, since it yields information concerning the physiological characteristics of the individual (13).

Barach's Energy Index

The Barach Test was used to determine the amount of energy the heart expends in blood output(23). The measurements used are the systolic and diastolic pressure and the pulse rate per minute in a sitting position. Thus, the Energy Index is computed with the following formula:

$$\frac{\text{systolic pressure} + \text{diastolic pressure} \times \text{pulse rate}}{100}$$

Cameron Heartometer

A second test of cardiovascular condition is that using the Cameron Heartometer(6). This records the pulsations of the brachial artery transmitted by the blood pressure apparatus of the sphygmomanometer type. The Heartometer was validated against endurance items, and is a good indicator of present cardiovascular condition and relative amounts of fatigue. However, this machine is too complicated to use in schools, and experience is needed to analyze and interpret scores(22).

Crampton Blood Ptosis Test

The Crampton Blood Ptosis Test was one of the earliest cardiovascular tests(22). Crampton's objective was "to find a test of general physical condition that could be used in growth and development studies of youth."(33:529) The factors measured are: reclining pulse rate, reclining systolic blood pressure, standing pulse rate, and systolic blood pressure in standing position. The Crampton test seems to be a most useful measure for evaluating hospital patients in an extremely low state of physical fitness(33).

Foster Test

The basic premise in Foster's Test is that the "heart rate increases in proportion to physical exercise."(37:633) Also, that the pulse recovery rate is indicative of the subject's physical condition. The test consists of recording the pulse rate per minute while the subject is standing, then the subject runs in place for thirty seconds at a rate of one hundred eighty steps per minute. Immediately following this, the pulse rate is taken for five seconds and multiplied by twelve to give a rate per minute. The subject continues to stand at ease for forty-five seconds, at the end of which the pulse is counted again[37]. Foster states that "our purpose here is to suggest a test based on pulse rate, which we believe has the advantage of being simple, fairly accurate and positive and requiring only the use of a stop watch and the ability on the part of the observer to record the pulse accurately."[37:635] This test is weak in reliability, according to Willgoose[22], as it is not standardized thoroughly.

McCurdy and Larson Organic Efficiency Test

McCurdy and Larson[49] devised a test for college men to estimate the functional efficiency of the cardio-respiratory systems. The items included were sitting diastolic pressure, breath-holding for twenty seconds after the standard stair-climbing exercise, the difference between standing normal pulse rate and pulse rate two minutes after exercise, sitting pulse pressure, and standing pulse pressure[49]. At a later date, Larson[47] shortened that battery to three items which were sitting diastolic pressure, breath-holding after exercise, and standing pulse pressure.

Schneider Test

The cardiovascular index of Schneider remains one of the most used measures of physical condition[22]. The measurements include the pulse rate and blood pressure in the horizontal and standing positions, plus the recovery ability of the pulse rate after exercise[52]. Schneider made the following comment regarding the test:

> A performance test requires the subject to do something in which the amount and character of the work is regarded as the measure of fitness. These should be abandoned since none of them yields results that do not require interpretation and correction for interfering factors, such as knack, practice, alertness, interest, willingness to undergo discomfort and effort, cooperation and incentive.[54:146]

This test is a mild test of circulatory efficiency, which discriminates into large categories only. Therefore, it is not usable in differentiating between individuals at various levels from good to excellent physical condition.

Tuttle Pulse Ratio Test

The Tuttle Pulse Ratio Test was constructed for the purpose of considering the relationship of the resting pulse and the post-exercise pulse rate[60]. The pulse ratio represents the ratio of the resting pulse rate to the rate after exercise. This ratio is found by dividing the total pulse for two minutes, after a known amount of exercise, by the normal resting pulse for one minute[60]. The index is calculated from the following formula:

$$\frac{100 \times \text{number of steps obtained for 2.5 pulse ratio}}{50}$$

Willgoose[22] states that considerable research has been done, using the Tuttle Pulse Ratio, to substantiate the fact that the test is especially useful as a screening instrument to supplement the thorough physical examination.

Woodall Test

In 1959, Woodall[64] constructed a cardiovascular test to measure the physical fitness of girls. This was a test which consisted of running on a running board for thirty seconds at a pace set by an electric metronome. The reclining pulse rate was recorded before running, and the pulse rate was counted immediately after exercise for fifteen seconds. The subject then reclined on a cot to rest. The pulse rate was recorded again for fifteen seconds at thirty second intervals for two minutes. The pre-exercise resting pulse rate was subtracted from the post-exercise resting rate taken thirty seconds after exercise. The lower the difference, the better the cardiovascular condition of the subject.

Harvard Step Test

During World War II, Brouha and colleagues developed a test in the Harvard Fatigue Laboratories "to measure the general capacity of the body to adapt itself to hard work and to recover from what it had done."[25:31] This test is considered to be useful in separating college men into various levels of fitness. Training, or the absence of training, is also shown in the score achieved on this test. The Harvard Step Test was originally validated against the criterion of a work index which was based upon three factors of endurance: (1) treadmill running, (2) maximum heart rate per minute, and (3) blood lactate level. In explaining the Harvard Step Test, Brouha made the following statement:

> A satisfactory estimate of a man's fitness can be obtained by exposing him to a standard exercise that no one can perform in '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. For this purpose any type of exercise can be used provided that each subject works at a constant rate proportional to his body weight, that the exercise requires no unusual skill, and that the exercise puts the cardiovascular and the respiratory systems under real stress by involving large muscle groups.[(25:31)]

Brouha experimented with various types of tests in order to develop one in which the physiological reactions were such that muscular work could be measured. He found that reactions to moderate work were unreliable because the easier the work, the less clear cut were the differences between fit and unfit subjects[(25)]. As a result of Brouha's original study, using the step test with Harvard freshmen, the following observations were made: (a) the test picked out the best, the average, and the worst in the group of unknown subjects; (b) the comparison of scores in June with those in September indicated the effects of training; (c) men who had been excused from regular exercise because of illness deteriorated during the period from September to June, as indicated by their second score; (d) progress made by the low group was greater than that made by the good group, which indicated that the training program was adequate for the unfit but not hard enough for many of the fit men[(25)]. Brouha reported, too, that this type of test was the only one which was described for measuring general physical fitness for hard work in normal, healthy men[25]. The other tests (eg. Schneider, McCurdy and Larson) are useful in detecting various failures of the circulatory system, but they are not always reliable for assessing hard work in healthy individuals. There is little correlation between those tests' scores and the Harvard Step Test Index[25].

The only measurement recorded in the Harvard Step Test is the pulse rate on the deceleration after exercise. The pulse is counted for thirty second periods at one to one-and-a-half, two to two-and-a-half, and three to three-and-a-half minutes after the completion of the Five-Minute Step Test. Brouha felt that the initial heart rate before exercise was not important for the purposes of the test[25].

Brouha, Fradd, and Savage observed that the step test was a "reliable and rapid method of testing dynamic fitness...to check the functional efficiency of various groups of men already determined to be medically fit."[26:212] Keen and Sloan[45] reported that the value of the test as an indication of physical fitness for strenuous exertion is shown by the much better performance of students undergoing systematic physical training than those who were not in training. Larson and Yocum[13] commented that the Harvard Step Test shows improvement with training and shows retrogression without training.

Cook and Wherry[32] reported, in their study of endurance tests, that the final score of the Harvard Step Test is "much less contaminated by non-repeatable situational and chance factors than are the scores of the other tests studied."(32:110) A five-minute step test or a treadmill run are much better than a very mild test for differentiating the capacity for strenuous exertion, according the Cureton[7].

Gallagher and Brouha[39] adapted the five-minute Harvard Step Test to make it suitable for testing the physical fitness of boys by using the body surface area to determine the height of the step for each subject. The body surface area index was figured according to the height and weight of the subject. In this study, Gallagher and Brouha specified that boys with a body surface area index under 1.85 use the 18" step, and all boys over this index level use the regular 20" step. Brouha and Gallagher[27] also modified the original step test for use with high school girls. The girls stepped at a rate of thirty steps per minute for four minutes on a 16" step.

Sloan[57] conducted a study to determine the best height of the step for use by women. He found the Harvard Step Test useful as a test of capacity for strenuous exertion by women with the step height of 17". In the study each woman performed the test three times on different days, once on a 20" step, once at 18", and once at 16". Their scores were compared with a group of male medical students who had performed the test on a 20" step. The scores correlated best when the women used the 18" step. A second group of women was subjected to the test using steps at heights of 18", 17", and 16". These indices were then compared to the same group of men. The bench of 17" correlated most closely. Therefore, on the basis of these results, a lower bench was recommended for women.

Clarke[29] conducted experimentation using the Brouha step test to discover which physical education activity classes promoted the greatest change in the step test index. She modified the test by making the step 18" and the duration of exercise four minutes, or until the subject was exhausted. The scores of 296 students in the fall ranged from eighteen to ninety-one. The average score was 47.35 and just twenty-two percent of the subjects finished the four minutes of work. Following six weeks of outdoor sports, the test was given to 326 subjects. The range was eighteen to ninety-nine; the average score was 56.7, and thirty-four percent finished the four minutes of work. The final re-test was administered in March with 302 subjects participating. At that time, the scores ranged from twenty-two to one hundred four. The mean was sixty and forty-eight percent finished four minutes of work. The rank order of participants in activity courses was: swimming, field hockey, crew, tennis, dance, volleyball, and archery.

Keen and Sloan[45] reported that there is no correlation between body weight and the fitness index achieved on the Harvard Step Test. The investigators also found no correlation between length of leg and fitness index. However, there was a significantly high correlation found between resting pulse rate and fitness index. Those students who were undergoing routine physical training had higher fitness indices and lower resting pulse rates than the other subjects.

Contrary to what Keen and Sloan[45] reported, Elbel, Reid, and Ormond[36] found the coefficients of correlation obtained between the Harvard Step Test and height and weight indicated a relationship of the step test with these variables. Elbel and Holmer[35] found that the additional foot pounds of work performed by heavier subjects while doing the step up exercises does not cause an abnormal influence upon the pulse reactions as compared to the reaction of lighter subjects.

RESPIRATORY VARIABLES

It is widely acknowledged that the circulatory and respiratory systems are interdependent. As Brassfield explained:

> Respiration involves the coordinated participation of tissue fluids, blood, the circulation, many muscles, and a considerable part of the central nervous system. Not only does the circulation play an integral part in respiration but also provides the transportation system for food, waste, and hormones, and provides a means for the distribution and elimination of heat.[24:107]

Various physiological respiratory variables have been measured as indicators of endurance. Among them are oxygen debt, ventilation volume, respiratory rate, minute respiratory volume, oxygen consumption, and amplitude of respiration. Both Karpovitch[12] and Brassfield[24] stated that training brings about changes in the respiratory mechanism and its functioning. The effects which they believe are most pronounced are the increase in chest expansion, the slowing down of breathing rate, and the augmentation of depth of breathing.

Training decreases the total lung ventilation, according to Gould and Dye[9], Gemmill, Booth, Detrik, and Schiebel[40], Morehouse and Rasch[16], Karpovitch[12], Brassfield[24], Taylor[59], and Gemmill, Booth, and Pocock[41]. Morehouse and Rasch explained this by saying that "the pulmonary ventilation now keeps pace with the requirements for gaseous exchange rather than over-responding to the excitement of exercise. . . ."[16:26]

It is well-known that the trained person breathes much less air for the same accomplishment than does the untrained subject, as reported by Schneider[53] and Schneider and Ring[56]. In the Schneider and Ring study two subjects were followed during a period of training with regard to changes in their breathing. The authors reported that the breathing changes came about so gradually that it was impossible to say just when they started. Slight evidence of change was present after the second week of training, and maximum reduction was reached in from four to six weeks. The reduction of minute volume of breathing was fairly large and was most conspicuous with heavier loads[56]. Schneider and Ring also reported "the minute volume of breathing during rest showed no distinct change either during or after training in either subject."[56:113] Karpovitch stated that "the greater the learning factor involved in exercise, the greater the reduction in minute volume after training."[21:145]

The trained individual absorbs more oxygen from the air breathed than does the unconditioned person as shown by Morehouse and Miller[15], Brassfield[24], Schneider[19], Karpovitch[12], Bainbridge[1], Gould and

Dye[9], and Taylor[59]. The amount of oxygen consumed is increased as is the amount of carbon dioxide at rest and at work by the conditioned individual. Both the rate and depth of breathing are affected by training, according to Carlson and Johnson[4], Karpovitch[12], Rasch and Brandt[51], Brassfield[24], Schneider[19], and Gould and Dye[9]. The resting rate of breathing is slowed down and the amplitude of respiration is increased considerably.

RESPIRATORY MEASUREMENT

The Collins Respirometer[30] is a closed circuit spirometer for use in measuring respiratory excursions, lung volumes, and oxygen uptake. As the instructional manual explained:

> This system involves rebreathing into an inverted, counterweighted, water-sealed container with a pen arranged to record its movements.... The accumulation of carbon dioxide in the container is prevented by passage of exhaled gas through a scrubber; hence, progressive diminution of the gas volume within the bell is equivalent to oxygen uptake.[30:3]

This closed circuit spirometer is recommended as the simplest and most practical measuring device for respiratory variables[38]. The graphic recording permits direct reading of tidal volumes, respiratory rates, lung volumes, maximal breathing capacity, irregular breathing, sudden changes in pulmonary resting position, and technical difficulties noted during the test. A permanent record is produced for later analysis of breathing pattern, and direct recording of oxygen uptake eliminates the necessity for later gas analysis.[38]

WORK LOAD

When comparing scores of individuals on fitness tests, the amount of work accomplished by the subject is an important consideration. Lipovetz defined work as:

> Work, or "W", may be defined as the product of the force acting, "F", and the distance, "D", through which its point of application moves during its action and represented by the formula W = F x D.... No work is accomplished unless the force actually succeeds in producing motion in the body on which F is expended.(14:187)

The way in which Lipovetz suggests the functional efficiency of the heart may be determined is by the following formula:(14:205)

$$\text{Work (ft.lbs.)} = \frac{\text{Weight of body (lbs.) x no. of lifts x distance of lift}}{\text{pulse increase}}$$

As stated earlier, the more fit the individual, the more rapidly his pulse returns to normal after exercise. Morehouse and Miller state that "work is accomplished by the expenditure of energy."(15:225) They suggest that the following factors be considered in an appraisal of overall efficiency of performance: the rate of work, the load, the duration of work, the quality of work, speed of recovery following the work period(15).

TRAINING METHODS

Interval training is a type of training which has been used extensively for various types of athletic conditioning. Several research studies have compared interval training with other types of conditioning and have reached satisfactory conclusions with regard to the success of interval training. Bresnahan, Tuttle, and Cretzmeyer(3) state that careful consideration should be given to the intervals between the sectors. The runner should establish either an objective in minutes for each interval of jogging or an objective of a fixed distance covered in each interval.

In a study done by Holmes(62), several types of training were employed in order to find the most effective training method for improving fitness with young boys. The types of activites were interval training, steeplechase training, circuit training, and muscular endurance training. The interval program consisted of having the subjects run 440 yards and walk 440 yards alternately. Each day the boys tried to run their laps faster than they had the day before. The steeplechase training was continuous activity without rest over an obstacle course at a moderate rate of speed. The subjects ran up and down stairs, around various teaching areas of the men's gymnasium, around the block, and climbed up and down the bleachers. In the circuit training a regular sequence of running interspersed with varied activities was established. These activities were run 220 yards, hop 50 times, run 220 yards, do 3 push-ups, run 220 yards, do 15 sit-ups, run 220 yards, do 15 backward leg raises, run 220 yards, do 10 side leg raises, run 220 yards, do 10 sitting tucks. As the weeks progressed, the running distance and the number of repetitions of calisthenics were increased. The muscular endurance training was a program of continuous performance of calisthenics. The exercises included: push-ups, side leg raises, endurance hops, leg lifts, sit-ups, squat jumps, V sit-ups, and the burpee agility test. The number of repetitions was increased as the exercises became easier for the subjects.

Holmes' groups met for half an hour four days weekly for six weeks. In the results on the cardiovascular tests, the systolic amplitude of the Heartography and the Five-Minute Step Test, the interval and steeplechase subjects showed superiority in improvement. Holmes concluded that "the harder the training program, the greater are the changes which are produced."(62:45)

Morehouse and Rasch(16) claim that, in using the interval training method, the most satisfactory plan is that of increasing the number of repetitions of intervals, while holding the speed, distance, and rest intervals constant. In this manner, the authors explain, "progressively more work is accomplished, which will assure the achievement of the desired physical conditioning."(16:35) Hall reported that "long distance running is about the best kind of endurance-building there is, and every person should do a lot of it."(42:48)

Michael and Gallon(50) found that after three to six weeks of hard physical conditioning there is a plateau or leveling-off period. The authors stated that this plateau pattern could be due either to the "phychological drive span" or a true physiological cycle.

<u>Running</u>

In order to acquire condition it is not necessary to train in the fashion of professional athletes[20]. Short periods of jogging, striding, sprinting, and walking are sufficient to cause physiological changes, especially related to the cardio-respiratory systems[20]. According to Spalding's Track and Field Athletics for Girls:

> Jogging is a term applied to a slow, easy pace slightly faster than casual walking gait. A little of this should be included in the daily work out throughout the season. A quarter mile jog should always precede the regular work out so that the muscles will become sufficiently prepared for the efforts required in running....[20:58]

Crampton[5] reported that in order to develop endurance one must run. He described five types of running to build endurance: (1) long running: jogging at seven-minute-to-the-mile gait; (2) "just-over-distance" running: eg. the 100 yard sprinter gets accustomed to running 120 yards; (3) "just-under-distance": run three-quarters of a mile at your best and hardest, and jog the last quarter; (4) speed: run all-out for a short distance; and (5) striding: at three-quarters of the runner's top speed, run quarter, half, and three quarters. These five systems should be used by endurance runners throughout their training period according to the individual's needs.

The Farlek System of training was discussed by Bresnahan, Tuttle, and Cretzmeyer[3] as a conditioning program widely used by track coaches at the present time. The system "consists of acquiring an acceptable physical condition through a program of running. Those who use this system recommend that the running be done over a cross-country course which provides a soft, spongy surface. Distance and speeds are optional depending on both the capacity and the judgement of the individual runners."(3:28)

Bicycling

Bicycling, too, has shown a definite positive influence upon the condition of individuals. Karpovitch[44] studied fatigue and endurance of jail inmates and college students. A ten-week bicycle training program was conducted to condition the subjects. At the end of ten weeks some men rode more than six hours continuously.

Marsh[63] conducted a study using conditioning activities and bicycling to develop cardio-respiratory fitness and muscular endurance in boys aged nine and ten. The training period was thirteen weeks in length, during which the boys met on Saturday mornings to exercise en masse and to ride together. During the week the boys were encouraged to ride at home for half an hour or forty-five minutes daily, and to keep a record of their riding times. When tested at the end of the training period all the subjects improved significantly in their scores on the Brouha Five-Minute Step Test. The program was considered successful.

Johnson[11] reported that when pedaling a bicycle ergometer for twenty minutes with a work load of 560 kg. per minute training was achieved by riding four days a weeks with the same work load for twelve weeks.

SUMMARY

In light of the literature reviewed, it may be stated that cardio-respiratory condition is influenced by training. Changes in efficiency of the cardio-respiratory systems are shown by a decrease in resting pulse rate, increase in the pulse recovery rate after exercise of fixed intensity, increase in oxygen consumption, decrease in resting respiration rate, decrease in minute volume, and increase in amplitude of respiration. Conditioning is important in affecting changes in the cardio-respiratory systems as shown by the various tests, measures, and studies reviewed.

CHAPTER IV

PROCEDURE

The purpose of this study was to determine the effects of two different training programs on the cardio-respiratory systems of college women.

SELECTION OF SUBJECTS

The subjects for this study were eighteen freshmen and six sophomore women from the undergraduate students enrolled at The Woman's College of The University of North Carolina during the academic year 1961-62. Of the thirty subjects who started in the study, twenty-four completed the program. Seventeen of the twenty-four subjects were selected at random, using every twenty-second name in the freshmen and sophomore class lists, and the remaining seven were volunteers. No particular prerequisite qualifications were required for participation in the study. A copy of the information requested from each of the prospective subjects may be found in Appendix A. The ages of the subjects ranged from seventeen years to twenty years. The subjects' weights ranged from ninety-six pounds to one-hundred-seventy-one pounds, and the subjects ranged from sixty-one-and-one-half inches to seventy-one-and-one-quarter inches in height.

The running group consisted of nine freshmen and one sophomore who had no medical restrictions or physical handicaps of any kind. The subjects included in the bicycling group were nine freshmen and five sophomores, none of whom were restricted medically or had any physical handicaps. All subjects were enrolled in physical education classes which met twice a week. The representation in the various activity classes was as follows: body mechanics, 2; fencing, 1; folk dance, 2; golf, 2; recreational sports, 3; swimming, 4; tennis, 8; and volleyball, 2.

SELECTION OF MEASUREMENTS

The Harvard Step Test, as described by Clarke(29), was one of the measurements used to determine cardiovascular efficiency. The Recovery or Physical Fitness Index was used to rate the subject's cardiovascular responses to physical exercise. (See Figure 3 in Appendix B) Brouha(25) reported that the effects of training are indicated by the decrease in the recovery pulse rate.

The instructions given each subject prior to taking the Harvard Step Test were as follows:

1. This test measures your general condition of physical fitness.
2. You will step up and down on the eighteen inch step at a cadence of thirty steps per minute for four minutes, or until you can continue no longer. You will be taking a step 'up' every two seconds.
3. Place one foot on the step, step up and place the other foot next

to the first. Straighten the back and legs and immediately step down. (The experimenter demonstrated slowly.)

4. Keep time with the cadence set by the metronome and my commands of 'up and down'. It is permissible for you to change the lead-off foot if one leg tires, but please do not do this more than two or three times during the test.

The pulse rate recovery index was determined by the use of a chart in which a ruler was placed vertically from a point on the line entitled "duration of exercise in seconds" to a point on the line for the "sum of heart beats from one to one and one half, two to two and one half, and three to three and one half minutes of recover." (See Figure 4 in Appendix B.) The point at which the ruler crossed the Physical Fitness Index line indicated the subject's score for the test[(21)].

The Collins 13.5 Liter Respirometer was used to record each subject's breathing pattern. The respirometer was a closed circuit spirometer for use in measuring respiratory excursions, lung volumes, and oxygen uptake. The system involves rebreathing into an inverted, counterweighted, water-sealed container with two pens arranged to record its movements. Accumulation of carbon dioxide in the container is prevented by the passage of exhaled gas through a scrubber; hence, progressive diminution of the gas volume within the bell is equivalent to oxygen uptake[(30)].

The apparatus consists of a 13.5 liter spirometer of non-corroding materials. The spirometer bell was accurately calibrated on a solid steel form so that each millimeter excursion corresponds to a Volume displacement of 41.27 cc.[(30)]. The Collins Kymograph paper is graduated so that each cc. mark equals two cc. The water seal is enclosed between copper walls which are soldered to a cast bronze base. Air passages are all one and one quarter inches in inside diameter. The spirometer bell is accurately chain counterbalanced. The chain from the bell passes over a free running pulley and is attached to a pen which records fully all respiratory movement of lung volumes. The Reichert ventilometer, mounted on top of the pulley standard, activates a second pen which records only the inspiratory activity, and through a reduction gear train reduces the pen travel to 11.09 of the regular pen[30]. This allows rapid determination of minute ventilation and maximal breathing capacity.

The kymograph consists of a large aluminum drum motivated by two individual synchronous motors which rotate at a slow speed of 32 mm. per minute, or the fast speed of 1920 mm. per minute. The continuous roll of paper unwinds from a separate spindle, turning on a ball bearing stud[30]. Extra large low resistance inhalation and exhalation valves are mounted inside the spirometer chamber, which houses the instantly removable soda lime container.

The measurements taken on the Respirometer were respiratory rate, minute volume, respiratory amplitude, and oxygen uptake. These were all recorded simultaneously on the kymograph paper as the subject breathed into the machine through her mouth. Noseclips closed the nasal passages to prevent any inhalation or exhalation from taking place through the nose.

CONDUCT OF THE STUDY

A letter was sent to each of the subjects on March 12, 1962 which announced the beginning of the training programs. Also included in this letter was the following information: date, time, and place of initial testing; wearing apparel for testing; encouragement to keep the stated appointment on time or to notify the experimenter immediately if unable to keep the appointment. A copy of the letter may be found in Appendix A.

Initial Testing

All subjects were given the Harvard Step Test during the week of March 12, 1962. In addition, the measurements of the respiratory variables were recorded by the Respirometer for each girl. Each subject had an individual half-hour appointment with the experimenter which was scheduled at the convenience of the subject. The subject entered the Research Laboratory and sat quietly for five minutes in order to relax and become familiar with the surroundings. After recording background material on the Individual Data Sheet (see Appendix A), the experimenter counted the pulse at the radial artery for fifteen second intervals until three readings were the same.

After the pulse reading was complete, the experimenter explained the pertinent elements of the Respirometer to the subject. The following instructions were given to each subject:

Think about all kinds of pleasant things, and just forget about your

> breathing. Place the mouthpiece between your teeth and lips, and bite on the small tabs. I will place the noseclips on your nose. Are they comfortable? Now, just breath easily and think pleasant thoughts.

The free breathing valve remained open for a few minutes in order for the subject to become accustomed to breathing into the tubes and breathing just through the mouth. The subject breathed room air at this time, and no recording was made on the kymograph. The valve was closed after the few minutes of adjustment, and the subject breathed oxygen from the bell. The kymograph was turned on at the slow speed, and the recording commenced.

The subject breathed for three minutes, after which she was asked to expire fully and then continue to breath normally. A one minute interval was allotted between each of the following: two full expirations, two full inspirations, and two full inspiration-expiration combinations. Thus, the total recording consumed nine minutes.

After completing the respiratory recording, the subject was given instructions for the Harvard Step Test, and the test was administered. Immediately upon cessation of exercise, the subject sat down. She placed the respirometer mouthpiece in her mouth while the experimenter put the noseclips on the subject. The kymograph was turned on at slow speed. It was just fifteen seconds after the cessation of exercise when the recording of the subject's breathing was started. This recording continued for four minutes.

One minute after the cessation of exercise, the carotid pulse rate was counted as the first of three thirty second pulse rates to be observed and recorded. Immediately following the four minute post-exercise readings, the respirometer mouthpiece and noseclips were removed from the subject. The subject rested in the chair for a few minutes while the experimenter explained briefly about the respirometer recording made by that particular subject. The initial testing was completed by weighing the subject and measuring her height.

Groups

The subjects were ranked from high to low on the results of the Harvard Step Test. The subjects were placed in groups according to the following plan: #1, runner; #2, rider; #3, rider; #4, runner; #5, runner; #6, rider; #7, rider; and so forth. This was done in order to equate the fitness levels of the bicyclers and the runners as groups. Several of the subjects had previously requested to participate only as bicyclers in the study; thus these requests were considered wherever possible when establishing the two groups.

Initial Meeting

When the experimenter had established the groups, a meeting for all of the subjects was called for the purpose of explaining the detailed procedure for the training programs. The following information was presented to the subjects at that meeting:

1. The names of subjects in each of the groups.

2. Procedure for attendance: An attendance chart was posted on a bulletin board in the gymnasium on which each subject was to place a star at the completion of the activity each day. First week - blue stars; second week - red stars; third week - silver stars; fourth week - gold stars.

3. Explanation of where the bicycles were kept.

4. Explanation of the running course and the riding course, both outdoors and indoors, for the first week.

5. Emphasis on the importance of coming every time.

6. Comment on possible soreness.

7. Explanation of competition versus one's self as well as versus members of the other group, with emphasis on the former.

Outdoor Training Programs

The training programs were set up with "overload" and "interval" to be employed as the two basic principles. The distance which the two groups covered was identical, and the increase per week was also the same for the two groups. According to Morehouse and Rasch(16), interval training "employs the principles of specificity, tempo, and pace in an endurance training program." Those authors suggest that a convenient distance be traversed at the desired speed, one which is within the subject's endurance capacity. Thus, the training programs for this study were set up alternating fast and slow speeds for intervals of 440 yards. Each week the distance covered was increased in order to create "overload", but the distance of each interval remained 440 yards.

The subjects met Monday through Friday between five and six o'clock. The experimenter supervised both the running and the riding programs daily. If a subject was unable to attend the training session between five and six on a certain day, she came at another time, at her convenience, on that same day. If a subject was absent at any time during the week, she made up her absence on the following week-end, and reported it to the experimenter. The training program was four weeks in length. Johnson reported that four to six weeks are necessary for maximum cardiovascular efficiency to develop(11).

The runners ran on the playing fields of The Woman's College. Bresnahan, Tuttle, and Cretzmeyer(3) suggest that running be done over a cross-country course which provides a "soft, spongy surface" in order to get the best results from training by running. The "course" was on a flat surface, but the dimensions of the course changed each week in order to prevent boredom on the part of the subjects. (See Figures 5, 6, 7 in Appendix B.)

The terms "run" and "walk" on the diagrams for runners indicated the general speed at which the subjects covered the distances. Each subject ran at a pace which she could maintain fairly steadily throughout the 440 yards. As the weeks progressed the runners were able to increase the speed at which they ran their laps. All subjects walked briskly.

The riders all rode Hercules English lightweight bicycles which had the standard three gears and hand brakes. The bicycles were ridden in second gear at all times throughout the training program. The terms "fast" and "slow" for the bicycle group generally described the pace at which the subjects traversed various sections of the riding courses. By "fast" each subject understood that she was to ride in a sitting position and to go as fast as she possibly could for the specified distance. This varied among the subjects. "Slow" indicated that the subject was to pedal along very easily, with minimum effort, for the specified distance marked "slow".

The bicyclers rode on both paved and unpaved roads near The Woman's College campus. (See Figures 9, 10, 11 in Appendix B.) The route remained similar each week, but was changed slightly to make the ride more interesting for the subjects. The "fast" and "slow" sections as well as the paved and unpaved areas of each route are indicated on the Bicycling Course diagrams.

The daily distance for both groups was as follows:

WEEK	RUNNERS	RIDERS
Week I	1 mile	1 mile
Week II	1.25 miles	1.25 miles
Week III	1.50 miles	1.50 miles
Week IV	1.50 miles	1.50 miles

The distance for both groups was not increased for Week IV. The experimenter felt, on the basis of observation, that the distance of 1.5 miles was a sufficient "overload" for all subjects. The course remained the same for Week IV due to the fact that all of the subjects and the experimenter felt that the Week III course was sufficiently challenging and interesting to warrant continued use.

Indoor Training Programs

In case of inclement weather, indoor running and riding programs were established weekly. (See Figure 8 in Appendix B.) Fortunately, the riders were able to ride the outdoor course throughout the training period. The bicyclers could have ridden indoors on small metal stands with a spring device on which the rear wheel rested. The friction provided by the roller on the spring was similar to that of riding on a paved road. The runners were in the gymnasium the first three days of the fourth week of training because of very wet fields.

Final Testing

A letter was sent to each of the subjects at the conclusion of the training programs which informed the participants of the time, date, and place of the final testing. A copy of the letter may be found in Appendix A.

All subjects finished training on approximately the same day. Final tests were administered to each subject within one to two days after she had completed her running or riding. Each subject was given the final tests at the same time of day as she was given the initial tests. When the subjects were tested they had all completed a distance of twenty-six and one-quarter miles in twenty days of training.

The final testing procedures were identical to those of the initial testing period, with one exception. During the pre-exercise period, the respiratory recording was just the normal breathing. The full inspirations and expirations were not to be included in the measurements used for determining the effects of training on the cardio-respiratory systems; thus, the subject's respiratory pattern was recorded as she breathed normally for a period of four minutes. The final testing procedure was as follows:

1. Rest for five minutes.
2. Sitting pulse rate recorded.
3. Sitting respiratory pattern recorded.
4. Harvard Step Test.
5. Post-exercise respiratory pattern recorded.
   Post-exercise pulse rate recorded.
6. Weight recorded.

The final testing was completed on Wednesday of the fifth week.

TREATMENT OF DATA

Since this study was designed to compare the differences that might exist before and after training in the physiological reactions recorded at base rate and post-exercise, the "t" formula[8] for matched pairs was used to compute the significance of the mean of the differences. The "t" was computed for each of the two groups separately.

The other primary purpose of this study was to compare the two training groups in the variables measured; therefore, the analysis of covariance technique[17] was employed. The use of this procedure permitted the comparison of the two groups, in selected physiological variables, while eliminating the sources of variability which existed prior to the experiment and which might have been sources of error.[17]

CHAPTER V

PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to determine what effects two different training programs had on selected cardio-respiratory variables on college women. The programs were identical in duration and frequency of exercise, but the activities differed. The two activities were riding bicycles and running. The physiological reactions measured were pulse rate, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption. These were all recorded at base level and after exercise both before and after the four-week training programs. The respiratory reactions were recorded simultaneously by a respirometer. A photostat of such a recording is found in Appendix B, Figure 12. The cardiovascular reaction was measured by counting pulse rate, which was done by the experimenter. The exercise used was the Harvard Step Test as adapted for college women by Clarke[29].

For the purpose of discussion, each of the testing periods will be referred to by a specific Roman numeral. The symbols are as follows:

I - base level score before training

II - post-exercise ratio score before training

III - base level score after training

IV - post-exercise ratio score after training

$\frac{I + II}{2}$ - base level and post– exercise scores averaged for initial tests before training

$\frac{III + IV}{2}$ - base level and post-exercise scores averaged for final tests after training

A ratio score was computed for each subject on tests II and IV by dividing the raw score for each variable by the Harvard Step Test Index score. This was done in order to make the scores of tests II and IV comparable by taking into consideration the amount of work done by each subject at each of the testing sessions (II and IV). For example, one subject was able to perform the Harvard Step Test for just ninty-five seconds before training and her respiration rate after this exercise was twenty-one inhalation-exhalation cycles per minute. Another subject performed the Harvard Step Test for the maximum 240 seconds and her respiration rate after exercise was also twenty-one cycles per minute. For the purpose of comparison, it was necessary to compute a ratio for each subject to equate the scores within variables. In this case, the ratio score for the first subject for respiration rate after exercise before training (II) was .6364. The ratio for the second subject was .2333. Thus, the ratio score for respiration rate shows the real difference between these two subjects in this variable, whereas the raw scores for respiration rate after exercise before training (II) for these two subjects showed no difference.

The statistical technique of averaging the base level and post-exercise scores for the initial test, $\frac{I + II}{2}$, and the base level and post-exercise scores for the final test, $\frac{III + IV}{2}$, was used in order to note any changes which were great enough to appear when this method was employed.

The Roman numerals represent various times during the conduct of the study. Each of the five physiological reactions measured will be discussed, in turn, by referring to the Roman numeral used as the chronological symbol. The raw scores and ratios for each test item for each of the training groups on the initial and final tests may be found in Appendix C on Tables XI - XXII.

STATISTICAL ANALYSES

Since this study attempted to determine whether or not either or both of the training programs were of sufficient duration and intensity to show significant changes in the variables measured, both at base level and post-exercise, the "t" formula[8] for matched pairs was used to compute the significance of the mean of the differences. The "t" was computed separately for each of the two groups. It was decided that the five per cent level of confidence or better was the level at which the statistics would be accepted as significant.

The other purpose of this study was to compare one group of bicyclers and one group of runners in the variables measured; therefore, the analysis of covariance technique[18] was employed. The use of this procedure permitted the comparison of the two groups, in the selected physiological variables, while eliminating the sources of variability which existed prior to the experiment and which might have been sources of error[18]. This technique provided the experimenter with a means of attaining a measure of control of initial individual differences.

In order to equate the groups with regard to level of physical fitness before starting the training programs, the Harvard Step Test was administered to each subject. The subjects were ranked and placed in training groups accordingly. (See Chapter IV, page 35) A "t" was computed to test the significance of difference between the means on the Harvard Step Test Index scores for the two groups. A "t" of .0381 indicated that there was no statistically significant difference between the groups. The following information explains the "t":

	N	M	σ	"t"
Bicyclers	14	51.2	19.30	.0381
Runners	10	48.5	19.50	

In effect, these two groups were equated on the basis of the Harvard Step Test Index scores. The writer recognizes that, in physiological studies especially, there are many other variables which were perhaps unequal and even unknown.

The analysis of all statistical procedures and results will be presented by specific variables. The order of the presentation of variables is as follows: pulse rate, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption. The mean of the differences and analyses of covariance are presented and analyzed with each variable throughout the discussion.

PULSE RATE

Much research has found the pulse rate to be a valid measure of the effectivenss of athletic training[43,34]. The resting pulse rate has been found to be lower after training in many studies[24,4,9,48], and is therefore considered to be an acceptable criterion by which to judge the effectiveness of conditioning. Morehouse and Miller[15], and others[46,45,9,61] reported that the heart recovers more rapidly at the cessation of exercise in the trained subject than in an untrained subject.

The test for significance of the mean of the differences for pulse rate was applied to the bicyclers and to the runners both before and after training at base level and post-exercise. A summary of these computations is found in Table I.

With the subject in sitting position, the pulse rate for the bicyclers at base level was not significant in the before and after training scores. This is in accordance with the findings of Tuttle and Walker[61] in their study regarding training and heart response. Those authors found that there was no significant change in the resting heart rate of their subjects after training. The runners in this study changed significantly at the five per cent level of confidence, with the mean of test III being the lower. The means for the runners were as follows: test I, 19.6; test III, 17.9. The sitting pulse rate for the runners was significantly lower after the training program, hopefully as a result of the training by running.

The Harvard Step Test[25] was used to measure the cardio-respira-

TABLE I

SIGNIFICANCE OF THE MEAN OF THE DIFFERENCES FOR MATCHED PAIRS FOR MEASUREMENT OF PULSE RATE AND HARVARD STEP TEST INDEX SCORES FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Treatment of Groups	Mean of the Differences	"t"
Pulse Rate		
Before and After Training (I-III)		
Bicyclers	.6428	1.0658
Runners	1.7000	2.2785*
Harvard Step Test Index		
Before and After Training (II-IV)		
Bicyclers	32.4285	7.7082***
Runners	28.1000	4.5498***

* - Significant at the 5% level of confidence
*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

tory responses to exercise. The higher index score indicated the most efficient circulatory systems in regard to the recovery of the pulse rate for one to one-and-one-half, two to two-and-one-half, and three to three-and-one-half minutes after cessation of exercise. Both bicyclers and runners showed a significant difference at the one per cent level of confidence in their scores, with the mean of test IV being the larger. The means for the bicyclers were as follows: test II, 51.18; test IV, 76.64. The means for the runners were as follows: test II, 48.5; test IV, 77.0. The significant change, indicated by the difference scores, is in accordance with research(15,46,45,9,61) which reported that the heart rate recovers more rapidly after exercise in the trained individual than in the untrained individual. The cardiovascular efficiency of both bicyclers and runners was changed in a positive direction during the four-week training programs.

Figures 1 and 2 show the length of time, in seconds, each subject was able to perform the Harvard Step Test at the initial test and at the final test for the bicyclers and the runners. It can be seen, from these figures, that there was considerable improvement in the length of time each subject was able to continue to step test. This improvement in the length of time all of the subjects were able to perform the Harvard Step Test on the final test was hopefully due to the respective training programs. However, the writer felt that the motivation was greater for the subjects on the final test than on the initial test. All of the students had trained

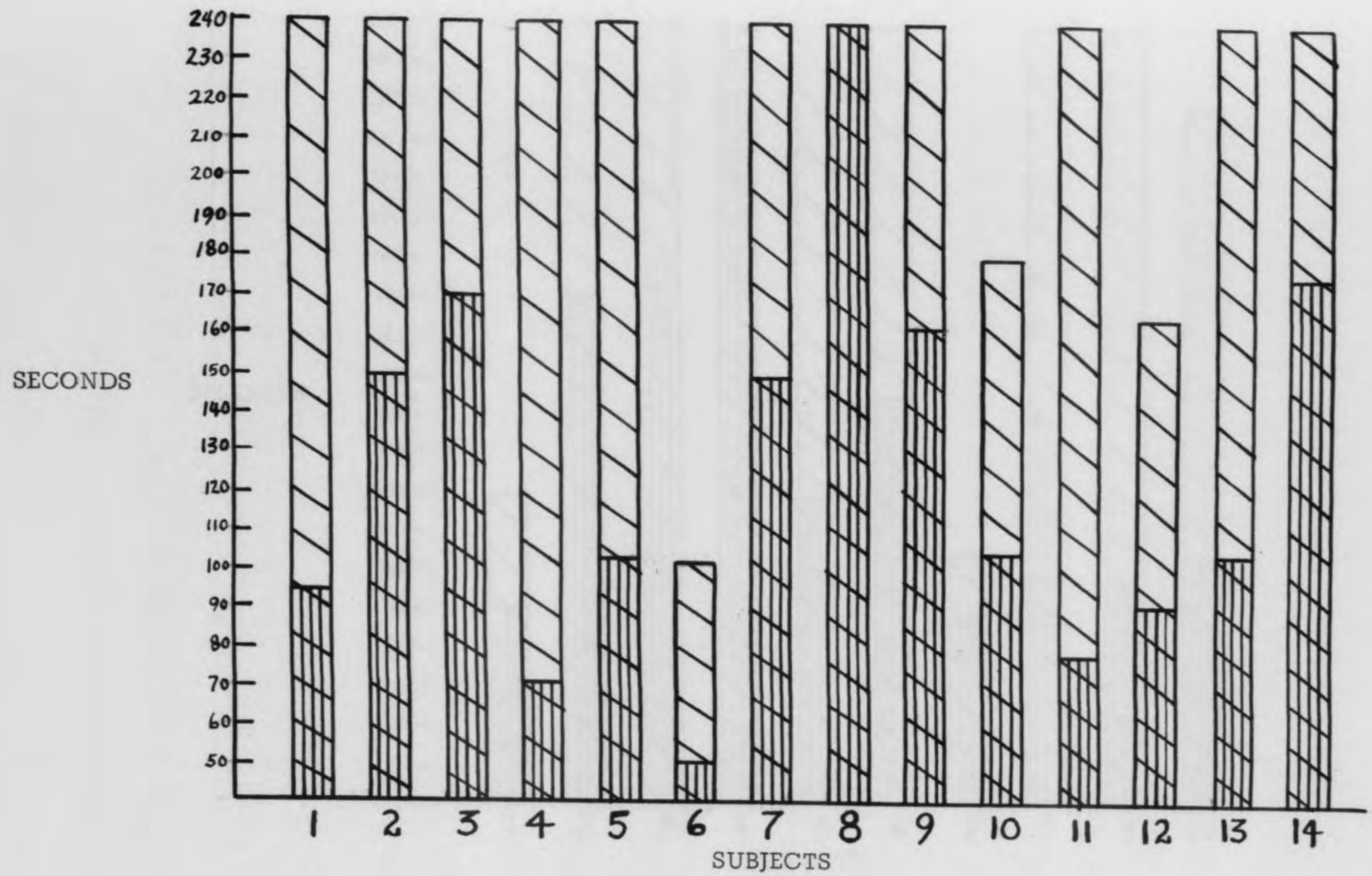

FIGURE 1

BAR GRAPH FOR BICYCLERS:
DURATION OF INITIAL AND FINAL HARVARD STEP TEST

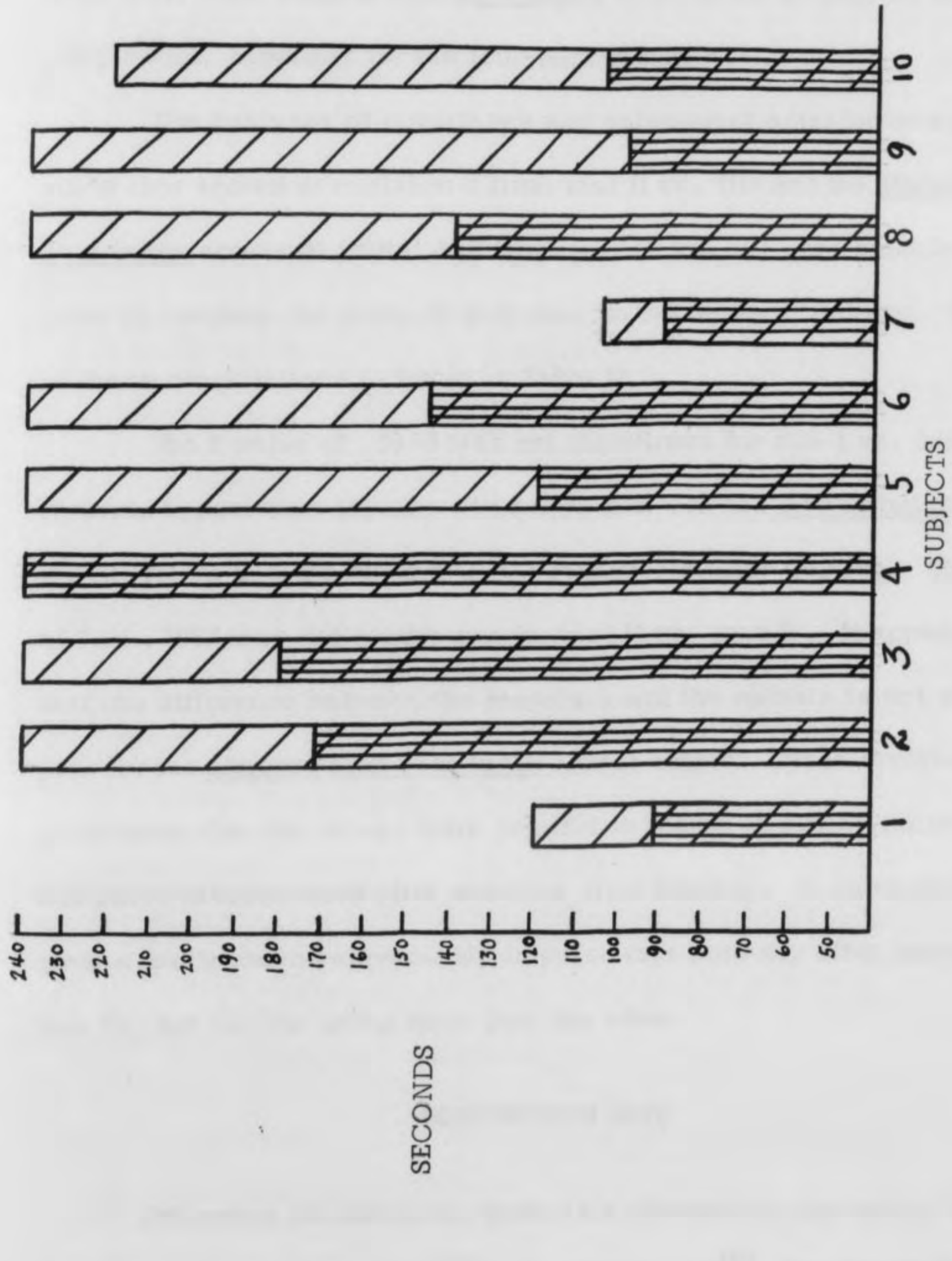

FIGURE 2

BAR GRAPH FOR RUNNERS:
DURATION OF INITIAL AND FINAL HARVARD STEP TEST

diligently for four weeks, and naturally they expected great results after all of the hard work and time spent on conditioning. Therefore, on the final test, each subject was determined to continue as long as she possibly could, hopefully for the four-minute maximum.

The analyses of covariance and subsequent adjusted means for pulse rate scores at initial and final test (I vs. III) and the Harvard Step Test Index scores at initial and final test (II vs. IV) were calculated in order to compare the group of bicyclers to the group of runners. A summary of these computations is found in Table II.

The F value of .3950 was not significant for test I vs. test III. It would appear then that the difference between the sitting pulse rate for the bicyclers and the runners is not significant after training. The value of F of .1057 was not significant for test II vs. test IV. It appears then that the difference between the bicyclers and the runners is not significant for the Harvard Step Test Index scores either. These results seem to indicate that the groups were parallel in regard to sitting pulse rate and pulse rate recovery after exercise after training. In summary, both groups had improved appreciably in pulse rate recovery after exercise on test IV, but not one group more than the other.

RESPIRATION RATE

Following conditioning, there is a decrease in the rate of respiration, according to Brassfield[24], Gould and Dye[9], Rasch and Brandt[51],

TABLE II

ANALYSES OF COVARIANCE AND SUBSEQUENT ADJUSTED MEANS FOR PULSE RATE AND HARVARD STEP TEST INDEX SCORES ON ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (# per Min.)
1. I vs. III:					
Between groups + error	1910.46	22			
Within groups (error)	1875.19	21	89.2948		
Difference	35.27	1	35.2700	.3950	
Bicyclers					79.7184
Runners					74.7961
2. II vs. IV:					
Between groups + error	5143.45	22			
Within groups (error)	5117.70	21	243.70		
Difference	25.75	1	25.75	.1057	
Bicyclers					77.6591
Runners					75.5773

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

Schneider[19], Karpovitch[12], Carlson and Johnson[4], Gemmill, Booth, and Pocock[41], and Knehr, Dill, and Neufeld[46]. This is most obvious during periods of strenuous physical exertion and during recovery periods following exercise[12,19,51].

In this study, the test for significance of the mean of the differences for respiration rate was applied to the bicyclers and to the runners both before and after training at base level and post-exercise. A summary of these computations is found in Table III.

A diminishing respiratory rate was not significant at base level for either bicyclers or runners in the before and after training scores. This may have been due to the length and/or severity of the training programs. Perhaps four weeks are not sufficient to effect a change in respiratory rate at base level. As the research previously mentioned indicates, the change is most easily seen during exercise and following exercise in the recovery period.

Both groups had a positive directional change, statistically significant at the one per cent level of confidence, in the rate of respiration between the initial and final post-exercise test (II-IV). The means for the bicyclers' ratio scores were as follows: test II, .5505; test IV, .3151. The means for the runners' ratio scores were as follows: test II, .5104; test IV, .3306. Thus, the means for test IV, after training, were the lower. The rate of respiration for the bicyclers and for the runners was diminished significantly, in the post-exercise measurement after training.

TABLE III

SIGNIFICANCE OF THE MEAN OF THE DIFFERENCES FOR MATCHED PAIRS FOR MEASUREMENT OF RESPIRATORY RATE FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Treatment of Groups	Mean of the Differences	"t"
Base Level		
Before and After Training (I-II)		
Bicyclers	1.1928	1.4161
Runners	.0030	.0030
Post-Exercise		
Before and After Training (II-IV)		
Bicyclers	.2354	3.1070***
Runners	.1798	4.8595***

*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

The respective "ts" of 3.1070 and 4.8595 are both significant. It appears that during both training programs the respiratory rate of the subjects was significantly improved.

The analyses of covariance and subsequent adjusted means for respiratory rate were computed at various stages in the training programs: (1) at base level (I vs. III) for initial and final test, (2) post-exercise scores (II vs. IV) for initial and final test, and (3) averaging base level scores and post-exercise scores $\left(\frac{I + II}{2} \text{ vs. } \frac{III + IV}{2}\right)$ at initial and final test. These calculations on the bicyclers and the runners were made in order to compare the two training groups in this variable. A summary of these computations is found in Table IV.

The value of F was 9.1574, significant at the one per cent level of confidence, for test I vs. test III, with the adjusted mean of the bicyclers being the lower. The difference in respiratory rate between the bicyclers and the runners at base level is significantly different in favor of the bicyclers, hopefully due to the bicycling training program. The difference between the bicycle group and the running group on test II vs. test IV was also significant at the one per cent level of confidence, with the adjusted mean of the bicyclers again being the lower. The bicyclers' respiration rate was significantly slower than that of the runners' post-exercise after training which may possibly have been influenced by the bicycling training program.

TABLE IV

ANALYSES OF COVARIANCE AND SUBSEQUENT ADJUSTED MEANS FOR RESPIRATORY RATE FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (# per Min.)
1. I vs. III:					
Between groups + error	211.7631	22			
Within groups (error)	147.4607	21	7.0219		
Difference	64.3024	1	64.3024	9.1574***	
Bicyclers					13.6042
Runners					15.5184
2. II vs. IV:					
Between groups + error	-.2467	22			
Within groups (error)	.1593	21	.0076		
Difference	.0874	1	.0874	11.5000***	
Bicyclers					.3092
Runners					.3388

TABLE IV (continued)

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (# per Min.)
3. $\frac{I + II}{2}$ vs. $\frac{III + IV}{2}$					
Between groups + error	41.9475	22			
Within groups (error)	37.2984	21	1.7761		
Difference	4.6491	1	4.6491	2.6176	
Bicyclers					7.1777
Runners					8.1502

*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

These results surprised the experimenter. One would expect running to put a greater strain on the muscles involved in respiration, and thus increase their strength and endurance potential. However, the difference between the bicyclers and the runners in this variable after training may have been the result of many factors. The writer's speculation is that perhaps the bicyclers were able to establish a pattern of inspiration-expiration during their riding which could be maintained while they rode both "fast" and "slow" sections of their course. The runners, on the other hand, may not have been able to maintain a regular respiration rate pattern due to the strenuousness of their "fast" running. Thus, no regular breathing rate tempo was established for the runners either at base level or post-exercise.

When the base level scores averaged with post-exercise scores for the initial tests, $\frac{(I + II)}{2}$, were compared to the base level scores averaged with post-exercise scores for the final tests, $\frac{(III + IV)}{2}$, the F value of 2.6176 showed no significant difference between the bicycling group and running group. This seems to indicate that when combining the scores for respiration rate at base level with the respiration rate post-exercise scores there is no significant difference between the bicyclers and the runners. It appears that the statistical technique of combining the two scores $\left(\frac{I + II}{2}, \frac{III + IV}{2}\right)$ may negate the statistical significance found when each of the two scores was treated separately.

In summary it may be stated that the rate of respiration improved appreciably for both groups during their respective training programs. The bicyclers' scores showed a greater improvement than did the runners both at base level and post-exercise, hopefully due to their training program.

AMPLITUDE OF RESPIRATION

Amplitude of respiration is sensitive to a training program, as reported by Brassfield[24]. According to Rasch and Brandt[51], Schneider[19], Karpovitch[12], and Carlson and Johnson[4], the depth of breathing is augmented as a result of frequent and regular exercise.

The test for significance of the mean of the differences for amplitude of respiration was applied to the bicyclers and to the runners both before and after training at base level and post-exercise. A summary of these computations is found in Table V.

There was no statistically significant difference in respiration amplitude at base level (I-III) in the before and after training scores for either bicyclers or runners. Again, as in the rate of respiration, this may have been due to the duration and/or severity of the conditioning program. Karpovitch[12] explained that the difference between a trained and an untrained person, with regard to amplitude of respiration, may not be seen clearly at rest or at basal conditions. It is during exercise and recovery from exercise that the trained individual shows superiority

TABLE V

SIGNIFICANCE OF THE MEAN OF THE DIFFERENCES FOR MATCHED PAIRS FOR MEASUREMENT OF AMPLITUDE OF RESPIRATION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Treatment of Groups	Mean of the Differences	"t"
Base Level		
Before and After Training (I-III)		
Bicyclers	11.7857	.5472
Runners	17.5000	1.1083
Post-Exercise		
Before and After Training (II-IV)		
Bicyclers	6.5572	5.7049***
Runners	5.7014	4.8859***

*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

in the greater depth of his breathing.

In the post-exercise (II-IV) scores for both bicyclers and runners there was a significant difference between the initial and final test at the one per cent level of confidence in amplitude of respiration. The means for the bicyclers' post-exercise raw scores for amplitude of respiration were: test II, 614.21; test IV, 676.64. The means for the runners' post-exercise raw scores for amplitude of respiration were: test II, 636.5; test IV, 656.7. Thus, the means for test IV, after training, were the larger. The depth of breathing, after exercise, was augmented significantly for both groups after training which seems to indicate that the training may have been of sufficient duration and intensity to influence the amplitude of respiration of both groups in the post-exercise scores.

The analyses of covariance and subsequent adjusted means for amplitude of respiration were computed at various stages in the training programs: (1) at base level (I vs. III) for initial and final test, (2) post-exercise scores (II vs. IV) for initial and final test, and (3) averaging base level scores and post-exercise scores $(\frac{I + II}{2}$ vs. $\frac{III + IV}{2})$ at initial and final test. These calculations on the bicyclers and the runners were made in order to compare the two training groups in this variable. A summary of these computations is found in Table VI.

In test I vs. test III the value of F at 1.0467 was not significant for amplitude of respiration. This seems to indicate that there was no significant difference between the bicyclers and the runners for this

TABLE VI

ANALYSES OF COVARIANCE AND SUBSEQUENT ADJUSTED MEANS FOR AMPLITUDE OF RESPIRATION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (ml.)
1. I vs. III:					
Between groups + error	10.5685	22			
Within groups (error)	10.0667	21	.4794		
Difference	.5018	1	.5018	1.0467	
Bicyclers					2.9936
Runners					2.6964
2. II vs. IV:					
Between groups + error	137.5399	22			
Within groups (error)	137.3752	21	6.5417		
Difference	.1647	1	.1647	.0252	
Bicyclers					8.8407
Runners					9.8239

TABLE VI (continued)

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (ml.)
3. $\frac{I + II}{2}$ vs. $\frac{III + IV}{2}$					
Between groups + error	43.0358	22			
Within groups (error)	42.9581	21	2.0456		
Difference	.0777	1	.0777	.0380	
Bicyclers					6.1079
Runners					5.9931

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

variable at base level. The value of F for test II vs. test IV was not significant at .0252 which appears to imply that the difference between the two training groups was not significant for amplitude of respiration as recorded after exercise. The final analysis of covariance for amplitude of respiration was that calculated by averaging test I and test II vs. the average of test III vs. test IV. The F value of .1380 was not significant. Thus, the difference between the bicycle group and the running group was not significant when averaging the tests. The results of the analyses of covariance seem to indicate that the groups performed similarly in regard to amplitude of respiration after training. In summary it may be stated that the amplitude of respiration improved appreciably for both groups during their respective training programs, but that neither group improved significantly better than the other one.

MINUTE VOLUME OF RESPIRATION

Evidence is available which indicates that there is a reduction in the minute volume of respiration as a result of training[46,19,12,56,53]. It is well-known that the trained individual breathes much less air for the same accomplishment than does the untrained person[19]. According to Schneider[19], the reduction of the minute volume of breathing is most conspicuous with heavy loads of work. Schneider and Ring[56] stated that the minute volume of breathing for any given load of work decreases with training, reaching its lowest level in from four to six weeks.

In this study, the test for significance of the mean of the difference for minute volume of respiration was applied to the bicyclers and to the runners both before and after training at base level and post-exercise. A summary of these computations is found in Table VII.

The reduction of minute volume of respiration was not significant at base level (I-III) for either bicyclers or runners in the before and after training scores. This is in accordance with Schneider(19) and Karpovitch(12) who reported that this reduction is most conspicuous with heavy loads of work. The effect of training shows itself so gradually that only after weeks of training may a slight evidence be observed at the base level(12).

Both groups had a positive directional change, statistically significant at the one per cent level of confidence, in the minute volume of respiration between the initial and final post-exercise tests (II-IV). The means for the ratio scores (II, IV) for the bicyclers were: test II, .2049; test IV, .1288. The runners' ratio scores (II, IV) were: test II, .2021; test IV, .1301. Thus, the means for test IV, after training, were the lower. The reduction of minute volume for the bicyclers and runners was significant in the post-exercise measurement after training which seems to indicate that the minute volume of respiration for both groups was improved during their respective four-week training periods.

The analyses of covariance and subsequent adjusted means for minute volume of respiration were computed at various stages in the training programs: (1) at base level (I vs. III) for initial and final test, (2) post-

TABLE VII

SIGNIFICANCE OF THE MEAN OF THE DIFFERENCES FOR MATCHED PAIRS FOR MEASUREMENT OF MINUTE VOLUME OF RESPIRATION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Treatment of Groups	Mean of the Differences	"t"
Base Level		
Before and After Training (I-III)		
Bicyclers	.0442	.2866
Runners	.1237	.0585
Post-Exercise		
Before and After Training (II-IV)		
Bicyclers	.0762	5.1141***
Runners	.0719	5.0993***

*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

exercise scores (II vs. IV) for initial and final test, and (3) averaging base level scores and post-exercise scores ($\frac{I + II}{2}$ vs. $\frac{III + IV}{2}$) at initial and final test. These calculations on the bicyclers and the runners were made in order to compare the two training groups in this variable. A summary of these computations is found in Table VIII.

The reduction of minute volume of respiration for test I vs. test III was significant as shown by an F value of 6.9815. The adjusted mean of the bicyclers was the lower. The difference in minute volume of respiration between the bicyclers and the runners at base level was significant in favor of the bicyclers, hopefully due to their training program. The value of F for test II vs. test IV was not significant at 0.00. It appears that the difference between the groups for the post-exercise scores after training for minute volume of respiration is nonexistent. This seems to indicate that the groups were identical in regard to post-exercise minute volume after training, possibly as a result of their training programs. When the base level scores averaged with the post-exercise scores for the initial test, ($\frac{I + II}{2}$), were compared to the base level scores averaged with the post-exercise scores for the final test, ($\frac{III + IV}{2}$), the difference between the bicycling group and the running group was not significant as revealed by the F value of .0048. This indicates that when comparing the averaged scores for minute volume of respiration, ($\frac{I + II}{2}$ with $\frac{III + IV}{2}$), there is no

TABLE VIII

ANALYSES OF COVARIANCE AND SUBSEQUENT ADJUSTED MEANS FOR MINUTE VOLUME OF RESPIRATION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (liters)
1. I vs. III:					
Between groups + error	4.1714	22			
Within groups (error)	6.2484	21	.2975		
Difference	2.0770	1	2.0770	6.9815*	
Bicyclers					2.6995
Runners					2.7391
2. II vs. IV:					
Between groups + error	.0474	22			
Within groups (error)	.0474	21	.0023		
Difference	0	1	.0000	0.0000	
Bicyclers					.1284
Runners					.1306

TABLE VIII (continued)

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (liters)
3. $\frac{I + II}{2}$ vs. $\frac{III + IV}{2}$:					
Between groups + error	1.7363	22			
Within groups (error)	1.7367	21	.0827		
Difference	.0004	1	.0004	.0048	
Bicyclers					1.4117
Runners					1.4373

* - Significant at the 5% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

significant difference between the two training groups. In summary concerning minute volume of respiration, it may be stated that both groups improved significantly during the four weeks and that the bicyclers had a significantly lower minute volume of respiration prior to exercise (I vs. III).

OXYGEN CONSUMPTION

Following conditioning of sufficient duration and intensity, there is an increase in the amount of oxygen consumed by the subject according to Gould and Dye[9], Bainbridge[1], Karpovitch[12], Guyton[10], Taylor[59], and Schneider[53]. A trained person can utilize a greater portion of his oxygen than can the untrained one. A trained individual has a greater capacity for delivering oxygen to the tissues as a result of both improved respiratory and circulatory adjustments[9]. Taylor reported in his "Studies in Exercise Physiology"[59] that oxygen consumption levels are of great significance because of the prevailing view that the ability to absorb oxygen is a limiting factor in individual physical performance.

In this study, the test for significance of the mean of the differences for oxygen consumption was applied to the bicyclers and to the runners both before and after training at base level and post-exercise. A summary of these computations is found in Table IX.

Oxygen consumption was not significantly changed at base level for either bicyclers or runners in the before and after training scores.

TABLE IX

SIGNIFICANCE OF THE MEAN OF THE DIFFERENCES FOR MATCHED PAIRS FOR MEASUREMENT OF OXYGEN CONSUMPTION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Treatment of Groups	Mean of the Differences	"t"
Base Level		
Before and After Training (I-III)		
Bicyclers	.1964	.7527
Runners	.0000	.0000
Post-Exercise		
Before and After Training (II-IV)		
Bicyclers	8.5559	4.3077***
Runners	8.3178	4.8141***

*** - Significant at the 1% level of confidence

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

This may have been due to the length and/or intensity of the training programs. Perhaps four weeks were not of sufficient duration to effect a change in oxygen consumption at base level. Karpovitch(12) stated that the difference between the trained and untrained person, regarding oxygen consumption, is most pronounced when heavy loads of work are carried. The effect of training shows itself so gradually that only after weeks of exercise may a slight evidence be observed.

Both groups had a positive directional change, statistically significant at the one per cent level of confidence, in oxygen consumption post-exercise (II-IV) between the initial and final test. The means for the bicyclers for the ratio scores (II, IV) were as follows: test II, 24.20; test IV, 19.49. The means for the runners for the ratio scores (II, IV) were as follows: test II, 24.13; test IV, 15.80. It is possible that both groups adjusted to an increased level of efficiency in which less oxygen was needed for physiological functions during recovery after exercise and an improvement had been made in the ability of the body to utilize oxygen, resulting in an increased percentage of the oxygen available being consumed. These results seem to indicate that the bicycling and the running programs were both effective in influencing the oxygen consumption of the groups.

The analyses of covariance and subsequent adjusted means for oxygen consumption were computed at various stages in the training progrms: (1) at base level (I vs. III) for initial and final test, (2) post-exercise scores (II vs. IV) for initial and final test, and (3) averaging base level scores and post-exercise scores $\left(\frac{I + II}{2}\right.$ vs. $\left.\frac{III + IV}{2}\right)$ at initial and final test. These calculations on the bicyclers and the runners were made in order to compare the two training groups in this variable. A summary of these calculations is found in Table X.

The F value of .2962 for test I vs. test III was not significant. It would appear that the difference between bicyclers and runners is not significant for the amount of oxygen consumed at base level. The value of .0152 was not significant for test II vs. test IV. It appears then that the difference between bicyclers and runners was not significant for oxygen consumption post-exercise. When initial test $\left(\frac{I + II}{2}\right)$ were compared to the final scores $\left(\frac{III + IV}{2}\right)$ the difference between the two training groups was not significant. This seemed to indicate that when averaging the scores for initial tests and comparing them to the averaged scores on the final tests there was no significant difference between the bicyclers and the runners in this variable. Once again it may be seen that both groups showed improvement during the four weeks on the variable of oxygen consumption, but neither training program can claim superiority.

SUMMARY

The statistical analyses in this study have identified the significant changes which occurred in each of the five variables between the initial and final tests and between the scores for the bicyclers and the

TABLE X

ANALYSES OF COVARIANCE AND SUBSEQUENT ADJUSTED MEANS FOR OXYGEN CONSUMPTION FOR ONE GROUP OF BICYCLERS AND ONE GROUP OF RUNNERS

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (ml)
1. I vs. III:					
Between groups + error	11.2357	22			
Within groups (error)	11.0794	21	.5276		
Difference	.1563	1	.1563	.2962	
Bicyclers					3.9110
Runners					4.0746
2. II vs. IV:					
Between groups + error	322.7293	22			
Within groups (error)	322.4965	21	15.3570		
Difference	.2328	1	.2328	.0152	
Bicyclers					15.6278
Runners					15.8275

TABLE X (continued)

Source of Variation	Sum of Squares of Error of Estimate	df	Mean Squares	F	Adjusted Means (ml)
3. $\frac{I + II}{2}$ vs. $\frac{III + IV}{2}$					
Between groups + error	99.9541	22			
Within groups (error)	99.8611	21	4.7553		
Difference	.0930	1	.0930	.0196	
Bicyclers					9.7719
Runners					9.8981

I - Base Level Before Training
II - Post-Exercise Before Training
III - Base Level After Training
IV - Post-Exercise After Training

runners, hopefully influenced by the respective training programs which took place between the testing sessions. The significant changes were as follows:

Base level (I-III)

1. The only significant base level change between the initial and final test scores occurred in the runners' pulse rate, with the mean of the final test being the lower, showing substantial improvement.

2. The two significant differences between groups at base level (I vs. III) took place in respiration rate and minute volume of respiration; the bicyclers were the superior group in both variables.

Post-exercise (II-IV)

1. The post-exercise differences between the initial and the final test were significant for both bicyclers and runners in all the variables tested, with the scores of the final test showing a positive directional change.

2. In post-exercise scores, the respiration rate of the bicyclers was significantly different from the runners with the bicyclers exhibiting the slower rate of breathing.

All other analyses proved not to be significant.

These data reveal that all variables were improved during the four-week training period regardless of the training program prescribed. If the training programs were the cause of the improvement, then they may both be considered of sufficient duration and intensity.

If the pulse rate is considered the best index of cardiovascular efficiency, then the runners may claim superiority with the lower base level pulse rate after training.

On the other hand, the bicyclers showed improvement in respiration rate at base level and after exercise and in minute volume of respiration at base level after training.

These isolated cases of significant changes in variables between groups identify no pattern or consistency. So perhaps it is best to conclude that one training program was just as successful as the other.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was conducted to determine the effects of two specific training programs on selected cardio-respiratory variables on college women. The subjects were divided into two groups. Their programs were identical in duration and frequency of exercise, but the activities differed. The two activities were riding bicycles and running. The physiological reactions measured were pulse rate, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption. The respiratory variables were all recorded simultaneously by a respirometer. The cardiovascular reaction was measured by counting the pulse rate, which was done by the experimenter.

The measurements for each group were treated statistically to ascertain the significance of the mean of the differences between the initial and final tests in regard to directional change. These differences were computed separately for the bicyclers and for the runners. The measurements were also used to determine whether or not a significant difference existed between the two training groups after training.

FINDINGS

Pulse Rate

1. There was no statistically significant difference between the initial and final sitting pulse rate scores of the bicyclers.

2. There was a statistically significant difference at the five per cent level of confidence between initial and final test for the sitting pulse rate of the runners. The mean was lower after training, indicating a positive directional change.

3. Both the bicyclers and the runners showed a statistically significant difference at the one per cent level of confidence between the initial and final Harvard Step Test Index scores. The means of the final test were higher.

4. There was no statistically significant difference between the bicyclers and the runners in sitting pulse rate after training.

5. The difference between the bicyclers and the runners was not statistically significant for the Harvard Step Test Index scores before training.

6. There was no statistically significant difference between the bicyclers and the runners after training for the Harvard Step Test Index scores.

Respiration Rate

1. There was no statistically significant difference between the initial and final base level scores for either the bicyclers or the runners in respiration rate.

2. Both the bicyclers and the runners showed a statistically significant difference at the one per cent level of confidence between the initial and final post-exercise score. The means of the final test were the lower, indicating a positive directional change.

3. There was a statistically significant difference at the one per cent level of confidence between the bicyclers' and the runners' respiration rate at base level after training. The bicyclers showed the greater positive change.

4. There was a statistically significant difference at the one per cent level of confidence between the bicyclers and the runners in respiration rate post-exercise after training. The bicyclers were the superior group.

5. There was no statistically significant difference between the bicyclers and the runners in respiration rate when the base level scores averaged with the post-exercise scores before training were compared to the base level scores averaged with the post-exercise scores after training.

Amplitude of Respiration

1. There was no statistically significant difference between the

initial and final base level scores for either the bicyclers or the runners.

2. There was a statistically significant difference at the one per cent level of confidence between the initial and final post-exercise test for both the bicyclers and the runners in amplitude of respiration. The means of the final test were the larger, indicating a positive directional change.

3. There was no statistically significant difference between the bicyclers and the runners in amplitude of respiration at base level after training.

4. There was no statistically significant difference between the bicyclers and the runners in post-exercise amplitude of respiration after training.

5. There was no statistically significant difference between the bicyclers and the runners when the base level scores averaged with the post-exercise scores before training were compared to the base level scores averaged with the post-exercise scores after training.

Minute Volume of Respiration

1. There was no statistically significant difference between the initial and final base level scores for the runners or the bicyclers in minute volume of respiration.

2. There was a statistically significant difference at the one per cent level of confidence between the initial and final post-exercise test

for the _bicyclers_ and the _runners_ in minute volume of respiration. The means for the final test were lower in both groups, showing a positive directional change.

3. There was a statistically significant difference at the five per cent level of confidence between the bicyclers and the runners in minute volume of respiration at base level after training. The _bicyclers_ were the superior group.

4. There was no statistically significant difference between _the bicyclers and the runners_ in post-exercise minute volume of respiration.

5. There was no statistically significant difference between the _bicyclers and the runners_ when the base level scores averaged with the post-exercise scores before training were compared to the base level scores averaged with the post-exercise scores after training.

Oxygen Consumption

1. There was no statistically significant difference between the initial and final base level scores for the _runners_ or the _bicyclers_ in oxygen consumption.

2. There was a statistically significant difference at the one per cent level of confidence between the initial and final post-exercise test for the _bicyclers_ and the _runners_ in oxygen consumption. The means for the final test were higher in both groups, showing a positive directional change.

3. There was no statistically significant difference between the bicyclers and the runners in oxygen consumption at base level after training.

4. There was no statistically significant difference between the bicyclers and the runners in post-exercise oxygen consumption after training.

5. There was no statistically significant difference between the bicyclers and the runners when the base level scores averaged with the post-exercise scores before training were compared to the base level scores averaged with the post-exercise scores after training.

CONCLUSIONS

Improvement in cardio-respiratory efficiency of college women may be influenced by training. There are undoubtedly many conflicting opinions regarding which type of training is best for various types of activities. The following conclusions are made, based upon the data obtained in the present study, as to the results of these two training programs of four weeks duration on college women.

1. Significant improvement in pulse rate recovery, respiration rate, respiration amplitude, minute volume of respiration, and oxygen consumption after exercise occurred in both four-week training programs, consisting of bicycling and running.

2. The four-week running training program was adequate to in-

fluence significant improvement in sitting pulse rate.

3. The bicycling training program was not adequate to influence the pulse rate significantly at base level.

4. Neither of the two training programs was effective in influencing a significant base level change in respiration rate, respiration amplitude, minute volume of respiration, or oxygen consumption.

5. The four-week bicycling training program was significantly superior to the running training in affecting changes in respiration rate and minute volume of respiration at base level, as well as in the post-exercise respiration rate.

6. Neither type of training was superior to the other in affecting a greater change in pulse rate, respiration amplitude, or oxygen consumption at base level.

7. Neither type of training was superior to the other in influencing a greater change in pulse rate recovery, respiration amplitude, minute volume of respiration, or oxygen consumption after exercise.

8. Neither type of training was superior to the other in influencing a greater change in pulse rate, respiration rate, respiration amplitude, minute volume of respiration, or oxygen consumption when the base level averaged with post-exercise scores before training were compared to the base level averaged with post-exercise scores after training.

Therefore, it appears, from the data collected, that all variables were improved during the four-week training period regardless of the training program prescribed. If the training programs were the cause of the improvement, then they may both be considered of sufficient duration and intensity to effect changes in post-exercise scores.

If the pulse rate is considered the best index of cardiovascular efficiency, then the runners may claim superiority with the lower level pulse rate after training.

On the other hand, the bicyclers showed improvement in respiration rate and minute volume of respiration at base level. In addition, the respiration rate again showed a greater change after exercise for the bicyclers after training.

However, these isolated cases of significant changes in variables between groups identify no pattern or consistency. So perhaps it is best to conclude that one training program was just as successful as the other.

CRITIQUE

The following suggestions are recommended for possible procedural revisions and statistical analyses for the benefit of any further study which relates to the findings of this study:

1. Familiarize the subjects with all measuring instruments before conducting any initial testing.

2. Rank the subjects and equate the training groups on all variables before starting the training programs, if possible.

3. Increase the length of the training programs and administer tests at various intervals during the programs as well as initially and finally.

4. Administer all tests several times in order to obtain average readings for each subject in all of the physiological variables to be used in the study.

5. Include leg strength as an additional variable to be measured for a more extensive study of the effects of these two types of training.

6. Include one more statistical procedure. Take the difference between the base level and post-exercise scores at the initial test and at the final test for each variable, and compute the significance of the means of those differences.

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APPENDIX

RECRUITMENT OF SUBJECTS

SUBJECTS WERE TOLD:

1. Selected to be in thesis study.
2. Development of fitness by daily activity; bicycling or running.
3. Hard work.
4. Maximum of an hour five days a week.
5. Five weeks.
6. Will not develop bulgy muscles.

SUBJECTS WERE ASKED:

1. Grades - if satisfactory to allow time for training program.
2. Dining room work - would interfere with time of training.
3. A copy of their schedules.
4. If sincerely interested in developing fitness.

March 12, 1962.

Dear

Here we go, at last! The Fitness Study (Bicycling & Running) is about to begin. As a matter of fact, I would very much like to see YOU on

(SHARP!)

at the Research Laboratory (in Rosenthal, opposite the gymnasium) for your initial testing session.

Please wear your gymsuit - or bermudas (something in which you can move easily), and tennis shoes.

When you arrive, please make yourself comfortable in the chair outside the door. I shall invite you in when the person preceeding your appointment is finished. This short session will take approximately fifteen or twenty minutes.

If, for any reason, you CANNOT come at the above time, PLEASE let me know IMMEDIATELY by calling the OLD INFIRMARY EXT. 283. If I am not there, please leave a message including when and where I can call you back.

IT IS MOST IMPORTANT THAT YOU DO COME AT YOUR SCHEDULED TIME, IF AT ALL POSSIBLE!!

I look forward to seeing you again, and to getting started with the study.

Thank you for your cooperation.

Sincerely,

INDIVIDUAL DATA SHEET

NAME:____________________ AGE:________ CLASS:________

HEIGHT:____________________ WEIGHT:________

P.E. ACTIVITY:________________ STUDY GROUP:________

TIME OF TESTING:________________ LAST MEAL:________

COMMENTS: GENERAL HEALTH:________

MENSTRUAL PERIOD?________

April 13, 1962.

Dear

Here it is Friday-the-thirteenth, a lucky day on which to be concluding our bicycling and running program! You must feel somewhat accomplished at this point, having covered a distance of twenty-six and a quarter miles in twenty days of training! Quite a good record!

However, before all is completely finished, there is one more step, or rather, series of steps - namely, the Harvard ones in the Research Laboratory. This is a reminder that your appointment at the lab is:

(SHARP!)

If you wear tennis shoes and clothes in which you can move easily, I am sure you will be most successful in the testing.

One very important suggestion for you: GET A GOOD NIGHT'S SLEEP PRIOR TO TAKING THIS FINAL TEST!!! You will be amazed at how much better your score will be as a result of adequate rest before this strenuous activity. Honest! I know it's almost impossible to get as much sleep as you would like - but please try, just this one night. Thank you.

See you in the Research Laboratory at the above time - all rested and ready for the final plunge. Thank you so much for your cooperation!

Sincerely,

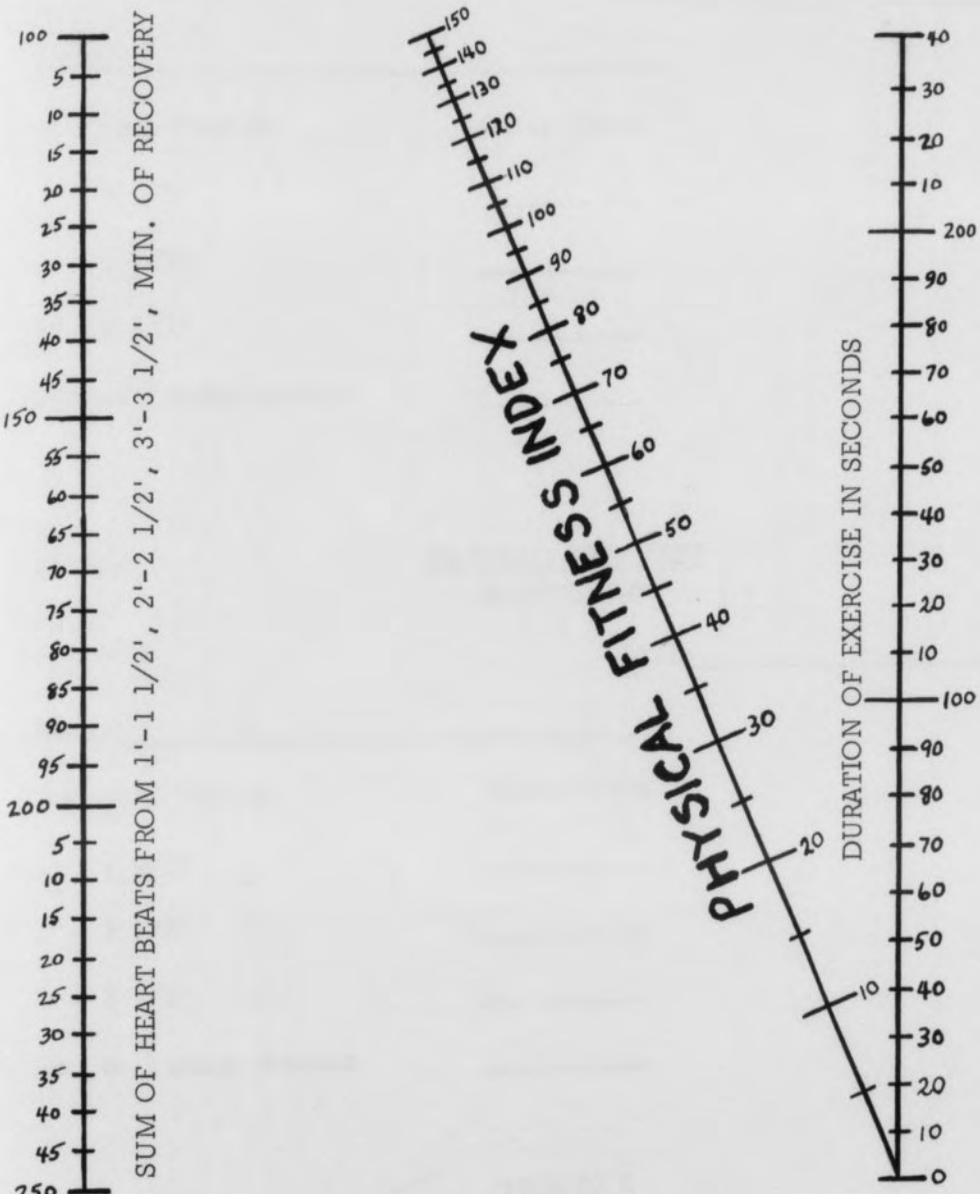


FIGURE 3

CHART FOR DETERMINING PHYSICAL FITNESS INDEX FOR WOMEN

INITIAL:

HARVARD STEP TEST

Scoring Form

DATE:____________________________

NAME:______________________________________

Recovery Period	Pulse Count
1' - 1 1/2'	__________
2' - 2 1/2'	__________
3' - 3 1/2'	__________
Sum of 3 pulse counts	__________

FINAL:

HARVARD STEP TEST

Scoring Form

DATE:____________________________

NAME:______________________________________

Recovery Period	Pulse Count
1' - 1 1/2'	__________
2' - 2 1/2'	__________
3' - 3 1/2'	__________
Sum to 3 pulse counts	__________

FIGURE 4

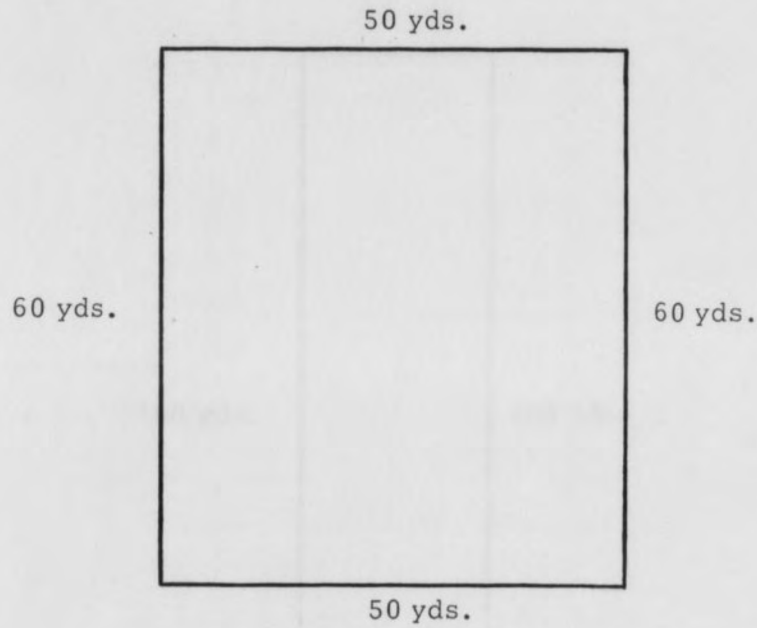


FIGURE 5

RUNNING COURSE: WEEK I

COURSE:

DISTANCE	LAPS	SPEED
.25 miles	2	run
.25 miles	2	walk
.25 miles	2	run
.25 miles	2	walk
1 mile total	8 total	2 run total 2 walk total

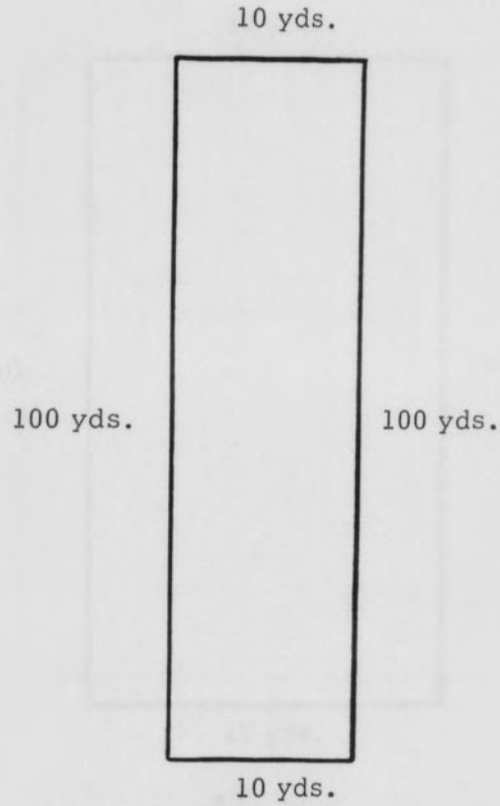


FIGURE 6

RUNNING COURSE: WEEK II

COURSE:

DISTANCE	LAPS	SPEED
.125 miles	1	run
.25 miles	2	walk
.25 miles	2	run
.25 miles	2	walk
.25 miles	2	run
.125 miles	1	walk
1.25 miles total	10 total	5 run total 5 walk total

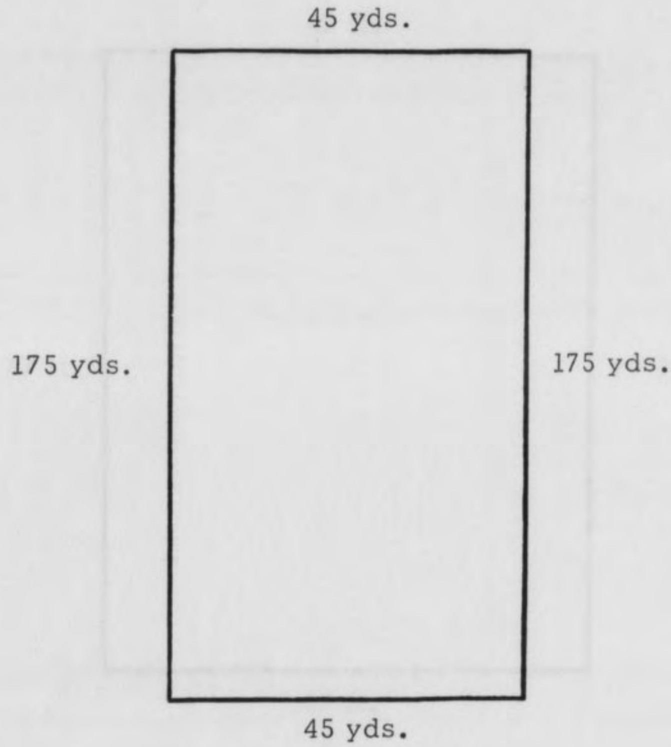


FIGURE 7

RUNNING COURSE: WEEKS III & IV

COURSE:

DISTANCE	LAPS	SPEED
.25 miles	1	run
.25 miles	1	walk
.25 miles	1	run
.25 miles	1	walk
.25 miles	1	run
.25 miles	1	walk
1.50 miles total	6 total	3 run total 3 walk total

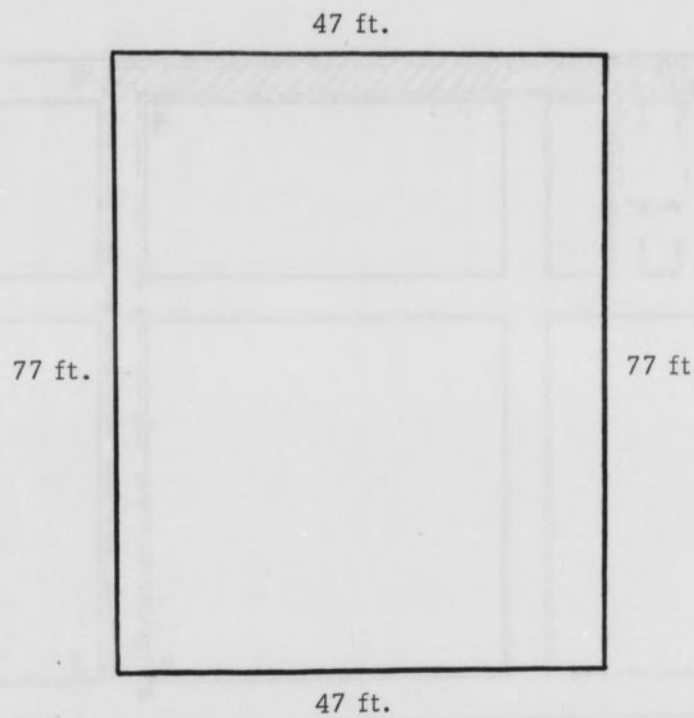


FIGURE 8

INDOOR RUNNING COURSE

COURSE:

5 laps plus 1 length = 440 yards.

WEEK I:

20 laps + 4 lengths = 1 mile: alternate run-walk every five laps.

WEEK II:

25 laps + 5 lengths = 1.25 miles.

WEEK III:

30 laps + 6 lengths = 1.50 miles.

WEEK IV:

same as Week III.

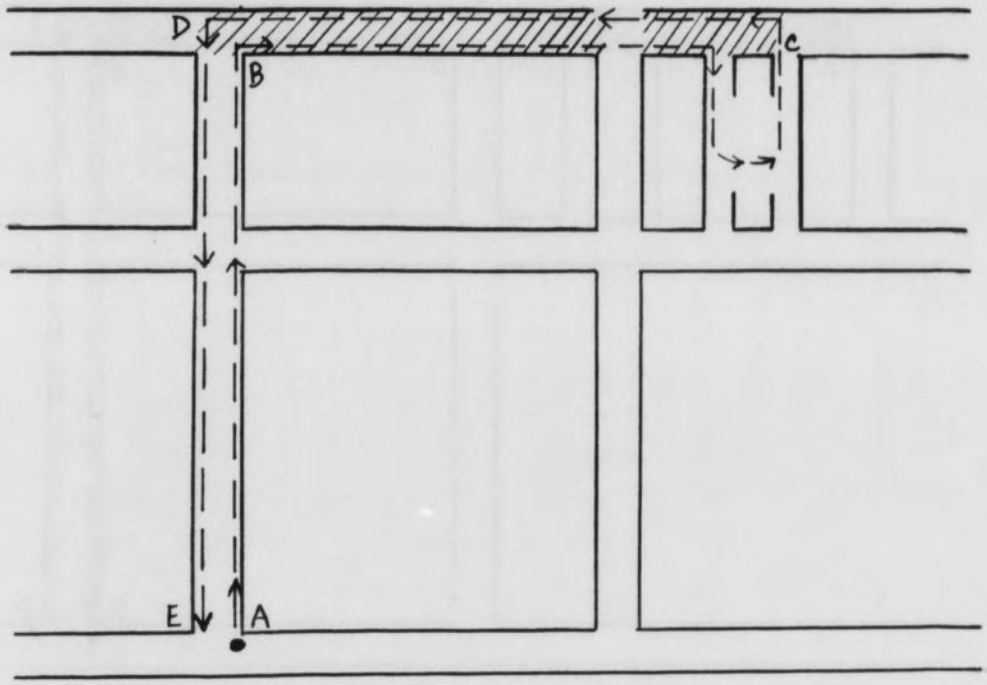


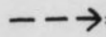
FIGURE 9

BICYCLING COURSE: WEEK I

COURSE:

DISTANCE	SPEED	POINTS
.25 miles	fast	A to B
.25 miles	slow	B to C
.25 miles	fast	C to D
.25 miles	slow	D to E
1.00 miles total	2 fast total 2 slow total	

 = Unpaved road

 = Bicyclers' paths

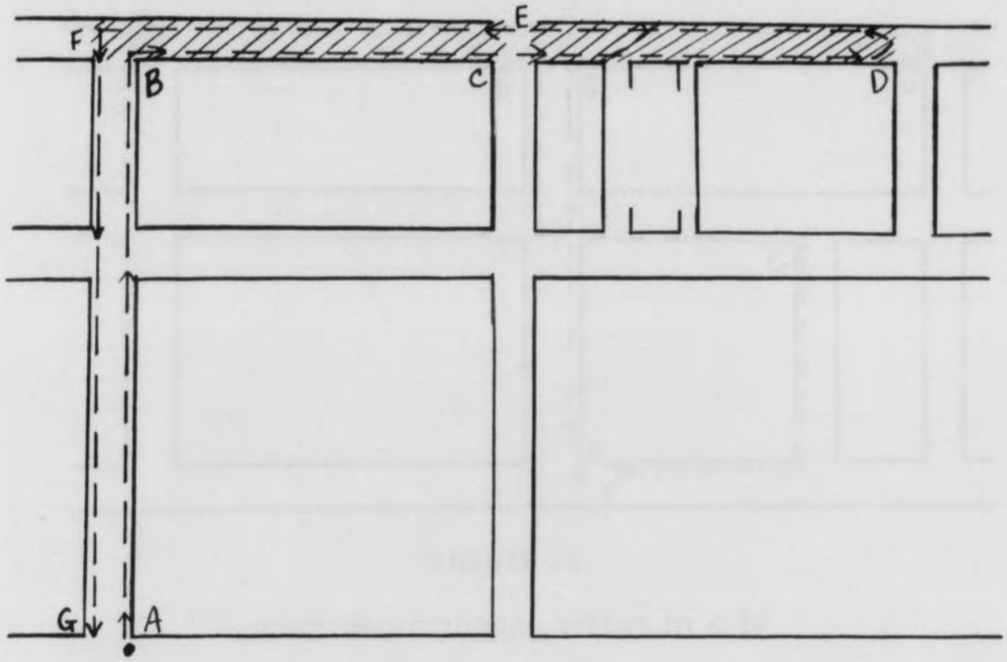


FIGURE 10

BICYCLING COURSE: WEEK II

COURSE:

DISTANCE	SPEED	POINTS
.25 miles	fast	A to B
.25 miles	slow	B to C
.125 miles	fast	C to D
.125 miles	slow	D to E
.25 miles	fast	E to F
.25 miles	slow	F to G
1.25 miles	3 fast total 3 slow total	

▨ = Unpaved road

– – → = Bicyclers' path

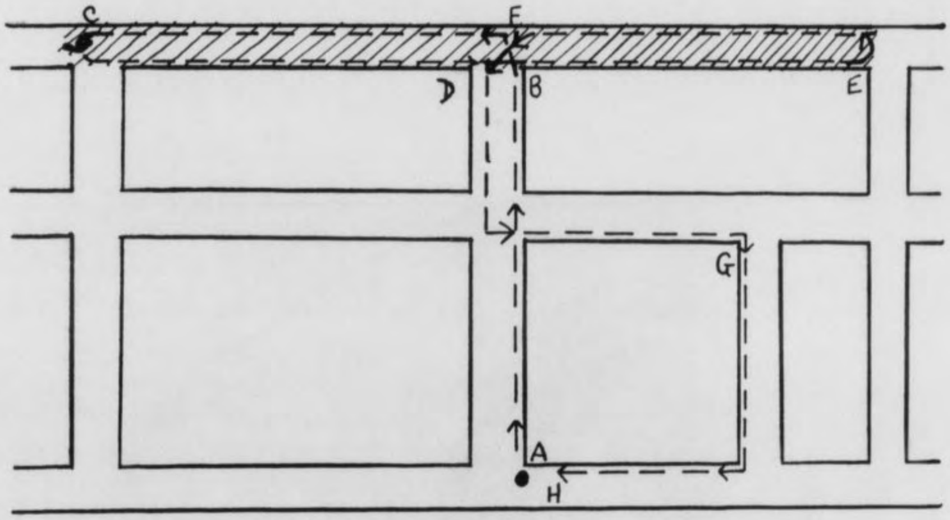


FIGURE 11

BICYCLING COURSE: WEEKS III & IV

COURSE:

DISTANCE	SPEED	POINTS
.25 miles	fast	A to B
.25 miles	slow	B to C
.25 miles	fast	C to D
.25 miles	slow	D to E
.25 miles	fast	E to F
.25 miles	slow	F to H
1.50 miles	3 fast total 3 slow total	

 = Unpaved road

- - → = Bicyclers' path

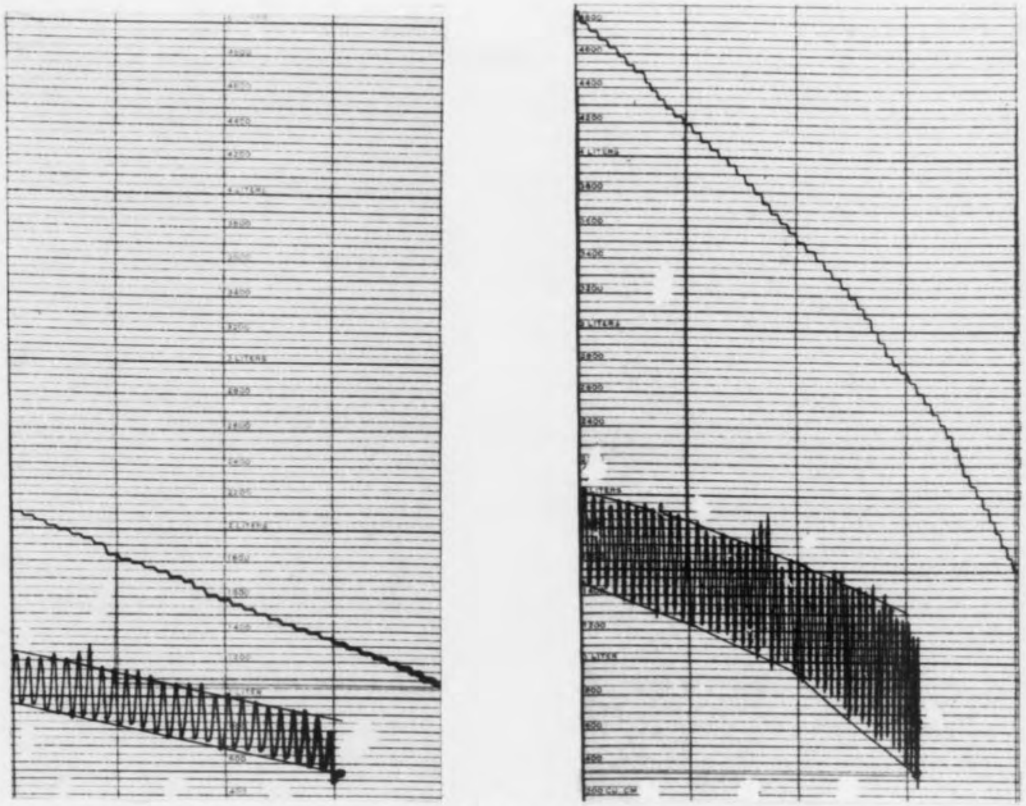


FIGURE 12

SAMPLE RESPIROMETER RECORDING

BASE LEVEL POST-EXERCISE

TABLE XI

RAW SCORES FOR THE BICYCLE GROUP AT BASE LEVEL AT INITIAL TEST (I)

INITIAL TEST

	Sitting Pulse Rate	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	80	13	250	2.7026	400
2.	100	17	225	2.4043	350
3.	100	16	225	2.3522	450
4.	92	15	250	2.9491	400
5.	88	10	350	1.7644	400
6.	72	17	275	2.3067	475
7.	92	15	225	2.1426	275
8.	72	15	300	2.7514	350
9.	84	8	600	3.1806	450
10.	88	24	300	4.4415	350
11.	64	16	275	2.7093	400
12.	80	13	400	3.2080	400
13.	72	14	250	2.2735	500
14.	100	13	250	2.6849	450

TABLE XII

RAW SCORES FOR THE BICYCLE GROUP POST - EXERCISE AT INITIAL TEST

INITIAL TEST

	HST Index	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	33	21	569.00	7.9205	1000
2.	44	21	712.50	10.7573	1450
3.	58	20	562.00	6.5353	800
4.	27	23	581.25	7.4968	850
5.	34	22	635.00	9.0195	750
6.	20	17	612.50	4.0380	950
7.	52	26	493.75	8.2465	1000
8.	90	21	612.50	8.0147	925
9.	47	22	643.75	9.4797	850
10.	35	26	700.00	10.9614	1100
11.	38	23	662.50	9.0306	1050
12.	34	16	575.00	6.3557	700
13.	45	22	625.00	7.5412	800
14.	61	23	618.75	9.9366	900

TABLE XIII

RATIOS COMPUTED BY DIVIDING THE POST-EXERCISE RAW SCORES BY THE HARVARD STEP TEST INDEX SCORES AT INITIAL TEST FOR THE BICYCLE GROUP (II)

	INITIAL TEST			
	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	.6364	17.2424	.2400	30.3030
2.	.4695	16.1932	.2445	32.9545
3.	.3448	9.9897	.1127	13.7931
4.	.8519	21.5278	.2777	31.4815
5.	.6471	18.6765	.2653	22.0588
6.	.8500	30.6250	.2019	47.5000
7.	.5000	9.4952	.1586	19.2308
8.	.2333	6.8056	.0891	10.2778
9.	.4681	13.6968	.2017	18.0851
10.	.7647	20.5882	.3224	32.3529
11.	.6053	17.4342	.2376	27.6216
12.	.4706	16.9118	.1869	20.5882
13.	.4889	13.8889	.1676	17.7778
14.	.3770	10.1434	.1629	14.7541

TABLE XIV

RAW SCORES FOR THE BICYCLE GROUP AT BASE LEVEL AT FINAL TEST (III)

FINAL TEST

	Sitting Pulse Rate	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	76	15.33	250.00	2.7378	300
2.	100	17.00	237.50	2.4043	350
3.	100	10.33	275.00	2.0681	525
4.	68	13.66	237.50	2.1007	400
5.	88	10.00	300.00	1.8830	350
6.	84	16.33	250.00	2.6416	450
7.	92	15.00	237.50	2.5880	400
8.	72	13.33	300.00	2.5288	450
9.	84	8.33	637.50	3.9609	450
10.	88	14.66	550.00	4.8635	425
11.	64	14.00	262.50	2.3443	375
12.	60	11.00	275.00	1.7770	300
13.	72	17.33	250.00	2.7346	450
14.	100	13.00	275.00	2.6186	250

TABLE XV

RAW SCORES FOR THE BICYCLE GROUP POST-EXERCISE AT FINAL TEST

FINAL TEST

	HST Index	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	74	30.00	587.50	11.7698	1100
2.	74	20.66	662.50	9.1121	1400
3.	75	15.66	700.00	7.1093	875
4.	85	24.33	600.00	8.7735	750
5.	67	25.00	850.00	12.7271	1100
6.	34	19.66	606.25	7.4654	1175
7.	88	26.66	525.00	9.4804	1100
8.	97	20.33	662.50	8.3030	1250
9.	72	18.66	743.75	9.5452	900
10.	67	24.33	856.25	12.4041	1150
11.	100	22.33	806.25	9.3773	1400
12.	78	18.33	625.00	7.1113	900
13.	80	26.33	625.00	9.9348	1275
14.	80	28.66	625.00	7.3857	1375

TABLE XVI

RATIOS COMPUTED BY DIVIDING THE POST-EXERCISE RAW SCORES BY THE HARVARD STEP TEST INDEX SCORES AT FINAL TEST FOR THE BICYCLE GROUP (IV)

	FINAL TEST			
	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	.4054	7.9392	.1591	14.8649
2.	.2792	8.9527	.1231	18.9189
3.	.2088	9.3333	.0948	11.6667
4.	.2862	7.0588	.1032	8.8235
5.	.3731	12.6866	.1900	16.4179
6.	.5782	17.8309	.2196	34.5588
7.	.3030	5.9659	.1077	12.5000
8.	.2096	6.8299	.0856	12.8866
9.	.2592	10.3299	.1326	12.5000
10.	.3631	12.7799	.1851	17.1642
11.	.2233	8.0625	.0938	14.0000
12.	.2350	8.1028	.0912	11.5385
13.	.3291	7.8125	.1242	15.9375
14.	.3583	7.8225	.0923	17.1875

TABLE XVII

RAW SCORES FOR THE RUNNING GROUP AT BASE LEVEL AT INITIAL TEST (I)

INITIAL TEST

	Sitting Pulse Rate	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	92	16	250	2.7082	375
2.	88	15	300	2.9998	475
3.	68	7	375	1.5974	425
4.	60	19	275	2.9333	425
5.	80	12	250	2.0228	300
6.	80	15	300	2.5873	450
7.	76	24	250	3.0065	350
8.	72	19	225	2.7525	600
9.	72	18	250	3.8283	325
10.	96	22	250	3.4224	350

TABLE XVIII

RAW SCORES FOR RUNNING GROUP POST-EXERCISE AT INITIAL TEST

INITIAL TEST

	HST Index	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	27	20	425.00	6.4877	825
2.	53	23	625.00	9.5507	1175
3.	67	15	887.50	7.7586	1350
4.	99	22	581.25	7.6820	925
5.	41	18	625.00	7.2362	1050
6.	49	24	731.25	11.4593	950
7.	33	25	700.00	10.3636	1275
8.	47	35	550.00	10.9558	1075
9.	43	17	906.25	9.7470	1150
10.	32	21	537.50	7.1153	825

TABLE XIX

RATIOS COMPUTED BY DIVIDING THE POST-EXERCISE RAW SCORES BY THE HARVARD STEP TEST INDEX SCORES AT INITIAL TEST FOR THE RUNNING GROUP (II)

INITIAL TEST

	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	.7407	15.7407	.2403	30.5556
2.	.4340	11.7925	.1802	22.1698
3.	.2239	13.2463	.1158	20.1493
4.	.2222	5.8712	.0776	9.3434
5.	.4390	15.2439	.1765	25.6098
6.	.4898	14.9235	.2339	19.3878
7.	.7576	21.2121	.3140	38.6636
8.	.7447	11.7021	.2331	22.8723
9.	.3953	21.0756	.2267	26.7442
10.	.6563	16.7969	.2224	25.7813

TABLE XX

RAW SCORES FOR THE RUNNING GROUP AT BASE LEVEL AT FINAL TEST (III)

FINAL TEST

	Sitting Pulse Rate	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	92	15.66	200	2.6965	400
2.	80	17.00	250	3.0518	400
3.	64	8.00	400	1.6079	450
4.	60	23.33	225	3.0072	325
5.	80	11.66	275	2.3303	450
6.	52	16.00	250	2.3893	300
7.	76	16.66	250	2.3628	500
8.	72	21.33	225	2.9689	450
9.	60	17.00	300	3.0784	450
10.	80	20.33	175	4.4417	350

TABLE XXI

RAW SCORES FOR RUNNING GROUP POST-EXERCISE AT FINAL TEST

FINAL TEST

	HST Index	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	37	21.66	487.50	8.5155	850
2.	88	26.33	531.25	9.2205	1025
3.	86	15.00	775.00	6.3168	1200
4.	94	23.66	637.50	8.4848	1400
5.	89	16.66	618.75	7.1137	1150
6.	95	22.00	675.00	10.3750	1200
7.	39	24.33	700.00	9.2366	1050
8.	80	35.00	537.50	11.4192	1150
9.	95	20.00	887.50	11.7951	1500
10.	69	21.00	518.75	7.5670	900

TABLE XXII

RATIOS COMPUTED BY DIVIDING THE POST-EXERCISE RAW SCORES BY THE HARVARD STEP TEST INDEX SCORES AT FINAL TEST FOR THE RUNNING GROUP (IV)

FINAL TEST

	Res. Rate	Res. Amp.	Min. Res. Vol.	02 Cons.
1.	.5854	13.1757	.2301	22.9730
2.	.2992	6.0369	.1048	11.6477
3.	.1744	9.0116	.0735	13.9535
4.	.2517	6.7819	.0903	14.8936
5.	.1872	6.9522	.0799	12.9213
6.	.2316	7.1053	.1092	12.6316
7.	.6238	17.9487	.2368	26.9231
8.	.4375	6.7188	.1427	14.3750
9.	.2105	9.3412	.1242	14.7368
10.	.3043	7.5181	.1097	13.0435

Typed by: Marie Teague

Drawings by: Mary Lou Thornburg