A STUDY OF TRAINING METHODS UPON CARDIOVASCULAR EFFICIENCY OF VARSITY HIGH SCHOOL SPRINTERS AND DISTANCE RUNNERS

A Thesis

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by

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Approved for the Graduate Council

Dedicated

to

My Wife, Glenda

and

My Children

Brian, Kathy, and Kerry

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The investigator wishes to acknowledge his indebtedness to Dr. George C. Milton, who served as chairman for this study, and to Dr. Ray G. Heath, for his statistical assistance.

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JDF

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Chapter 1

INTRODUCTION

As long as records have been recorded man has effortlessly tried to better himself. In all fields of endeavor, and notably physical activities, competition has been crucially rigid. As the levels of competition progressively increased between individuals, communities, educational institutions and now between nations the training techniques have through the years become more stringent.

As athletic prowess becomes more superior, training becomes more definite and refined. Coaches on all levels develop training procedures, and promote successful techniques and eager athletes undergo the rigorous programs.

One such area of development has been in the effects of training individuals and the result in terms of cardiovascular efficiency. In this one area alone the researchers have devoted many hours of study in investigating the many different approaches to cardiovascular efficiency.

THE PROBLEM

Physical educators, athletic coaches and participants have a major concern for the development of cardiovascular or circulatory endurance through participation in physical activity. In the case of athletic coaches, the selections of

training techniques must be made before the season starts so the techniques in the cardiovascular efficiency development of the athlete will be satisfactory. From the wide variety of training techniques to select from, the coach must understand the needs and finally the results of these different programs.

Statement of the Problem

It is the purpose of this study to shed more light on the differences, if any, which exist between two methods of cardiovascular efficiency training upon high school track athletes. This study attempted to study the following questions:

1. Will a distance running program of six weeks significantly improve cardiovascular efficiency of high school varsity distance running participants?

2. Will a sprint running program of six weeks significantly improve cardiovascular efficiency of high school varsity sprinters?

3. What will be the comparative effectiveness between the two different training programs?

Statement of the Hypothesis

There is no significant improvement in the cardiovascular efficiency of high school varsity distance runners after a six week training program.

There is no significant improvement in the cardiovascular efficiency of high school varsity sprinters after a six week training program.

There is no significant difference in the comparative effectiveness of the different training programs upon cardiovascular efficiency after a six week training program.

Purpose of the Study

The primary purpose of this study was to compare the effectiveness of a long distance running program to a sprint running program; each lasting for six weeks, six days a week, upon the cardiovascular efficiency of high school varsity participants as measured by the Harvard Step Test.

Significance of the Study

This study was made in order to investigate the effectiveness of two methods of developing cardiovascular efficiency through one test, the Harvard Step Test. Two different methods of training were utilized, a distance running program (Group 1), and a sprint running program (Group 2). The study lasted for six weeks, six days a week.

DEFINITIONS OF TERMS

For clarification of specific terminology used in this paper the following definitions are presented.

Distance runners

Members of a varsity track team who run either the 880 yard run, one mile run, or two mile run in high school track meets.

Modified Harvard Step Test

A test to determine the cardiovascular efficiency and is performed by having the subject step on to a platform eighteen inches high and then back down. The subject must make these steps up and down at the rate of thirty steps per minute for five minutes. After the test is completed, the subject's pulse is taken one, two, and three minutes after exercise; and the pulse counts are recorded.

Recovery pulse

The sum total of the three pulse counts that were recorded after the five minutes of step test performance on an eighteen inch bench with one minute rest periods between pulse counts.

Sprinters

Members of a varsity track team who run either 100, 220, or 440 yard dashes in high school track meets.

Time trial

A preparatory trial or rehearsal by which (a) the athlete can assess his weaknesses and so plan his future training, (b) he can accustom the body-mind to steady hard running at an overload pace, which may be less than the

projected racing pace, and (c) he can develop his courage and self-confidence. Successive trails should produce progressively better performance in which the time is but one factor (11).

LIMITATIONS OF THE STUDY

This investigation was limited to the varsity track sprinters and distance runners at Wyandotte High School, Kansas City, Kansas. The investigation was not concerned with height, weight, attitude, motivation, or activities of the subjects being tested such as eating, sleeping, and recreation habits. The investigator had no control over the subjects training prior to the official starting date for the track season.

This investigation was designed to test the level of cardiovascular efficiency attained in the six week training program and not to test speed or strength.

Chapter 2

REVIEW OF RELATED LITERATURE

The primary purpose of this study was to compare the effectiveness of a long distance running program to a sprint running program; each lasting for six weeks, six days a week, upon the cardiovascular efficiency of high school varsity participants as measured by the Harvard Step Test.

This chapter on review of literature was divided into two major sections: 1) studies related to the non-varsity athlete and 2) studies related to the varsity athlete in relationship to cardiovascular development.

STUDIES RELATED TO THE NON-VARSITY ATHLETE

A study was conducted by Smith (15) to determine if a six-week program of calisthenics would significantly improve the cardiovascular efficiency of unselected college freshmen males. The subjects took part in the six-twelve Green Beret program for thirty minutes, four times a week, Monday through Thursday, for six weeks. The conclusion of the study indicated that the exercise program would significantly improve the cardiovascular efficiency of college males between the ages of seventeen and twenty-one years. And the Harvard Step Test is a valid and reliable indicator of cardiovascular efficiency of college males.

The degree of relationship which exists between the Harvard Step Test and a three minute Treadmill Test upon the cardiovascular efficiency of college males at Kansas State Teachers College of Emporia was conducted by Goodrich (8). The investigation involved sixty full-time male students. These students were selected from three physical education activity classes designed for the development of physical fitness as well as skill development: intermediate tennis, weightlifting, and physical fitness.

The subjects were administered the Harvard Step Test mid-way through the semester, followed in two to three days by the Treadmill Test, with the exception of the physical fitness group.

Goodrich found that a positive correlation of .33 for the total group, which demonstrated the relationship between the performance on the Harvard Step Test and the Treadmill Run. The tennis group yielded a positive correlation of .58, and the weight lifting group yielded a positive .44, which indicates there is a positive correlation between the performance on the Harvard Step Test and the Treadmill Run.

When the two tests were compared the results indicate a comparable amount of cardiovascular efficiency of college males is required. And a degree of relationship does exist between the Harvard Step Test and the Treadmill Run upon cardiovascular efficiency of college males.

A comparison study of rope skipping and jogging was conducted by Baker (3) to determine the effects upon cardiovascular efficiency that result from programs of rope skipping and jogging.

The Harvard Step Test was administered to ninety-two male college students in order to determine their level of cardiovascular efficiency. The subjects were then randomly divided into two groups; Group I skipped rope for ten minutes daily for six weeks and Group II jogged thirty minutes a day for six weeks. Upon completion of the conditioning programs the subjects again were administered the Harvard Step Test and comparisons were made from the pre-exercise and post-exercise data.

Baker's conclusions of this study were that a daily ten minute program of rope skipping will significantly improve ($p=.05$) cardiovascular efficiency as measured by the Harvard Step Test, and that a daily thirty minute program of jogging will significantly improve ($p=.05$) cardiovascular efficiency as measured by the Harvard Step Test, and that a ten minute daily program of rope skipping is as efficient as a particular thirty minute daily program of jogging for improving cardiovascular efficiency as measured by the Harvard Step Test.

Wild (17) conducted a study to analyze and compare the effectiveness of isometrics and calisthenics upon the development of cardiovascular efficiency in junior high school males. The Harvard Step Test was given to all subjects in the first three class periods of the nine week quarter,

and it served as the initial measure of cardiovascular efficiency.

The class was randomly assigned to two training groups: Group I trained by calisthenic exercise for eight minutes each class period; Group II trained by isometric contractions for eight minutes each class period. Both of the groups trained two days one week and three days the next for a period of seven weeks.

The conclusions of Wild's study were as follows:

1. Although it was not significant, the seventh grade calisthenic training group showed a decrease in cardiovascular efficiency between the initial and final Harvard Step Tests.

2. The eighth grade calisthenic training group showed an improvement in cardiovascular efficiency after the training program, but it was not a significant improvement.

3. The ninth grade calisthenic training group showed a slight decrease in cardiovascular efficiency after the training program.

4. The seventh grade isometric training group showed a non-significant increase in cardiovascular efficiency after the training program.

5. The eighth grade isometric training group showed a non-significant increase in cardiovascular efficiency after the training program (17:36-37).

Antel and Cumming (2) carried out a study that presents evidence that emotional factors can significantly alter the results of submaximal work tests based on pulse rate alone, and that exercise heart rate of 170 beats per minute may be further increased by emotion. Painful or threatening stimuli produced increases in pulse rate during exercise over a pulse rate range of 100-175 beats per minute. It was indicated in

this study that the increase was only 4-7 beats per minute in nine emotionally stable boys, but was over 25 beats per minute in one emotionally labile patient. This study indicates why some students have a increased heart rate prior to competition.

An investigation by Harper, Billings, and Mathews (9) on the comparative effects of two physical conditioning programs on cardiovascular fitness used three matched groups of college men. Of the 25 men, eight took part in a modified Army conditioning program of calisthenics and marching, nine participated in an interval training program involving running and the third group of eight men acted as the control group and participated in recreational activities. Harvard Step Test indexes were recorded to evaluate differences after meeting five days a week for seven weeks. The results were that those in the calisthenic group showed no significant improvements in maximum oxygen consumption, but did show significant improvement in the Harvard Step Test. The interval trained group showed improvement on the two fitness tests, and the control group did not significantly improve.

Milton (12) conducted a study to determine the effectiveness of three programs of distance running and a program of isometric exercises upon the development of cardiovascular efficiency.

There were 463 male students given the Harvard Step Test as an initial measure of cardiovascular efficiency at Kansas State Teachers College, Emporia. They were divided

into four groups and trained four days a week for seven weeks, and the Harvard Step Test was again administered at the completion of the training program.

The groups and their training exercises are as follows: Group I ran for ten minutes each day; Group II ran twenty minutes each session; Group III ran thirty minutes each session; and Group IV engaged in thirty minutes of isometric exercises each session.

The significance of the mean gain between initial and final Harvard Step Test scores was established for each group. And an analysis of variance and orthogonal comparisons were used to compare the effectiveness of the four programs on Cardiovascular efficiency improvement. Regression was used to find any relationship between the amount of running and of the effects of the training programs for subjects of high and low cardiovascular conditions was made.

The findings were as follows:

1. Cardiovascular efficiency may be significantly improved by participation in running programs, and also by isometrics.

2. The running programs will bring about more improvement than isometrics.

3. Increasing running during training does not bring about proportionate increases in cardiovascular efficiency.

4. For subjects of high initial CVE [cardiovascular efficiency] , running programs of ten and/or twenty minutes a day are most effective in producing cardiovascular fitness. Also, an isometric exercise program is as effective as a program of running for thirty minutes a day in regard to changes in CVE for subjects of high initial status.

5. For subjects of low initial cardiovascular fitness, all four training programs are equally effective in improving CVE.

6. An isometric exercise program is significantly more effective in improving cardiovascular efficiency for subjects of low initial fitness than for subjects of high initial cardiovascular fitness (12:57-58).

Eighteen college females at South Dakota State University, Brookings, South Dakota were studied by Yeager and Brynteson (18). The women were divided into three groups which trained 10, 20, or 30 minutes a day at a heart rate of 144 beats per minute, three days per week for six weeks on a bicycle ergometer. Yeager gave all participants a pretest and posttest to determine the effects of the conditioning programs on cardiovascular efficiency. Two tests were administered to the training groups. They were: (A) Astrand Test of Predicted Maximal Oxygen Uptake (B) A test of physical work capacity. The conclusions of this study were as follows:

1. All three groups significantly improved in cardiovascular efficiency between Test I and Test II.

2. Predicted maximal oxygen uptake values increased five, five, and eight ml/kg per minute in the 10, 20, and 30 minute groups, respectively.

3. The 30 minute group, showed more consistent increase in cardiovascular efficiency than the other two (18:591).

Farid (7) studied forty college males at Sacramento State College, Sacramento, California for a period of four weeks on cardiovascular response. The subjects were randomly assigned into three experimental groups and one control group with ten men in each training group.

The groups were divided according to heart beat: Group I, 120-130 beats per minute; Group II, 140-150 beats per minute; Group III, 160-170 beats per minute. Analysis of group difference revealed that the 140-150 and 160-170 training groups improvement was significantly different from other groups. No other differences were statistically significant. It was noted that the study supported the hypothesis that when training to improve one's physical capacity to do work, the severity of the training effort is related to, but not proportional to, intensity of the training.

STUDIES RELATED TO THE VARSITY ATHLETE IN RELATIONSHIP TO CARDIOVASCULAR EFFICIENCY DEVELOPMENT

Cureton (6) observed no improvement in the post-step recovery pulse response among ten varsity basketball players followed over a competitive season. He attributed this to the fact that most of the players reported at the beginning of the season in good condition and that to improve them further would have demanded unusually heavy training.

Seven basketball athletes at the University of Texas, Austin, were studied by Campbell (5) to determine the effect of a season of competition on the heart. To produce a peak of 180 heart beats per minute preseason and postseason recovery of the heart was observed; and a variation of the resting heart rate between the preseason and postseason trials was not statistically significant.

A study by Adams (1) was undertaken to determine the effects of a season of track and field training and competition on several physical fitness measures that have been shown to be significantly different in athletes as compared to nonathletes and/or to change as a result of physical training.

The study was administered at the University of California, Davis, California. Skinfold and girth measurements, vital capacity, maximum breathing capacity, and pulse recovery counts after five minutes of bench stepping were taken on members of a college track and field team. The tests were conducted at the beginning, middle, and end of a season of training and competition.

The conclusions of the study are as follows:

1. There was no significant difference in body weight, several girth measurements, estimated body density, VC [vital capacity], and MBC [maximum breathing capacity] as a result of a three months of training and competition for college track and field.

2. A significant reduction in post-bench-step pulse recovery counts was noted, while no significant reduction in resting or post-bench step terminal heart rate was observed.

3. In no instance were significant differences observed between parameters measured at midseason (after 7 weeks of training) and at the end of the season.

4. The distance runners group was the only team subgroup to show significant reduction in step test recovery pulse counts.

5. The throwers group differed materially from the other team subgroups in virtually all parameters (1:13).

Tuttle and Walker (16) investigated the chronic effects of a season of training and competition on the heart response using fourteen track athletes. Each athlete participated in a training schedule consisting of one to two hours of jogging, sprinting, and distance running, and working in his particular special event. And each participant took part in the school's varsity track meets.

Work of measured intensity was performed, to study the response of the heart exercise. The exercise was stool-stepping at the rate of 35 steps per minute.

Their conclusions were:

1. There was no significant change in the resting heart rate, pulse rate immediately following exercise, rate above the resting rate after precise and primary recovery time, and recovery time.

2. The recovery pulse was less after the season indicating that there was an improvement in physical condition as shown by the fact that fewer heart beats were required in reaching the resting level.

3. Wherever the data showed trends toward altered cardic response, it was always in favor of more efficient heart action (16:81).

Roskamm (14) found that training at a heart rate of 70% of the difference between the heart rate at rest and that during maximum effort was effective in significantly improving physical work capacity. However, his data indicated that interval training under the same condition was equally effective or even more effective in improving the maximum work performance.

To determine the effects of a warm-up and a lack of a warm-up on the heart rate during specified exercise routines involving eight members of the University of North Carolina track and cross-country team was conducted by Howard (10). The variables of anticipatory increase in heart rate, maximum heart rate, and recovery decrease in heart rate were studied.

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

1. Routine I — Fifteen 100 yard runs at a moderate pace, in succession, without a warm-up, (twenty to twenty-five seconds per 100 yards).
2. Routine II — Fifteen 100 yard runs at a moderate pace, in succession, after a warm-up.
3. Routine III — A 440 yard run, executed in sixty-five seconds, without a warm-up.
4. Routine IV — A 440 yard run, executed in sixty-five seconds, after a warm-up.
5. Routine V — A Harvard Step Test (10:361).

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

Statistical analysis of the various factors involved showed that there was a high negative correlation ($r = -.8693$) between the maximum heart rate achieved during strenuous

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

SUMMARY

The two major categories under which the related literature was classified were: 1) studies related to the non-varsity athlete, and 2) studies related to the varsity athlete in relationship to cardiovascular efficiency development.

In the studies reported concerning activities of the non-varsity athlete upon cardiovascular efficiency, it was found that calisthenics (15), rope skipping (3), jogging (3) and isometric exercise (17) (12) will significantly improve cardiovascular efficiency. Milton (12) noted that

running programs will bring about more improvement than isometrics.

Of the investigations concerning the varsity athlete in relationship to cardiovascular efficiency development, there were six studies reviewed. Two studies were found to be successful in the development of cardiovascular efficiency. The other four studies found no significant increase in cardiovascular efficiency. Cureton (6) attributed this to the fact that most of the players reported at the beginning of the season in good condition and that to improve them further would have demanded unusually heavy training.

Chapter 3

METHODS AND PROCEDURES

The primary purpose of this study was to compare the effectiveness of a long distance running program to a sprint running program; each lasting for six weeks, six days a week, upon the cardiovascular efficiency of high school varsity participants as measured by the Harvard Step Test.

POPULATION AND SAMPLING

Wyandotte High School is located in Kansas City, Kansas and is a three-year institution, consisting of grades ten through twelve. Its basic purpose is to provide an adequate education for all students who meet requirements for admission in Unified School District 500 and who reside in the Wyandotte High School attendance area.

Wyandotte High School is located in the population center of the city. It is surrounded by the most established residential districts of the city. The building, with its famous twin towers, has a capacity for some 2,000 students. Its 1,800 seat auditorium, 2,000 seat gymnasium, and a short 60' x 28' swimming pool make it one of the most comprehensive buildings in the city, although it is now overcrowded.

The present building opened on September 13, 1937 as a replacement for the original school at Ninth Street and Minnesota Avenue, which was destroyed by fire on March 3, 1934.

There were fourteen male distance runners and nineteen male sprinters selected for this study. These subjects were sophomores, juniors, and seniors enrolled at Wyandotte High School during the second semester of the 1973 school year. All of the subjects volunteered for track and all had passed the Kansas State High School Activities Association physical examination for all students who participate in a varsity high school sport.

MATERIALS AND INSTRUMENTATION

At the first practice session of the season, the investigator explained to the subjects the procedure of the study and the importance of the subject's cooperation in the outcome of the study. To assist in the perfection of the testing procedure, volunteer students from another class practiced the procedure with the investigator. These students would not be involved in the study except as the pilot testing group.

The initial and final modified Harvard Step Tests were administered in identical situations in such a manner that the procedures employed for the initial test would be followed for the final test. An indoor bleacher, housed in an indoor track, was utilized for the eighteen-inch steps upon which

the subjects would be required to be tested. The indoor area also provided a regulated temperature throughout the duration of the testing portion of the study. Each subject was given a card with his name and the name of the testers. The card also had a place to record the three pulse rates for both initial and final tests and a place to total the three count.

The total group assembled in one small section of the bleachers, in such a way there would not be more than eight inches of space between subjects in a sitting position. Upon command all subjects were requested to number off by threes. These three groups would then be the testing subgroups. The subjects number "2" would be the first testee for the Harvard Step Test whereas the subjects numbered "1" and "3" would be identified as the testers. After having all the subgroups situated in terms of testees and testers the above-mentioned card was distributed to each subgroup. The testee then filled in his name and the testers.

After reviewing the test procedure, the testee stood facing an eighteen-inch bench and followed the directions from a tape recorder which was used for convenience and accuracy. The commands were: "Ready, up, two, three, four, and so forth." The command "up" was called out every two seconds. On that command the testee stepped up on the bench with one foot. On the command "two" he stepped up with the other foot to an erect position. On the command "three" he stepped down with the lead foot, and on the command "four" he stepped down

with the other foot to the original starting position. The four counts made one complete cycle and the testee repeated the cycle at the rate of thirty cycles per minute for a maximum of five minutes. Each subject was expected to keep up with the cadence of the recorder. If the subject stopped the investigator had a stop watch available to start so the participants could finish the test.

At the end of five minutes, all number one subjects were instructed by the tape to sit down on the benches. The recorder then instructed the other two subjects to prepare to count the pulse of number one by checking the pulse rate at the right and left wrist respectively, using the radial artery. They had one minute to make the necessary adjustments and find the pulse. On the command "count" the pulse was counted for twenty seconds. The waiting period was determined by the command from the tape recorder as to when to start and when to stop. The counters then multiplied their count by three to convert pulse rates to beats per minute. This number was then recorded on the subject's card. Forty seconds later, the tape recorder again gave the command, "count," and a second period of counting of pulse took place. This procedure was repeated three times at one minute intervals. In like manner, each subject was tested by following the directions of the tape recorder. Should any subject fail to finish the five minutes, this was noted on his card and his pulse was counted for one minute after stopping along with the two succeeding counts. However, it

was not expected that there would be any subjects who could not complete the test.

DESIGN OF THE STUDY

This study was designed to study the differences, which may exist between two methods of cardiovascular efficiency training upon high school track distance runners and sprinters.

The workouts selected for this study were collected over a four year period. A log book of training sessions was studied and the indicated workouts were selected for this study.

To test the level of cardiovascular efficiency the Harvard Step Test was selected. The Harvard Step Test is a valid measure of physical fitness (4) and no other testing devices were available.

DATA COLLECTION

The distance runners (Group 1) and sprinters (Group 2) were required to practice Monday through Saturday for approximately two hours each day. The school track located on the campus was used for the training program. In case of inclement weather the 220 yard indoor track located under the stadium was used.

A student manager was assigned to each test group to record the performance of each individual after he ran the specified distance. After the workout the investigator

computed the mean time for each individual and kept this information in a log book. Charts were kept so that the investigator could compare these mean times for the next workout. After the mean times were computed each runner was told of his progress for the day. At the next practice session the participants were encouraged to better their previous best average for that particular workout.

The participants in Group 1 followed a practice schedule as follows: First and second week, Monday running ten to twelve miles continuously; Tuesday, running 440 yards sixteen times with three minutes rest after each run; Wednesday, same as Monday; Thursday, running 660 yards ten times with five minutes rest after each run; Friday, running 880 yards two times with six minutes rest after each run, running 660 yards three times with five minutes rest after each run, running 440 yards five times with three minutes rest after each run, and running 220 yards eight times with two minutes rest after each run; Saturday, running time trials. Third and fourth week was the same as weeks one and two except the set of runs was increased by two repeats. And the rest period remained the same. Fifth and sixth week, was the same as weeks one and two except the set of runs ran were increased by four repeats. The rest period remained the same.

Group 2 followed a practice schedule as follows: First and second week, Monday, jogging three to five miles, fifteen minute rest period, running 660 yards four times with seven minutes rest after each run; Tuesday, running

440 yards six times with five minutes rest after each run; Wednesday, running 330 yards eight times with five minutes rest after each run; Thursday, running 220 yards eight times with four minutes rest after each run; Friday, running 110 yards ten times with two minutes rest after each run; Saturday, running time trials. Third and fourth week, was the same as weeks one and two except each distance to be run was increased by two repeats of that distance. The rest period remained the same. Fifth and sixth week, was the same as weeks one and two except that each distance to be run was increased by four repeats. The rest period remained the same.

The warmup for both groups consisted of jogging one-half mile and ten minutes of calisthenics before each practice session. The warmup was the same each day for the entire six week study.

The warmdown for Group 1 consisted of jogging one mile at the end of the practice each day of the six week study. Group 2 jogged one-half mile after each practice for their warmdown each day of the six week training period.

DATA ANALYSIS

The purpose of this study was to determine which method of training would have the greatest effect on the cardiovascular efficiency of high school varsity sprinters and distance runners. To determine the significant difference of the two training groups two statistical procedures were

employed. They were: 1) the t-test, and 2) an analysis of covariance.

t-test

The t-test was utilized in this study because of the small sample size. Both the t-test for correlated and uncorrelated data was used dependent upon the particular analysis in question.

t-test for correlated data. The formula for the t-test using correlated data was as follows:

$$t = \frac{\bar{X}_D - \bar{X}_S}{\sqrt{\frac{s^2_D}{n_D} + \frac{s^2_S}{n_S} - 2r\left(\frac{s_D}{\sqrt{n_D}}\right)\left(\frac{s_S}{\sqrt{n_S}}\right)}}$$

where: $\bar{X}_D$ = mean score value for the distance runners

$\bar{X}_S$ = mean score value for the sprinters

s^2_D = variance found for distance runners

s^2_S = variance obtained for sprinters

n_D = sample number of distance runners

n_S = sample number of sprinters

r = correlation

s_D = standard deviation for distance runners

s_S = standard deviation for sprinters

df = n-1; where n = number of pairs

t-test for independent samples. The formula for the t-test using independent samples was as follows:

$$t = \frac{\bar{X}_D - \bar{X}_S}{\sqrt{\left(\frac{\Sigma x^2_D + \Sigma x^2_S}{n_D + n_S - 2}\right)\left(\frac{1}{n_D} + \frac{1}{n_S}\right)}}$$

where: $\bar{X}_D$ = mean score value for the distance runners

$\bar{X}_S$ = mean score value for the sprinters

Σx^2_D = sum of squares for distance runners

Σx^2_S = sum of squares for sprinters

n_D = sample number of distance runners

n_S = sample number of sprinters

$df = n_D + n_S - 2$: where n = number of pairs

Analysis of Covariance

The statistical method used to determine if the combined experimental programs provided significant results was the analysis of covariance.

The analysis of covariance is one of the most valuable tools of statistical inference. It was selected for this study because the number of subjects involved was a small quantity and that a pretest and posttest were administered (13).

Covariance may be defined as the mean of the products of the deviations from the mean, and it may be calculated from the formula:

$$COV = \frac{SP}{N}$$

The analysis of covariance involves the partitioning of the total sum of products. The total sum of products may be calculated from:

$$SP_t = \sum_{j=1}^{k} \sum_{i=1}^{nj} X_{ij}Y_{ij} - \frac{T_x T_y}{N}$$

Where T_x and T_y are the sums of the respective X and Y measures for all groups.

The sum of products between groups may be calculated from:

$$SP_b = \sum_{j=1}^{k} \frac{T_{xi}\ T_{yi}}{nj} - \frac{T_x T_y}{N}$$

Where T_{xi} and T_{yi} are the sums of the X and Y measures for the jth group.

The sum of products within groups may be calculated as a residual:

$$SP_w = SP_t - SP_b$$

Notice that only three terms need to be evaluated to complete the calculation. Consider the first term of the total sum of products:

$$\sum_{j=1}^{k} \sum_{i=1}^{nj} X_{ij}\ Y_{ij}$$

To evaluate this term, one need only (a) pair each X-score in the entire collection with its corresponding Y-score, and take the product of each pair and (b) sum all of these products. Next, consider the second term of the total sum of products and of the sum of products between:

$$\frac{T_x T_y}{N}$$

To evaluate this term, (a) take the sum of all of the X-measures in the entire collection, and do the same for the Y-measures, (b) take the product of these two sums, and (c) divide by N.

Finally, to evaluate the first term of the sum of products between: $\sum_{j=1}^{k} \frac{T_{kj}\ T_{yi}}{n_j}$

(a) take the sum of the X-measures for each group in the collection, and do the same for the Y-measures, (b) pair each X-sum with the Y-sum for the same group, and take the product for each group, (c) divide each product by the number of subjects in the group, and (d) sum for all groups.

All of the sums of squares, sums of products, mean squares, and degrees of freedom are represented in a summary table such as this:

Summary Table for the Analysis of Covariance

Source	df	SS_x	SP	SS_y	df'	SS'_y	MS'_y
Between							
Within							
Total							XXX

The two statistical procedures employed were the: 1) t-test, and 2) the analysis of covariance. In order to calculate the t-test and the analysis of covariance the Monroe 1785 calculator was used for all calculations.

Chapter 4

ANALYSIS OF DATA

The primary purpose of this study was to compare the effectiveness of a long distance running program to a sprint running program; each lasting for six weeks, six days a week, upon the cardiovascular efficiency of high school varsity participants as measured by the Harvard Step Test.

RESPONSE ANALYSIS

As described in Chapter 3, there was a total of fourteen distance runners and nineteen sprinters that participated in the initial training program. Upon completion of this investigation, only twelve distance runners or eighty-six percent finished the six week training program. And only eighteen sprinters or ninety-five percent finished the six week training program. Two of the participants moved out of town and one participant quit the track team after the pretraining Harvard Step Test was administered.

STATISTICAL ANALYSIS

The statistical methods used to determine the significant difference in this study were the t-test and the analysis of covariance. The t-test was used to determine the level of significance between Group 1 and Group 2. To determine

the significant difference between both Groups 1 and 2 the analysis of covariance was utilized.

Group 1

These participants were sophomores, juniors, and seniors enrolled at Wyandotte High School, Kansas City, Kansas during the second semester of the 1973 school year.

Pretraining and Posttraining Resting Pulse for the Harvard Step Test. Table 1 shows the pretraining and posttraining means of the resting pulse of Group 1. The pretraining resting pulse mean was 80.081 and a standard deviation of 12.164, while the mean value and the standard deviation on the posttraining resting pulse were 76.917 and 13.249 respectively.

Table 1

t-Test for the Pretraining and Posttraining Resting Pulse for Group 1 on the Harvard Step Test

Test	Number	Standard Deviation	Mean Values	*t*
Pretraining H.S.T.	12	12.164	80.081	2.207
Posttraining H.S.T.	12	13.249	76.917	

$t \geq 2.201$ with 11 df

At 11 degrees of freedom (df = n-1), a value greater than or equal to a $t = 2.201$ (.05 level of significance) was needed to reject the null hypothesis. Since the obtained value of $t = 2.207$ (refer to formula p. 26) was greater than

t = 2.201 the null hypothesis was rejected. It was concluded that there was a significant difference between the resting pulse of Group 1 (distance runners) on the pretraining and posttraining Harvard Step Test.

Pretraining and Posttraining Recovery Pulse for the Harvard Step Test. The total mean values of pretraining and posttraining results are shown in Table 2. Group 1 had a total pretraining mean value of 283.167 and a standard deviation of 38.033.

Table 2

t-Test for the Pretraining and Posttraining Recovery Pulse for Group 1 on the Harvard Step Test

Test	Number	Standard Deviation	Mean Values	t
Pretraining H.S.T.	12	38.033	283.167	0.998
Posttraining H.S.T.	12	38.462	275.917	

$t \geqslant 2.201$ with 11 df

For 11 degrees of freedom (df = n-1), a value greater than or equal to a t = 2.201 at the .05 level of significance was needed to reject the null hypothesis. Since the obtained value of t = 0.998 (refer to formula p. 26) was not greater than t = 2.201, the null hypothesis was retained. It was concluded that there was no significant difference between the pretraining and posttraining values for Group 1.

The reader will note in Table 1 that there was a significant difference in the resting pulse of Group 1, but in Table 2 there was not a significant difference in the recovery pulse. Due to the nature of the work this non-significant difference occured.

Group 2

The participants in Group 2 were sophomores, juniors, and seniors enrolled at Wyandotte High School, Kansas City, Kansas during the second semester of the 1973 school year.

Pretraining and Posttraining Resting Pulse for the Harvard Step Test. Table 3 shows the pretraining and post-training values of the resting pulse for Group 2 (sprinters). The mean resting pulse for the pretraining Harvard Step Test was 73.611 and the posttraining mean resting pulse was a value of 71.056. The table also shows the standard deviation for the pretraining resting pulse to be 9.623 and the posttraining standard deviation was 8.993.

Table 3

t-Test for the Pretraining and Posttraining Resting Pulse for Group 2 on the Harvard Step Test

Test	Number	Standard Deviation	Mean Values	t
Pretraining H.S.T.	18	9.623	73.611	2.77
Posttraining H.S.T.	18	8.993	71.056	

$t \geq 2.110$ with 17 df

Using 17 degrees of freedom (df = n-1), a value greater than or equal to a $t = 2.110$ at the .05 level of significance was needed to reject the null hypothesis. The null hypothesis was rejected because $t = 2.77$ (refer to formula p. 26) was greater than $t = 2.110$. It was concluded that there was a significant difference between the pretraining and posttraining resting pulse for Group 2 at the .05 level.

Pretraining and Posttraining Recovery Pulse for Group 2. The pretraining and posttraining recovery pulse (Table 4) for Group 2 after a six week training program was studied. Group 2 had a pretraining recovery pulse mean value of 263.889 and a standard deviation of 29.560, while the posttraining recovery pulse mean value was 256.067 and a standard deviation of 24.817.

Table 4

t-Test for Pretraining and Posttraining Recovery Pulse for Group 2 on the Harvard Step Test

Test	Number	Standard Deviation	Mean Values	t
Pretraining H.S.T.	18	29.560	263.889	1.474
Posttraining H.S.T.	18	24.817	256.067	

$t \geq 2.110$ with 17 df

At 17 degrees of freedom (df = n-1), a value greater than or equal to a t = 2.110 (.05 level of significance), was needed to reject the null hypothesis. Since the obtained value of t = 1.474 (refer to formula p. 26) was not greater than t = 2.110 the null hypothesis was retained. It was concluded that there was no significant difference between the recovery pulse on the pretraining and posttraining Harvard Step Test for Group 2.

Comparisons of Group 1 and Group 2 for the Resting Pulse

Pretraining Harvard Step Test Comparisons. Table 5 shows the pretraining resting pulse of Group 1 and Group 2. Group 1 had a mean resting pulse value of 80.081, while Group 2 had a mean resting pulse value of 73.611. The table also shows a standard deviation of 12.164 for Group 1 and a standard of 9.623 for Group 2.

Table 5

t-Test for Pretraining Resting Pulse for Group 1 and Group 2 on the Harvard Step Test

Group	Number	Standard Deviation	Mean Values	*t*
Distance	12	12.164	80.081	1.369
Sprinters	18	9.623	73.611	

$t \geqslant 2.052$ with 28 df

For 28 degrees of freedom ($df = n_D + n_S - 2$) at the .05 level of significance, a value of $t = 2.052$ was needed to reject the null hypothesis. The null hypothesis was retained because $t = 1.369$ was not greater than $t = 2.052$. It was concluded that there was no significant difference between the population means of Group 1 and Group 2 at the .05 level.

Posttraining Harvard Step Comparisons. The posttraining resting pulse (Table 6) for Group 1 and Group 2 after a six week, six days a week training program was studied. Group 1 had a mean resting pulse of 76.917, while Group 2 had a mean resting pulse of 71.056. The table also shows a standard deviation of 13.249 for Group 1 and 8.993 for Group 2.

Table 6

t-Test for Posttraining Resting Pulse for Group 1 and Group 2 on the Harvard Step Test

Group	Number	Standard Deviation	Mean Values	*t*
Distance	12	13.249	76.917	1.447
Sprinters	18	8.993	71.056	

$t \geqslant 2.048$ with 28 df

Using 28 degrees of freedom ($df = n_D + n_S - 2$), a value greater than or equal to a $t = 2.048$ (.05 level of significance), was needed to reject the null hypothesis. Since the obtained value of $t = 1.447$ (refer to formula p. 26) was not greater than $t = 2.048$ the null hypothesis was retained. It was concluded that there was no significant difference between the population means of Group 1 and Group 2.

Pretraining Harvard Step Test Recovery Pulse. The pretraining recovery pulse for Group 1 and Group 2 is shown in Table 7. Group 1 had a recovery pulse mean value of 283.167 and a standard deviation of 38.033. Group 2 had a recovery pulse mean value of 263.889 and a standard deviation of 29.560.

Table 7

t-Test for the Recovery Pulse for Group 1 and Group 2 on the Pretraining Harvard Step Test

Group	Number	Standard Deviation	Mean Values	*t*
Distance	12	38.033	283.167	1.561
Sprinters	18	29.560	263.889	

$t \geq 2.048$ with 28 df

At 28 degrees of freedom ($df = n_D + n_S - 2$), a value greater than or equal to a $t = 2.048$ (.05 level of significance), was needed to reject the null hypothesis. Since the obtained value of $t = 1.561$ was not greater than $t = 2.048$ the null hypothesis was retained. It was concluded that there was no significant difference in the mean value of the populations in the total recovery pulse value of the pretraining measures.

Posttraining Harvard Step Test Recovery Pulse. Table 8 shows the posttraining Harvard Step Test recovery pulse of Groups 1 and 2. The table shows the mean value of 275.917 and a standard deviation of 38.462 for Group 1, while the mean value and standard deviation of Group 2 were 256.067 and 24.817 respectively.

Table 8

t-Test for the Posttraining Recovery Pulse for Group 1 and Group 2 on the Harvard Step Test

Group	Number	Standard Deviation	Mean Values	*t*
Distance	12	38.462	275.917	1.671
Sprinters	18	24.817	256.067	

$t \geqslant 2.048$ with 28 df

Using 28 degrees of freedom at the .05 level of significance, a value of $t = 2.048$ was needed to reject the null hypothesis. The null hypothesis was retained because $t = 1.671$ (refer to formula p. 26) was not greater than or equal to $t = 2.048$. It was concluded that there is no significant difference in the mean scores of the two populations in the recovery pulse of the posttraining measures.

Analysis of Covariance for Pretraining and Posttraining Harvard Step Test Measures. The statistical procedure for the analysis of covariance was shown in Chapter 3, pages 27-28. The results of the pretraining and posttraining values were used to determine if there was a significant difference between the resting pulse of Groups 1 and 2.

Table 9 represents the results of the two groups over the six week training program. This test yielded an adjusted mean value of -289.04 between groups and a 19.2684 adjusted

mean value within groups. Using the covariates involved, an F-value of -15.0007 was obtained.

Table 9

Analysis of Covariance of Resting Pulse for Pretraining and Posttraining Harvard Step Test for Group 1 and Group 2

Source	df	SS_x	SP	SS_y	df'	SS'_y	MS'_y
Between	1	301.60	273.1	247.34	1	-289.04	-289.04
Within	28	3161.20	2967.4	3305.86	27	520.25	19.26
Total	29	3462.80	3240.6	3553.20	28	231.21	XXX

F needed at .05 level; 4.21

$$F = \frac{MS'_{by}}{MS'_{wy}} = -15.0007$$

The critical F-value for 1 and 27 degrees of freedom at the .05 level of significance was 4.21. The value of -15.0007 was obtained. Therefore, it was concluded that there was a significant difference with the F-ratio because -15.0007 is greater than 4.21 and the null hypothesis was rejected. The adjusted mean $\left(\overline{Y}'_D\right)$ for Group 1 was 80.13, which was significantly greater than the adjusted mean $\left(\overline{Y}'_S\right)$ of 68.87 for Group 2 with respect to the resting pulse.

Analysis of Covariance for Recovery Pulse on Pretraining and Posttraining Harvard Step Test Measures. The pretraining and posttraining recovery pulse rate for Groups

1 and 2 is shown in Table 10 below. An adjusted mean value of -15635.95 was found between the groups and a 982.20 adjusted mean value was determined within the groups. For the covariates involved, an F-value of -15.919 was acquired.

Table 10

Analysis of Covariance of Recovery Pulse for Pretraining and Posttraining Harvard Step Test for Group 1 and Group 2

Source	df	SS_x	SP	SS_y	df'	SS'_y	MS'_y
Between	1	2675.75	2533.0	2398.05	1	-15635.95	-15635.95
Within	28	30765.45	2116.5	26664.92	27	26519.32	982.20
Total	29	33441.20	23649.6	29062.97	28	10883.37	XXX

F needed at .05 level; 4.21

$$F = \frac{MS'_{by}}{MS'_{wy}} = -15.919$$

At the .05 level of significance on the F-Distribution Table the critical value of 1 and 27 degrees of freedom was 4.21. The value of -15.919 was obtained. It was concluded that there was a significant difference between the pretraining and posttraining recovery pulse measures of the two groups with the F ratio because -15.919 is greater than 4.21 at the .05 level. The adjusted mean $\left(\bar{Y}'_D\right)$ for Group 1 was 276.00, which was significantly greater than the adjusted mean $\left(\bar{Y}'_S\right)$ of 255.80 for Group 2 with respect to the recovery pulse.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to compare the effectiveness of a long distance running program to a sprint running program; each lasting for six weeks, six days a week, upon the cardiovascular efficiency of high school varsity participants as measured by the Harvard Step Test.

The subjects involved in this study were twelve varsity distance runners and eighteen varsity sprinters during the second semester of 1973 at Wyandotte High School, Kansas City, Kansas.

All subjects were given the Harvard Step Test on the first day of track practice, which served as the pretraining measure of cardiovascular efficiency. Both groups trained six days a week for a period of six weeks. At the end of the six week period, the Harvard Step Test was again administered to all subjects to obtain the post-training measure.

To determine the level of significance of the two training groups two statistical procedures were employed. They were: 1) the *t*-test, and 2) an analysis of covariance.

FINDINGS

The findings of the study were as follows:

1. After a six week training program of distance running (Group 1) the resting pulse was improved by a difference of 3.164 which was significant at the .05 level using the t-test as the statistical procedure.

2. After a six week sprint training program (Group 2) the resting pulse was improved by a difference of 2.555 which was significant at the .05 level utilizing the t-test.

3. Comparisons on mean resting pulse for Group 1 and Group 2 after a six weeks of training a difference of 5.861 was not significant at the .05 level with the t-test.

4. Comparisons on recovery rate for Groups 1 and 2 after a six week training program a difference of 19.850 was not significant at the .05 level when the t-test was used.

5. The program of long distance running group resulted in a greater change on resting pulse as compared to the resting pulse of the sprint training group on the analysis of covariance at the .05 level of significance.

6. The sprint training group resulted in a greater change on their recovery pulse as compared to the long distance running group recovery pulse as found by the analysis of covariance test at the .05 level of significance.

CONCLUSIONS

Within the limitations of this study the following conclusions were reached:

1. That resting pulse can be significantly improved through either a program of distance running or sprint training.

2. Harvard Step Test performance can be enhanced or improved by the two forms of training, but, not to a significant degree.

3. When comparing the long distance training program to the sprint training program there was a significant difference between the effects of the two programs in so far as recovery pulse after the Harvard Step Test.

RECOMMENDATIONS FOR FURTHER STUDY

As a result of the findings in this study, the following recommendations are suggested for further study:

1. Further studies should be made to compare non-athletes to athletes for cardiovascular efficiency in a senior high school after receiving various forms of training.

2. Studies should be made to determine the effects of detraining of athletic participation upon cardiovascular efficiency so as to evaluate the present findings more completely.

3. Further studies should be made using different age limits and sexes upon cardiovascular efficiency.

4. Further studies should be made to determine the cardiovascular efficiency obtained after a twelve month training program where tests of cardiovascular efficiency

would be made at every six weeks of the season to investigate the leveling off effects of training.

5. Further studies should be made to determine the cardiovascular efficiency obtained after a semester of physical education programs of large group and small group activities. (For example; touch football, basketball, volleyball, and gymnastics).

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BIBLIOGRAPHY

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APPENDIXES

APPENDIX A

HARVARD STEP TEST RECORD CARD

NAME_____ GROUP S or D

First Harvard Step Test		Second Harvard Step Test	
1 minute	_____	1 minute	_____
2 minutes	_____	2 minutes	_____
3 minutes	_____	3 minutes	_____
Total	_____	Total	_____

Name of Helper_____

WYANDOTTE HIGH SCHOOL
DAILY RECORD SHEET

DATE _____
PLACE _____

WU: WO: WD:

AVERAGE

1																											
2																											
3																											
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APPENDIX C

HARVARD STEP TEST
DATA SHEET

Group 1
Pulse Counts

Student initial	Pre-resting	Post-resting	Pre-recovery	Post-recovery
M.A.	72	70	295	253
B.F.	70	66	258	306
M.M.	69	60	246	223
R.P.	90	90	295	294
R.P.	90	80	303	318
B.R.	78	78	256	258
D.S.	90	74	296	270
G.S.	78	81	291	269
R.V.	69	66	204	228
D.W.	63	60	258	235
R.W.	102	102	334	324
J.Y.	90	88	342	333

APPENDIX D

HARVARD STEP TEST
DATA SHEET

Group 2
Pulse Counts

Student initial	Pre-resting	Post-resting	Pre-recovery	Post-recovery
G.A.	66	66	269	243
M.B.	78	75	283	276
M.B.	63	63	261	237
T.C.	75	66	283	270
A.E.	96	96	313	312
J.F.	72	72	281	277
J.H.	72	72	237	246
H.H.	66	62	222	256
J.J.	75	66	257	220
R.J.	80	72	285	279
R.J.	63	63	223	219
A.K.	75	75	285	255
D.M.	75	75	280	273
K.M.	84	78	300	279
A.M.	81	81	273	269
V.N.	57	56	201	247
D.R.	84	75	259	240
F.W.	63	66	238	222