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Stair-running as a Training Method

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STAIR-RUNNING AS A TRAINING METHOD

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STAIR-RUNNING AS A TRAINING METHOD

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

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STAIR-RUNNING AS A TRAINING METHOD
Abstract

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Under the supervision of Assistant Professor M. Thomas Woodall

The purpose of this investigation was to determine whether subjects who participated in a vigorous stair-running program experienced significant changes in explosive power, leg strength, and cardiovascular efficiency.

The following procedure was employed: Six male, freshman students at South Dakota State College volunteered to take part in the study conducted over a seven week period during the Spring semester of the 1964 school year. The subjects were tested initially and finally by the author using the Sargent Vertical Jump Test, cable-tension tests of knee extension strength and knee flexion strength, and the Harvard Step Test. In addition, initial and final resting heart-rates were taken as well as daily resting heart-rates during the training program. The training program lasted for twenty-five days and involved running up one flight of twenty-nine steps, followed by twelve flights of twelve steps and walking down. As the program progressed the number of repetitions per day increased, the pace for each repetition became faster, and the rest interval between repetitions was shortened.

As a result of the findings obtained during this investigation, the following conclusions appear warranted. A program of stair-running, as conducted in this study, may significantly decrease

resting heart-rates. It may also improve cardiovascular efficiency as measured by the Harvard Step Test. The Sargent Vertical Jump Test and cable-tension tests of knee extension strength and knee flexion strength failed to show mean gains or losses which were significant.

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Chapter I

INTRODUCTION

The effect of various training programs on the human body has long been a topic for discussion among physical educators, athletic coaches and physiologists. Although physical educators are concerned with physical fitness they are not interested in producing an individual who reaches the peak of condition necessary for strenuous athletic contests such as those found on the interscholastic or intercollegiate level. Individuals concerned with building strong competitive teams have gone to great lengths to provide the type of physical conditioning program they feel can best prepare the individual athlete to meet competition. This conditioning period must often be confined to a few short weeks where the level of physical attainment will, at best, be low.

Most coaches agree that in order to have champion athletes and championship teams the individual athletes must have muscular strength and cardiovascular conditioning sufficient to meet the challenges of prolonged, strenuous competition. It is, therefore, of primary concern to the coaches involved to develop strong cardiovascular and muscular systems in athletes in relatively short periods of time.

Feeling that explosive power, leg strength, and cardiovascular efficiency were of prime importance to a variety of athletic events, the author became interested in stair-running as a vehicle for improving these aspects of physical fitness.

The literature revealed no research pertaining strictly to the use of stair-running as a training method, however, Charles Paddock, the great sprinter of more than forty years ago, included in his daily running schedule sprints up a 200-yard hill at an angle of about thirty to forty degrees, or several flights of stairs.[1] Reference is also

[1]Ernst Jokl, M. D., Physique, Muscle Strength and Performance, Amateur Athlete, December, 1962, p. 15.

made to the use of stair-running in a pre-season conditioning program as a substitute for inclined hill running for track athletes by Dave Rankin,[2] Track Coach, Purdue University. Bill Ferrell,[3] Trainer at

[2]Dave Rankin, Training Program for Sprinters, Athletic Journal, December, 1962, p. 18.

[3]Bill Ferrell, Sports Illustrated, March 2, 1964, p. 8.

Arkansas, states that their football teams are now resuming the old practice of running the stadium stairs after becoming dissatisfied with the results of isometric exercises. Tommy Evans,[4] Wrestling Coach of

[4]From notes taken at the University of Minnesota Wrestling Clinic, November 9, 1963.

the 1963 National Champions reports stair-running as being an important part of their conditioning program.

A noted physiologist makes the following statement concerning stair-running. "It has been estimated that at the same rate of speed

one uses 15 to 17.7 times more energy in climbing to a certain height than he does in walking, on a level, a distance equal to that height."[5]

[5]Peter V. Karpovich, Physiology of Muscular Activity, p. 99.

The apparent lack of material in the field relating to stair-running seems to indicate a need for further study. It is for this reason that this investigation was begun.

Statement of Problem

The purpose of this study was to determine whether subjects who participated in a vigorous stair-running program experienced significant changes in explosive power, leg strength and cardiovascular efficiency.

Limitations of Study

The outstanding limitation in this investigation was the small number of subjects with which the investigator was able to work.

Assumptions

For the purpose of this study the following four items are listed as assumptions:

1. The subjects physical activity was confined to that of the training program.

2. Heart-rates taken after ten minutes at rest in the supine position, prior to exercise, properly represents the normal resting heart-rate of the individual.

3. Fluctuations in temperature of the unheated campanile had no effect on the results of the study or the conclusions made.

4. The training program was of sufficient length and intensity to cause desired changes in the measurements under investigation.

Chapter II

PROCEDURE FOR OBTAINING DATA

Subjects

Six male students enrolled, during the spring semester of the 1963-64 school year, in the service program of physical education at South Dakota State College volunteered as subjects. A physical examination was given each individual and no subject was used who possessed a history of physical defects or disorders of any type.

For the purpose of greater control over the activity of the subjects and due to the strenuous nature of the experiment, the subjects were exempted from the required physical education activity during the seven week period from February to the end of March, 1964.

The subjects selected were not at the time, nor had they previously been, members of an athletic team at South Dakota State College.

Through written and oral communication, each subject was urged to continue, throughout the experiment, his usual eating, sleeping, drinking, smoking, and exercise habits. All of the subjects were cooperative, displayed an interest in the study and agreed to follow the rules and regulations regarding their conduct.

Measurements

The measurements used in this study are considered in two categories: Those undertaken before the investigation began will be

referred to as the initial tests, and those used after the five week training period was completed will be referred to as the final tests. A familiarization period was conducted to acquaint the subjects with the various measuring devices during the week prior to the investigation.

Explosive Power

Initial and final Sargent Vertical Jump Tests were administered to each subject. The procedure for administration of the Sargent Vertical Jump Test was as follows: The subject dipped his fingers in chalk dust and assumed a position in front of a board calibrated in inches. While standing flat-footed the subject reached as high as possible and touched the board, thus leaving a chalk mark. The individual then swung his arms downward and backward taking a crouch position with knees bent approximately at right angles. The subject paused in this position, to eliminate the possibility of a double jump, and leaped upward as high as possible, swinging the arms forcefully forward and upward touching the board while at the highest point of the jump. The reaching height was subtracted from the jumping height and the best of three trials was recorded.

Leg Strength

Cable-tension tests of knee extension strength and knee flexion strength were administered initially and finally to each subject. The administrative procedure for the cable-tension test of knee extension strength was as follows: The subject was seated on a table

in a backward-leaning position, arms were extended to rear, hands grasping sides of the table. A regulating leg strap was placed midway between the knee and ankle joints with a pulling assembly attached to a hook beneath the table. A goniometer was used to check the standardized 115 degree tibiofemoral angle. A tensiometer was used to measure the strength of muscles that cause extension of the lower leg at the knee joint. When the subject was found to be in the correct position the author gave the command "pull." Three trials were performed and the highest of three readings was recorded for each subject. Right and left leg scores were added together to give a combined leg strength score for knee extension.

The administrative procedure for testing knee flexion strength was as follows: The subject assumed a prone lying position on a table with the parellae just at the edge, the head resting on folded arms. A regulating leg strap was positioned midway between the knee and ankle joints with a pulling assembly attached to a hook below and at the lower end of the table. A goniometer was used to check the tibiofemoral angle at a standardized 165 degrees flexion. A tensiometer was used to measure the strength of muscles that cause flexion of the lower leg at the knee joint. When the subject was found to be in the correct position the author gave the command "pull." Three trials were performed and the highest of three readings was recorded for each subject. Right and left leg scores were added together to give a combined leg strength score for knee flexion.

Harvard Step Test

The Harvard Step Test was administered initially and finally to determine cardiovascular efficiency as indicated by the Physical Efficiency Index, (PEI). The procedure for administration of the Harvard Step Test was as follows: The subject stepped up and down thirty times a minute on a bench twenty inches high. The cadence was held constant by use of a metronome. Stepping was done in four counts with the subject stepping all the way up on the bench with an erect body.

The stepping exercise continued for exactly five minutes as all subjects were able to complete the test. The duration of the exercise in seconds was recorded, 300 being the maximum for the full five-minute period.

Immediately after completing the exercise, the subject sat on a chair. The pulse was counted 1 to 1½, 2 to 2½, and 3 to 3½ minutes after the stepping ceased.

A Physical Efficiency Index (PEI) was computed, utilizing the following formula:

$$PEI = \frac{\text{Duration of Exercise in Seconds X 100}}{\text{2 X Sum of Pulse Counts in Recovery}}$$

Heart-rate

The heart-rate was taken each school day during the week prior to the training period, a total of five times. The first two days were used as periods of familiarization and were not used in the compilation of data. The remaining three heart-rates were averaged

to determine the initial resting heart-rate prior to the training period. The same procedure was followed after the five week training period to determine the final resting heart-rate. The heart-rate was also checked each day during the training period prior to exercise. The high and low recordings were rejected and the remaining three averaged to determine the average weekly heart-rates during the training program.

The subjects were asked to report at 5:00 P.M. each day. When the subjects arrived they assumed a supine position on individual mattresses placed on the floor in an isolated room. Ten minutes after they had assumed this quiet, resting position the author began checking heart-rates.

Training Program

The training program which began on February 17, 1964, and ended March 20, 1964, was conducted in the campanile on the campus of South Dakota State College. The training program lasted for twenty-five days and involved running up one flight of twenty-nine steps, followed by twelve flights of twelve steps. One repetition in the training program necessitated running up the stairs to the top of the campanile, at a certain pace, and walking down. Upon arriving at the bottom, subjects received a short period of rest. Table I describes the training program for all subjects. As Table I reveals, subjects were placed under increased stress as the program progressed. The

number of repetitions per day increased, the pace for each repetition became faster, and the rest interval between repetitions was shortened.

Table I

Training Program

Days	Number of Repetitions	Running Pace (Seconds)	Rest Interval (Minutes)
1-2	2	45	2.5
3-5	3	45	2.5
6-8	4	45	2.5
9-10	5	45	2.5
11-13	5	42	2.5
14-15	6	42	2.5
16-18	7	42	2.5
19-21	8	42	2.0
22-23	9	42	2.0
24-25	10	42	2.0

Chapter III

ANALYSIS OF DATA

The statistical analysis of the data used to determine whether subjects who participated in a vigorous stair-running program experienced significant changes in explosive power, leg strength, and cardiovascular efficiency appears in this chapter.

Conversion of Raw Scores

The raw scores (tension pounds) obtained on the strength tests were converted to pounds and the raw scores obtained for the Harvard Step Test were converted to Physical Efficiency Index points before the analysis began. The raw scores obtained on the Sargent Vertical Jump Test and the heart-rates required no conversion in this investigation.

Reliability

The reliabilities of three of the tests employed in this investigation were determined through a test-retest method. A rho or a rank order correlation was computed for each of the three tests. The reliability scores were as follows: Knee extension strength .84, Knee flexion strength .80, Sargent Vertical Jump .93. A test of reliability was not conducted for the Harvard Step Test. Although the reliability of the Harvard Step Test has been questioned by some, it is still widely used as an inexpensive method of testing cardiovascular efficiency since a great deal of equipment is not necessary.

Analysis of Data

The following six tests were administered: Sargent Vertical Jump, knee extension strength, knee flexion strength, Harvard Step Test, initial to final heart-rates, and average weekly heart-rates. For all the tests, except average weekly heart-rates, the initial and final means were determined as suggested by McCloy.[6] The standard

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[6] C. H. McCloy, and N. D. Young, Tests and Measurements in Health and Physical Education, p. 431.

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error of the differences between the initial and final means and the critical ratio was obtained. The null hypothesis was rejected if the obtained t ratio was greater than 4.03. The one percent level of confidence was chosen and five degrees of freedom were present in this investigation. In addition, an analysis of variance was conducted to determine if a significant difference occurred between average weekly heart-rates.

Table II shows the individual gain or loss, the average gain or loss, and the level of significance for each test.

Findings

Sargent Vertical Jump

It is interesting to note that a mean loss of .75 inches was observed for subjects on the Sargent Vertical Jump Test. A t ratio of .88 was found; therefore, the null hypothesis was accepted.

Table II

Individual Gain or Loss, Average Gain or Loss,

and Level of Significance for Each Test Item

Measurements	Subject Number 1	2	3	4	5	6	Average Gain/Loss	Stat. Sig. of Gain/Loss
Vertical Jump (inches)	.50	1	-1.50	-.50	-2	-2	-.75	.50
Knee Extension (pounds)	-78	-38	95	73	-144	-117	-34.8	.60
Knee Flexion (pounds)	-23	10	45	42	21	38	22.1	.10
Harvard Step Test (PEI Units)	13	11	13	15	19	1	12	.01*
Initial--Final Heart-rate (beats per min.)	-20	-4	-8	-11	-12	-18	-12.17	.01*

*Significant for this study

Knee Extension Strength

The mean loss for subjects on the cable-tension test of knee extension strength was 34.8 pounds. The critical ratio was calculated and found to be .68, which was not significant for this study and the null hypothesis was accepted.

Knee Flexion Strength

The mean gain for subjects on the cable-tension test of knee flexion strength was 22.1 pounds. The critical ratio was calculated and found to be 2.08, which was not significant for this study; therefore, the null hypothesis was accepted.

Harvard Step Test

The mean gain in cardiovascular efficiency for subjects on the Harvard Step Test is shown in terms of physical efficiency points and was found to be twelve points. The t ratio of 4.88 indicated significance at the one percent level of confidence, therefore, the null hypothesis was rejected.

Initial-Final Heart-rate

The mean gain in heart-rate efficiency, i.e., decrease in beats per minute, was found to be 12.17. (Table I) A t ratio of 4.89 was found, therefore, the null hypothesis was rejected. Figure 1 shows the average weekly heart-rates for individual subjects. It is interesting to note that all subjects, at all levels, decreased steadily in heart-rate after the first week in comparison with the initial heart-rate.

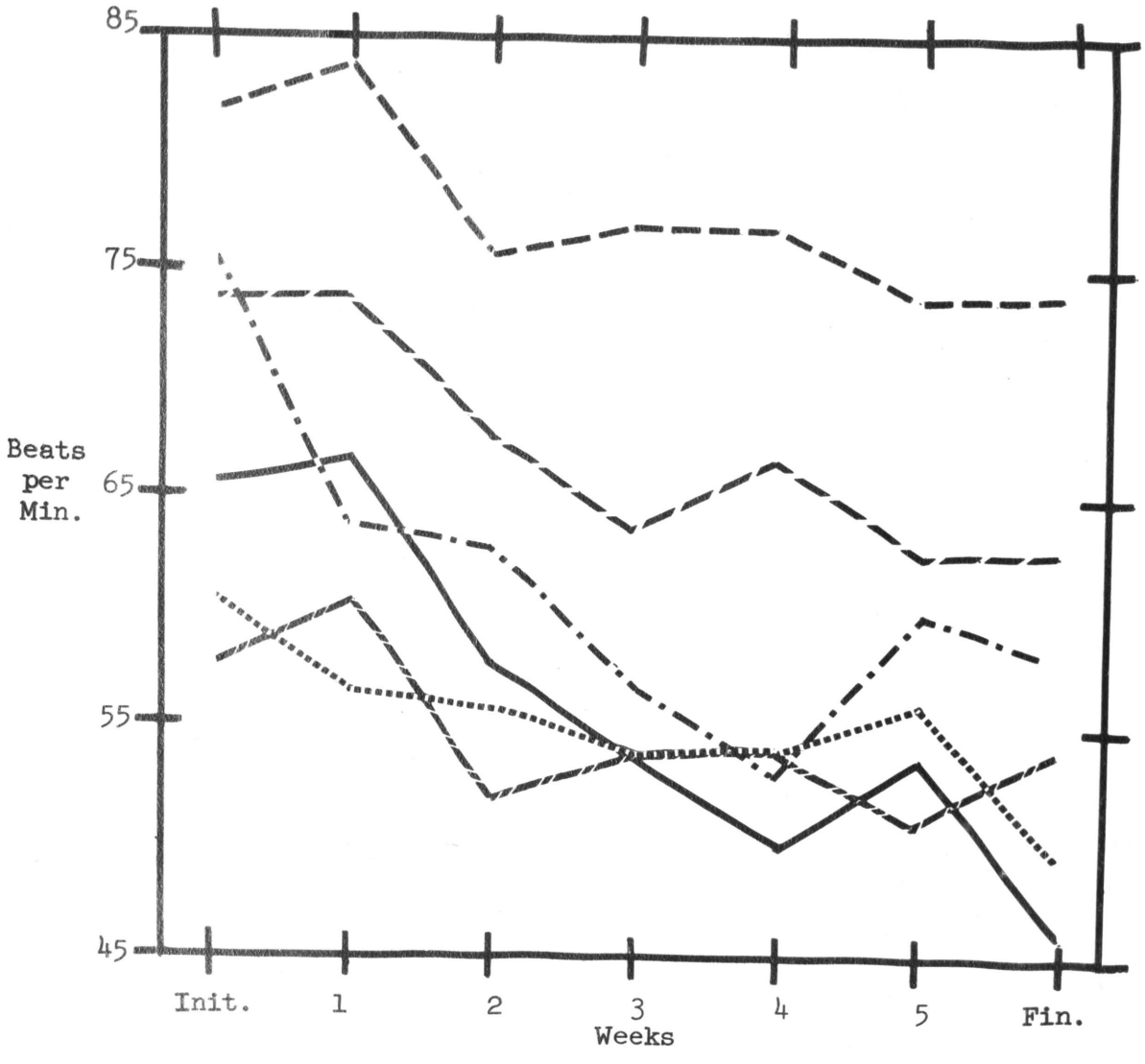

Figure 1

Average Weekly Individual Heart-rates

Legend:

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6

Average Weekly Heart-rate

Figure 2 illustrates graphically the average weekly heart-rate for the group. A decided decrease was shown for all but the fifth week in which heart-rates increased slightly.

An analysis of variance for average weekly heart-rates produced an F ratio of 14.42, which was significant at the one percent level of confidence. An F ratio of 3.47 was needed for rejection of the null hypothesis.

	ss	df	ms	F
(Treatments)	775	6	129.10	14.42
Within	3133	35	89.51	
Total	3908	41		

Duncan's Multiple Range Test[7] was then applied to the analysis of variance data to determine where significant differences occurred. It was found that at the one percent level of confidence, average weekly heart-rates decreased significantly between the initial week and the second, third, fourth, fifth, and final weeks. Statistically significant differences were also found between the average weekly heart-rates for the first week and the second, third, fourth, fifth, and final weeks. Although differences existed between the other weeks these differences were not significant for this study.

[7] Steel and Torrie, Principles and Procedures of Statistics, p. 108.

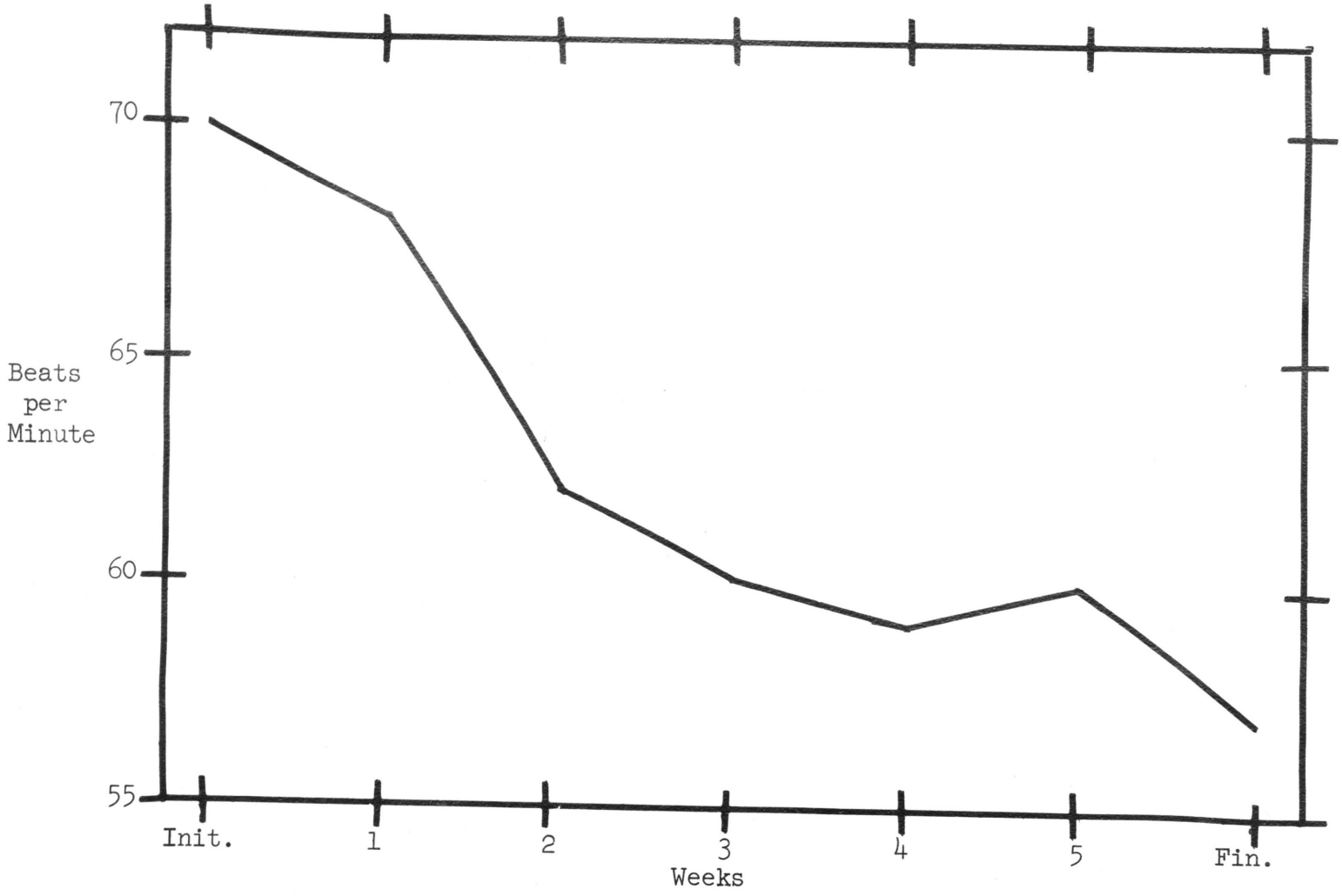

Figure 2

Average Weekly Group Heart-rates

Summary of Findings

The Harvard Step Test gains and heart-rate losses were found to be significant at the one percent level of confidence. In the other two tests, i.e., Sargent Vertical Jump Test and tests of leg strength, the mean losses and gains were not significant for this study.

Discussion

Due to the small number of subjects used in this investigation the author attempted to present an individual, as well as a group analysis, wherever possible.

It is difficult to explain why a mean loss was experienced in explosive power and knee extension strength, however, a contributing factor may have been the use of handrails while running up the stairs. It would seem that stair-running would contribute to strength gains in knee extension to a greater degree than to knee flexion since these are the muscles that are most involved in raising the body up the stairs. A follow-up test was given one week after the termination of the program to determine if fatigue may have been a factor in the strength loss. However, similar results were obtained on this test.

The increase in heart-rate for the fifth week of training may be easier to explain since this was the week in which all of the subjects were involved in mid-semester tests.

Chapter IV

SUMMARY

Problem

The purpose of this investigation was to determine whether subjects who participated in a vigorous stair-running program experienced significant changes in explosive power, leg strength, and cardiovascular efficiency.

Data

Participants in this study were male, freshman students at South Dakota State College during the Spring semester of the 1963-64 school year. The subjects participated in a five-week training program in which they met five times per week. A gradual increase in the work load was maintained throughout the training program in order to tax the subjects physically and physiologically.

Tests to measure explosive power, leg strength, and cardiovascular efficiency were administered during the week prior to, and the week following, the five-week training period. In addition, daily heart-rates were taken during the training period.

Findings

Resulting from the administration of a five-week stair-running program are the following findings:

(1) Subjects showed no significant gain or loss in explosive power as indicated by the Sargent Vertical Jump Test.

(2) No significant gains or losses were found in leg strength.

(3) There was a significant gain in cardiovascular efficiency as indicated by the results of the Physical Efficiency Index of the Harvard Step Test.

(4) A comparison of initial and final heart-rates revealed a significant decrease.

Conclusions

From the findings of this study, the following conclusions are drawn. The method of stair-running used in this study was an effective method of improving cardiovascular efficiency and decreasing heart-rate. A program of stair-running, as performed in this study, does not significantly affect explosive power and leg strength.

Recommendations for Further Study

Based on the experiences of the author in this study, the following recommendations are made: A similar study be conducted using a larger group of subjects under similar training conditions with an equal number of subjects acting as controls. A study be conducted using other methods of measuring leg strength.

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Notes taken at University of Minnesota Wrestling Clinic, November 9, 1963.

APPENDIXES

APPENDIX A

Raw Data: Sargent Vertical Jump Test (inches)

Subject	Initial	Final
1	19.5	20.0
2	21.0	22.0
3	19.0	17.5
4	20.0	19.5
5	19.5	17.5
6	23.5	21.5

APPENDIX B

Raw Data: Leg Strength Tests (pounds)

	Extension		Flexion	
Subject	Initial	Final	Initial	Final
1	720	642	350	327
2	558	520	323	333
3	490	585	297	342
4	547	620	390	432
5	560	416	317	338
6	707	590	316	354

APPENDIX C

Raw Data: Harvard Step Test*

Subject	1-1.5 min.	2-2.5 min.	3-3.5 min.
1	72	68	53
	63	52	49
2	64	54	52
	55	50	46
3	76	70	66
	64	59	55
4	74	72	64
	64	57	53
5	66	55	52
	59	43	39
6	63	56	54
	62	55	53

*Data denotes heart-rate during recovery

Nonunderlined number represents initial test data

Underlined number represents final test data

APPENDIX D

Raw Data: Heart-rates

Period Number	Subject Number 1	2	3	4	5	6
1	71	51	80	75	63	73
2	57	63	81	76	62	79
3	70	59	84	71	57	76
4	68	64	84	83	57	64
5	66	65	84	73	*	65
6	66	62	80	75	61	64
7	66	57	84	73	71	64
8	68	56	87	74	54	60
9	74	58	74	63	62	67
10	64	49	75	69	56	63
11	54	51	78	66	54	62
12	56	53	79	75	57	54
13	54	51	76	70	52	63
14	53	54	86	72	54	54
15	55	54	77	65	54	57
16	55	48	78	62	52	67
17	53	54	73	65	54	55
18	54	55	76	60	57	59
19	52	55	77	68	56	51
20	49	54	77	67	59	54
21	46	54	74	68	52	56
22	52	54	77	66	54	51
23	48	54	79	62	51	53
24	59	51	76	66	55	59
25	50	51	71	58	58	47
26	54	46	76	60	55	65
27	55	49	73	62	58	63
28	52	51	74	66	53	58
29	47	56	76	63	49	53
30	45	54	78	61	48	61
31	46	51	67	63	50	61

*Not recorded