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THE EFFECT OF ANKLE WEIGHTS ON THE DEVELOPMENT OF LEG STRENGTH, SPEED, AND GENERAL ENDURANCE OF COLLEGE WOMEN

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CHAPTER I

INTRODUCTION

For years advertisements for ankle weights have appeared in various sporting goods' catalogues. Manufacturers claim that the use of ankle weights provides coaches with an easy method of conditioning athletes. Such an advertisement appears in the Wolverine Sports Supply 1966 catalogue: (5)

> Weights employ the basic principle of 'overload training'... They develop the actual muscles used in track, baseball, football, basketball and other sports by making them work harder during warm-up practice... Improve your athletes in less time and get more out of available training periods. (5, p. 40)

Some coaches have used these weights in exercise programs either for pre-season conditioning or in regular training programs.

Only one unpublished study was found in literature written by a physical educator who used ankle weights for the purpose of training. No research has been published by established manufacturers to substantiate the claims of using ankle weights to improve athletic training. Only subjective reports written by coaches who have used these weights in their programs are available from manufacturers. James A. Murray (19), author of a book about weight training, states: "I have never seen any research reported on studies of the effects of weighted vests, ankle weights, or wrist weights on the strength and/or endurance of men or women". (19, p. 1)

Since manufacturers continue to claim their value as an effective method of conditioning athletes, and coaches and trainers continue to use weights, research is needed to present objective results to justify the use of these weights in developing strength, speed, and endurance.

Statement of the Problem

The purpose of this study was to determine the effects of ankle weights on leg strength, speed, and general endurance of college women. Associated with the problem was the extent of retention of this leg strength, speed, and general endurance.

Limitations of the Study

The number of subjects utilized in this study was limited to eighteen due to limited space, testing time, and equipment. Volunteers were solicited from the student body of Longwood College.

Another limiting factor was concerned with the amount of time that each student could devote to the exercise program. Only two exercise periods a week could be held because of conflicts with the college program.

Care was taken to control other variables such as diet, habits of sleep, and participation in sport activities. An attempt was made to keep these variables consistent throughout the conduct of the study.

The testing for retention was limited to a four week period, because of the examination schedule and the semester break.

Definitions of Terms

Since various terms used throughout the study were either controversial or unclear, definitions of words used in this study were needed.

Ankle Weights. Vinyl pockets filled with fine lead shot, in band form with canvas straps. Each weight weighs 2.5 pounds; each pair a total of 5 pounds. Made by Olympia (brand name), and purchased from Wolverine Sports Supply.

General Endurance. Total body endurance or physical efficiency. Includes both muscular and circular-respiratory endurance.

Overload Principle. The strengthening of a muscle by loading it over and above previous requirements. This may be done by shortening the length of time to perform the movement, increasing the speed of the movement, or adding weight to that portion of the body involved.

Speed. The rate at which successive movements of the same kind can be performed.

Strength. The ability to exert tension against resistance. The amount is dependent on the contractile power of the muscular tissue.

CHAPTER II

REVIEW OF RELATED LITERATURE

The literature related to this study will be presented under three headings. The first section will present published research directly related to training with the use of ankle weight. The second section will present written research on wearable type weights which relate to this specific study. The third section will consist of literature concerning the use of weights in the development of strength, speed, and general endurance.

Training with Ankle Weights

Two research studies were found specifically dealing with training using wearable ankle weights.

In the February 4, 1966 edition of the Richmond, Virginia newspaper appeared an article from Los Angeles reporting the results of a research project using ankle weights by Dr. Sam Neal Winningham of the University of Southern California. The article stated the following about this research project:

> ANKLE WEIGHTS SEEN NEEDLESS Wearing ankle weights in training does not help football players run faster during games,...Dr. Sam Neal Winningham had 30 men practice running in a six-week period wearing five-pound ankle weights. He found this group ran slower when timed later without the weights than a group that had practiced un-weighted. 'Improvement by practice was demonstrated', he said, 'but the amount of development was not dependent on the use of ankle weights. Their use cannot be recommended'.

When a letter inquiring about the study was sent to Dr. Sam Neal Winningham the letter was returned stamped that Dr. Winningham was unknown at the University of Southern California.

A Master's Thesis by Anderson (1) investigated the use of a weighted ankle spat to improve the jumping performance, agility, and endurance of high school basketball players. The study consisted of ten subjects who exercised for a seven week period.

The results showed improvement in jumping performance and agility of both the unweighted and weighted group. The improvement in jumping performance of the weighted group was the only improvement significant at the .05 level. The results also showed improvement in endurance of the unweighted group, but the weighted group decreased in endurance. The author recommended that any further studied should include a longer exercise period and more subjects.

Training with Wearable Weights

Four research studies were found which utilized other types of wearable weights.

Bierlye (2) conducted a study that compared a weight training program with an overload jumping program. The weights of the jumpers were held in the hand. There was an addition of weights every two weeks. The results indicated that the overload jumping group improved more than the weight training group at the .01 level of significance.

Nelson and Nofsinger (20) published a study which overloaded elbow flexion to increase speed.

> Twenty-three male subjects were tested for speed of elbow flexion immediately before and after the application of several levels of overload. These included no weight (control) and 15, 30, and 45 percent of the subjects' elbow flexion strength. No statistically significant differences were observed between the four conditions. However, a 'Kinesthetic illusion' of increased speed was manifested as all subjects stated they 'felt faster' during post overload trials. (20, p. 174)

Clarke (8) published a study which utilized the Delorme method of weighting. It placed a weighted shoe on the subjects which weighed 40, 45, 50, and 55 percent of the flexor muscle strength of the knee joint. The exercise consisted of repeated flexion in a prone position. The weighted shoe of 55 percent of the flexor muscle strength developed the most strength.

The fourth study by Stockholm (24) utilized a weighted vest. The subjects were divided into three groups: 1) no overload; 2) 5% of the body weight; and 3) 10% of the body weight. The exercise consisted of three jumps per day. The results indicated:

> Jumping with five percent overload caused a greater combined jumping improvement in performance than did jumping with ten percent overload. Both overload conditions caused a significant jumping improvement over jumping under no overload conditions... These findings seem to indicate that overloads of moderate resistance will tend to cause an improvement in a physical movement when utilized immediately before performing the same physical movement according to the results of the study. (24, p. 43)

The Use of Weights in Athletic Training and Physical Therapy

Physiologists and physical therapists have proposed that a muscle may be strengthened through

the application of weights. Literature to support these proposals can be found in athletic training and corrective physical education publications.

Athletic Training

Morehouse and Rasch (18), recommend for athletic training:

> Muscles grow larger and stronger only when required to perform tasks that place loads on them which are over and above previous requirements. This is the 'overload principle' which is the rationale for all progressive resistance exercise systems.... A heavy weight lifted a few repetitions will give greater strength gains than will a light weight lifted many repetitions, even though the total work load in each may be equivalent. (18, pp. 120-121)

Bresnahan, Tuttle, and Cretzmeyer (3) stated in a track and field publication that in order for a muscle to increase in strength and size it must be overloaded beyond normal conditions.

Scott and Crafts (9) recommend the use of weight training in women's track and field:

> Perhaps a word needs to be said here concerning the use of weight training. Weight training is not a new technique in conditioning but it is frequently misunderstood. It can and is being used in training women as well as men. Weight training literally means 'exercise with weights'. It is the technique of employing external weight resistance (overload principle) with exercises to develop muscle power and strength. (9, p. 158)

Overloading or weighting a warm-up movement prior to using that same movement in competition has received little study. Morehouse states that: (17)

> The procedure of warming up with an implement heavier than that used in competition has been advocated on the theory that the lighter implement felt so much better that performance would be improved. (17, pp. 213-214)

Morehouse (17) goes on to say that performance is not improved through the practice of warming up with a heavier or lighter implement. The best performance is noted when athletes warm up with the same implement they are to use in competition.

Scott and Crafts (9) disapprove of the use of a heavier shot in practice throws. They realize that the strength of the girl will be increased, but they feel that "either a heavier or lighter object produces a different technique than that required for official competition".

Corrective Physical Education Literature

The use of weights is recommended in the fields of corrective physical education and physical therapy.

A statement concerning the use of weights in physical therapy was made by Peebler and Thomas: (22)

> Physical therapy investigated exercise with weights, hoping to speed up recovery periods and to aid the body in restoring various functions to normal. The results have led to extensive use of weight resistance exercise in physical therapy. (22, p. 58)

Logan (16) and O'Donoghue (21) in separated publications suggest the use of iron boots for strengthening the knee and thigh to correct knee injuries, and Stafford (23) recommends the use of weight, ranging from five pounds, to increase the strength of the stumps of amputees.

It is evident from these studies that there is a dearth of research on the effect of ankle weights on the development of leg strength, speed, and general endurance, and that which does exist varies in consistency of results. This factor is also evident in the limited research available on the use of other types of wearable weight.

There is little doubt as to the value of weights in corrective physical education and physical therapy. Physiologists all agree that muscles grow larger and stronger when required to perform contractions that place loads on them above previous requirements, but experts in athletic training can not agree to their use.

CHAPTER III

PROCEDURE

The procedure described in this chapter was used in the selection and pairing of subjects, the selection and administration of the leg strength, speed, and general endurance tests, and the selection and administration of the exercise program.

Selection and Pairing of Subjects

The subjects were eighteen women enrolled at Longwood College from September 1966 to January 1967. Volunteers were solicited by the researcher. The subjects were then paired according to their score on a test for general endurance. The results of the pairing are included in Appendix A.

The subjects were placed in two groups of nine subjects each. The two groups were asked to perform a selected exercise program. One group, the control group, performed the exercises without ankle weights, and the other group, the experimental group, performed the exercises with two and one half pound ankle weights strapped on each leg.

Selection of Tests

To indicate the effect of ankle weights on the control and experimental groups, tests were selected to measure leg strength, speed, and general endurance. An adapted back strength

dynamometer was used to measure leg strength, a fifty yard dash to measure speed, and a modified Harvard Step Test to measure general endurance.

The reliability of the tests was checked by comparing the scores on the first two administrations of the three tests. The scores were submitted to the Pearson Product Moment formula. (12)

$$r_{xy} = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)\ (\Sigma y^2)}}$$

x = deviation of scores from the mean of the first test
y = deviation of scores from the mean of the second test

The correlation coefficients for the reliability of the tests were:

Test	r_{xy}
Leg Strength	.79
Speed	.96
General Endurance	.84

A reliability coefficient of .75 or above is acceptable, but it is recommended that a test have a reliability coefficient of .85 or above for accurate results. (11)

Administration of Tests

Leg strength, speed, and general endurance tests were administered to the eighteen subjects twice during the two week period before the exercise program began, once during the week following the completion of the eleven weeks of exercise, and

four weeks after the program was terminated. Directions were standardized and read to all subjects prior to the performance of the tests. The directions to the subjects are included in Appendix B.

Leg Strength

Equipment. A back strength dynamometer (13) was adapted to measure leg strength by the addition of a belt to hold the lifting bar in place (10). The belt was 5½ feet long, 6 inches wide, and ¼ inch thick, made of rubberized, tightly woven canvas with a loop that fitted over the end of the lifting bar. The position of the feet was marked on the base of the dynamometer.

Procedures for Testing. (a) The subject stood on the foot marks on the base of the dynamometer, with the feet about six inches apart and parallel, and held the lifting bar near the center with an overhand grip (palms facing inward) so that the bar rested at the junction of the upper thigh and abdomen. The hands were used for bar-balancing and positioning, and the subject was cautioned not to use the arms in lifting.

(b) The loop of the belt was placed on the left end of the lifting bar, and then carried around behind the subject as low as was comfortable over the gluteal muscles. The free end was looped over, down, and around the other end of the lifting bar, and tucked under so that it rested against the body.

(c) The subject bent her knees until there was a 115 to 124 degree angle between the thigh and the lower leg. The tester measured this angle with a goniometer, and adjusted the length of the chain to this position to make sure that the chain was straight and tight.

(d) The tester made sure that the subject's knees were straight ahead, her arms and back straight, and head erect, with her eyes looking straight ahead.

(e) The subject lifted steadily and forcibly upward; driving her legs downward as hard as possible.

(f) Upon completion of maximum lift, the knees were nearly, yet not fully, extended to assure that maximum effort was recorded. If the legs failed to approach an almost straight position, or if the knees actually 'locked' or straightened out, a second lift was taken 30 seconds later, with an additional adjustment of the chain. It was possible to estimate the potential lift by noting the degree of muscularity of the subject's legs. Therefore, the stronger subjects were started at a lower chain link, to allow for the extra distention.

(g) The scale reading on the first trial or on the second trial, if the chain adjustment was necessary, was recorded. This scale reading was multiplied by 3 (the mechanical advantage of the lever) to obtain the leg strength of the subject in pounds.

Speed

Equipment. Starting line, finish line, stop watch, and recording sheet.

Procedures for Testing. (a) The subject stood at the starting line with her feet behind the line in any position as long as only her feet touched the ground.

(b) The subject ran at maximum speed to the finish line, having been instructed previously as to the importance of continuing at maximum speed until she had passed the finish line.

(c) The tester started the watch at the end of the starting signal and stopped it as the subject crossed the finish line.

(d) The time it took the subject to run the 50 yards was recorded.

(e) If the subject fell while being timed, she stopped and began again after a rest of 30 seconds.

(f) One trial was given per subject for the test for speed.

General Endurance

Equipment. A stable bench 18 inches high, a large electric clock with a second hand, a stop watch, a chair for subject, and a recording sheet.

Procedures for Testing. (a) The subject remained as quiet as possible before testing while sitting in a chair. The pulse rate was recorded while she maintained this resting position.

(b) The subject stood and faced the bench. The method and rhythm to be used were described. The recorder counted as follows; up; up; down; down. The cadence was kept to thirty steps per minute. It was explained to the subject that she could step up with either foot first, and change during the exercise at any time as long as the rhythm was maintained. If she lost the rhythm of the cadence, she waited one round and started again on the next series of counts.

(c) The subject tried to step so that she could experience the height of the step. It was explained that she should breathe fully throughout the test and straighten the knees completely on top of the bench.

(d) A two per second cadence count was used to guide the subject in performing the step test at the proper rate of speed, 30 complete executions per minute. She began her step test on the second series of counts. The subject continued the exercise as long as possible with a maximum of 4 minutes, the total number of seconds completed was recorded.

(e) The pulse rate of the subject was taken 1-1½, 2-2½, and 3-3½ minutes after exercise.

(f) The recorded pulse rates were submitted to Karpovich's (14) formula for physical efficiency.

$$\text{General Endurance} = \frac{\text{Time of Stepping in seconds} \times 100}{2 \text{ (sum of 3 counts of the pulse)}}$$

Selection of the Exercise Program

The exercise program consisted of full laps around a standard basketball court (94' x 50'), squat thrusts (4 count), and vertical jumps next to a wall. These exercises were selected because it was recommended that they developed leg strength and general endurance. (7) (4) It was impossible to include an exercise to specifically develop speed because the development of speed is a result of the development of strength. (15)

Administration of the Exercise Program

The two groups met at 8:00 p.m. on Tuesday and Thursday nights for a period of eleven weeks. The exercise sessions lasted long enough for the subjects to perform the required exercises. During the program there was an increase in the number of repetitions of exercises every two weeks. A schedule of exercises is included in Appendix C. All subjects were asked not to take part in any other training courses during the period of this study.

Exercises

Running. The subjects ran the required number of times around a standard basketball court (94' x 50'). The subjects in the control group were paired with the subjects in the experimental group to

eliminate the necessity of timing. They were started, ran, and finished in 9 pairs.

Squat Thrusts. The subjects performed the required number of 4 count squat thrusts in unison with one permanent counter. The body positions for the various counts were:

1- The subject's body was lowered from standing to squat position with the hands placed on the floor on the outside of the legs.

2- The subject's legs were extended behind the hands so that the body was in a push-up position.

3- The subject's legs were drawn back into a squat position.

4- The subject's body was raised back into a standing position.

Vertical Jumps. The subjects stood underneath individual tapes placed 2' 3" above their height with the right side of the body next to the wall. On the signal the subjects jumped vertically and touched on or over their measured tape. If they did not at least touch their line they signaled the counter at the end of the required jumps, and they repeated the faulty jumps at that time.

Statistical measurements used to evaluate the resulting difference obtained in testing are included in the next chapter.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter is concerned with analysis and interpretation of data relevant to the purpose. The purpose of this study was to determine the effect of ankle weights on the development of leg strength, speed, and general endurance of college women.

The statistical analysis of the data included the means of the scores on the tests of leg strength, speed, and general endurance, and the significance of the differences of the means. Formulas used are included in Appendix D. The data was interpreted in light of the degree of improvement and retention of leg strength, speed, and general endurance.

The Effect of Ankle Weights on Leg Strength, Speed, and General Endurance

The effect of ankle weights on the development of leg strength, speed, and general endurance was indicated by comparing the difference of mean scores obtained on the pre exercise, post exercise, and retention administrations of the three tests.

Leg Strength

Improvement.

The mean of the control group for the pre exercise test was 259 pounds, and for the post exercise test it was 293 pounds. The leg strength of the control group improved 34 pounds. The

difference between the means was significant at the .12 level. (Table I)

TABLE I

Means and Significance of the Differences Between the Means of the Leg Strength Tests

Test	Means	Mean Differences	t	Level of Significance
CONTROL GROUP				
Pre Exercise	259.00			
		+34	.790	.12
Post Exercise	293.00			
		-34		
Retention	259.00			
EXPERIMENTAL GROUP				
Pre Exercise	248.00			
		+73	1.975	.07
Post Exercise	321.00			
		+ 6		
Retention	327.00			

Note: Only those t test scores at the .05 or .01 level of significance are considered statistically significant.

The mean of the experimental group for the pre exercise was 248 pounds, and for the post exercise test it was 321 pounds. The leg strength of the experimental group improved 73 pounds. The difference between the means was significant at the .07 level. (Table I)

Both the control and experimental groups indicated an improvement of leg strength of 34 and 73 pounds respectively. Neither improvement was statistically significant, but the results seem to indicate that this particular exercise program did improve leg strength, and the use of weights may have increased the degree of improvement.

Retention.

The mean score of the control group for the post exercise test was 293 pounds, and for the retention test it was 259 pounds. The leg strength of the control group decreased 34 pounds over the four week retention period. (Table I)

The mean score of the experimental group for the post exercise test was 321 pounds, and for the retention test it was 327 pounds. The leg strength of the experimental group improved 6 pounds over the four week retention period. (Table I)

The control group decreased 34 pounds, and the experimental group increased 6 pounds over a four week retention period. It is logical that a certain amount of decrease in performance is expected to occur after the termination of a training program. This factor was true in the case of the control group, but not for the experimental group which had an increase of 6 pounds after the termination of the exercise program. It can only be surmized that other factors such as participation in other activities and the relative short retention period may have contributed to the deviations, but no statistical evidence can be presented in this study.

Another factor which may have influenced the results of these findings was the relatively low reliability coefficient of the leg strength test

which was .79. Though a coefficient of .75 or above is acceptable, it is recommended that a test have a reliability coefficient of .85 or above for accurate results.

Speed

Improvement.

The mean of the control group for the pre exercise test was 8.0 seconds, and for the post exercise test it was 7.7 seconds. The speed of the control group improved .3 seconds. The difference between the means was significant at the .11 level. (Table II)

TABLE II

Means and Significance of the Differences Between the Means of the Speed Tests

Test	Means	Mean Differences	t	Level of Significance
CONTROL GROUP				
Pre Exercise	8.0	+.3	1.010	.11
Post Exercise	7.7	-.1		
Retention	7.8			
EXPERIMENTAL GROUP				
Pre Exercise	8.4	+.3	.912	.11
Post Exercise	8.1	0		
Retention	8.1			

Note: Only those t test scores at the .05 or .01 level of significance are considered statistically significant.

The mean of the experimental group for the pre exercise test was 8.4 seconds, and for the post exercise test it was 8.1 seconds. The speed of the experimental group improved .3 seconds. The difference between the means was significant at the .11 level. (Table II)

The control and the experimental group increased their speed at approximately the same rate, each improved .3 seconds. The increase in both groups was not statistically significant, but it would seem to indicate that the exercise program did have some effect on improvement.

Retention.

The mean score of the control group for the post exercise test was 7.7 seconds, and for the retention test it was 7.8 seconds. The speed decreased .1 second over the four week retention period. (Table II)

The mean score of the experimental group for the post exercise test was 8.1 seconds, and for the retention test it was 8.1 seconds. The speed remained constant over the four week retention period. (Table II)

Both the control and the experimental group remained fairly constant during the retention period. Perhaps, a longer retention period would have indicated a return to the pre exercise condition.

General Endurance

Improvement.

The mean of the control group for the pre exercise test was a general endurance score of 27.3 points, and for the post exercise test it was 29.0 points. The general endurance of the control group improved 1.7 points. The difference between the means was significant at the .13 level. (Table III)

TABLE III

Means and Significance of the Differences Between the Means of the General Endurance Tests

Test	Means	Mean Differences	t	Level of Significance
CONTROL GROUP				
Pre Exercise	27.3			
		+1.7	.363	.13
Post Exercise	29.0			
		+3.9		
Retention	32.9			
EXPERIMENTAL GROUP				
Pre Exercise	26.4			
		+5.3	1.099	.10
Post Exercise	31.7			
		-4.1		
Retention	27.6			

Note: Only those t test scores at the .05 or .01 level of significance are considered statistically significant.

The mean of the experimental group for the pre exercise test was a general endurance score of 26.4 points, and for the post exercise test it was 31.7 points. The general endurance of the experimental group improved 5.3 points. The difference between the means was significant at the .10 level. (Table III)

Both the control and experimental groups indicated an improvement of general endurance of 1.7 and 5.3 points respectively. Neither improvement was statistically significant, but the results seem

to indicate that this particular exercise program did improve the general endurance of both the unweighted and weighted groups, and the use of weights may have increased the degree of improvement.

Retention.

The mean score of the control group for the post exercise test was a general endurance score of 29.0 points, and for the retention test it was 32.9 points. The general endurance increased 3.9 points over the four week retention period. (Table III)

The mean score of the experimental group for the post exercise test was 31.7 points, and for the retention test it was 27.6 points. The general endurance decreased 4.1 points over the four week retention period.

The control group increased 3.9 points, and the experimental group decrease 4.1 points over a four week retention period. These findings were similar to those obtained in the leg strength results, except the control group decreased and the experimental group increased. No statistical evidence can be presented which might explain the increase in retention in general endurance, but the two factors previously mentioned, a longer retention period and more control over the activity program of the subjects, may have effected the results of the retention of general endurance.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to indicate the effect of ankle weights on the development of leg strength, speed, and general endurance. Eighteen Longwood College students volunteered to be subjects. The subjects were paired according to their score on a test for general endurance, and placed in two groups of nine subjects each. The two groups were asked to perform an exercise program consisting of vertical jumps, squat thrusts, and laps for an eleven week period. One group, the control group, performed the exercises without ankle weights, and the other group, the experimental group, performed the exercises while wearing five pound ankle weights.

To indicate the effect of ankle weights on the control and experimental groups, tests were selected to measure leg strength, speed, and general endurance. An adapted back strength dynamometer was used to measure leg strength, a fifty yard dash to measure speed, and a modified Harvard Step Test to measure general endurance.

In the analysis of the effect of the ankle weights, the researcher concentrated on the improvement in leg strength, speed, and general endurance as a result of the exercise program, and the retention of these variables over a four week period. The statistical analysis of the data included the means of the scores on the tests of leg strength,

speed, and general endurance, and the significance of the differences of the means.

Conclusions

As a result of the analysis of the effect of ankle weights on the development of leg strength, speed, and general endurance, the following conclusions seem to be warranted:

1. The leg strength of both the control and the experimental groups improved 34 and 73 pounds respectively during the duration of the exercise program. Neither improvement was statistically significant.

2. Over a four week retention period the control group indicated a decrease and the experimental group indicated an increase in leg strength.

3. The increase in leg strength of the experimental group may be contributed to the participation in other activities and the relatively short retention period, but no statistical evidence can be presented in this study.

4. The speed of both the control and experimental groups improved .3 seconds during the duration of the exercise program.

5. Over a four week retention period the speed of both the control and experimental groups remained constant.

6. The general endurance of both the control and the experimantal groups improved 1.7 and 5.3 points respectively during the duration of the exercise program.

7. The control group indicated an increase and the experimental group indicated a decrease in general endurance over a four week retention period.

8. The increase in general endurance of the control group may be contributed to the participation in other activities and the relatively short retention period, but as was the case in the retention of the leg strength, no statistical evidence can be presented in this study.

Recommendations

At the conclusion of this study the following recommendations are made for future research in this specific area:

1. The study may be extended to include a larger number of subjects.

2. Specific controls may be placed on diet, habits of sleep, and activities during the duration of the study.

3. The exercise sessions may be extended to include a greater number of repetitions.

4. The type of exercises included in the program may be varied.

5. The exercise and retention periods may be extended to include a longer period of time.

APPENDIX A

PAIRING OF SUBJECTS

Control		Experimental	
Number	Score	Number	Score
1	40.49	2	39.22
3	36.59	4	38.96
5	35.71	6	34.97
7	33.71	8	34.89
9	32.97	10	29.41
11	21.79	12	25.85
13	20.68	14	18.13
15	15.07	16	16.86
17	15.68	18	13.59
19	13.02	20	13.43
	265.71		265.31
Mean=	26.571	Mean=	26.531

Paired according to the results
of the first administration
of the test for general endurance.

AGE, HEIGHT, AND WEIGHT OF CONTROL GROUP

No.	Name	Height	Weight	Age
1	Stone, B.	64"	120	19
3	Erdman, J.	63"	106	19
5	Pettis, A.	67"	109	18
7	Carr, L.	63"	115	20
9	Tibbs, J.	66.5"	128	19
11	Barnes, A.	65"	128	19
13	Wood, M.	64"	118	19
15	Snead, F.	62.5"	125	19
17	Sasnett, B.	66"	127	20

AGE, HEIGHT, AND WEIGHT OF EXPERIMENTAL GROUP

No.	Name	Height	Weight	Age
2	Tribby, D.	61"	116	20
4	Halstead, P.	62"	121	19
6	Wright, S.	64"	124	19
8	Shultz, P.	62"	118	19
10	Bain, F.	62"	110	18
12	Bates, T.	63"	115	19
14	Carr, B.	64"	120	19
16	Colom, I.	60"	110	19
18	Mills, V.	64"	126	20

APPENDIX B

DIRECTIONS TO THE SUBJECT

Leg Strength Test

1. "Stand on the base of the dynamometer with your feet on the marked spots. Take hold of the lifting bar with your palms facing inward, and place the bar at the junction of your thighs and abdomen."
2. "Bend your knees until I tell you to stop, and hold this position."
3. "Now and throughout the test keep your knees straight ahead, your arms and back straight, your head erect, and your eyes looking straight ahead."
4. "On the signal 'Ready Go' lift steadily and forcibly directly upward; by straightening and driving your legs downward as hard as you can. Exert maximum effort."

DIRECTIONS TO THE SUBJECT

Speed Test

1. "Run a 50 yard dash as a test of your speed."
2. "Begin on the signal 'Ready Go' and run as fast as you can to the finish line."
3. "Begin in any position you wish as long as your feet are behind the starting line, and only your feet touch the ground."
4. "Do not slow down as you near the finish line, but run as fast as you can past the finish line. Exert maximum effort."
5. "If you should fall during the dash do not continue. You will be given another trial after you rest."

DIRECTIONS TO THE SUBJECT

General Endurance Test

1. "Sit in this chair and relax before testing."
2. "Stand up in front and face the bench."
3. "When I give you the starting signal you will step up and down on the bench; 30 steps per minute for 4 minutes. I will call the cadence to you like this: up; up; down; down; etc. That will be the count for one step. you may step up with either foot first, and may change lead feet during the exercise at any time as long as you maintain the rhythm."
4. "Practice the step once. Throughout the exercise breathe fully and straighten the knees completely on top of the bench."
5. "I will give you the starting signal 'Ready Go' and begin counting. Wait and listen to the first series of counts and begin stepping in time on the second series of counts."
6. "Continue the exercise as long as possible exerting maximum effort. I will stop you at 4 minutes."

APPENDIX C

EXERCISE PROGRAM

Weeks	Vertical Jumps	Squat Thrusts	Vertical Jumps	Laps
1	10	10	10	2
2	10	10	10	2
3	12	12	12	3
4	12	12	12	3
5	14	14	14	4
6	14	14	14	4
7	16	16	16	5
8	16	16	16	5
9	18	18	18	6
10	18	18	18	6
11	20	20	20	7

APPENDIX D

FORMULAS

Mean

The formula used to compute the mean of the scores was: (12)

$$M = \frac{\sum X}{N}$$

X = the raw scores
M = the arithmetic mean
N = the number of scores

Significance of the Difference of the Means

The formula used to compute the significance of the difference of the means is a simplified Fisher's formula for uncorrelated means in two samples of equal size. (12)

$$t = \frac{M_1 - M_2}{\sqrt{\frac{\sum x_1^2 + \sum x_2^2}{N_i\ (N_i - 1)}}}$$

M_1 = mean of the first test
M_2 = mean of the second test
x_1 = deviation from the mean of the first test
x_2 = deviation from the mean of the second test
N_i = number of raw scores

APPENDIX E

Figure 1. A Pair of Five Pound Ankle Weights.

Figure 2. Subject Wearing Ankle Weights.

Figure 3. A Leg Strength Dynamometer.

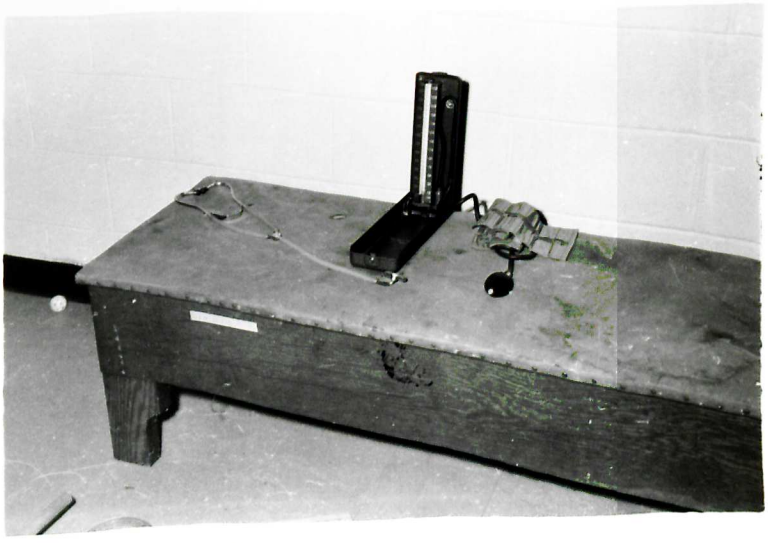

Figure 4. Equipment for Harvard Step Test.

Figure 5. Paired Subjects Prepared for Exercise.

Figure 6. Subjects Performing Squat Thrusts.

Figure 7. Subjects Performing Squat Thrusts.

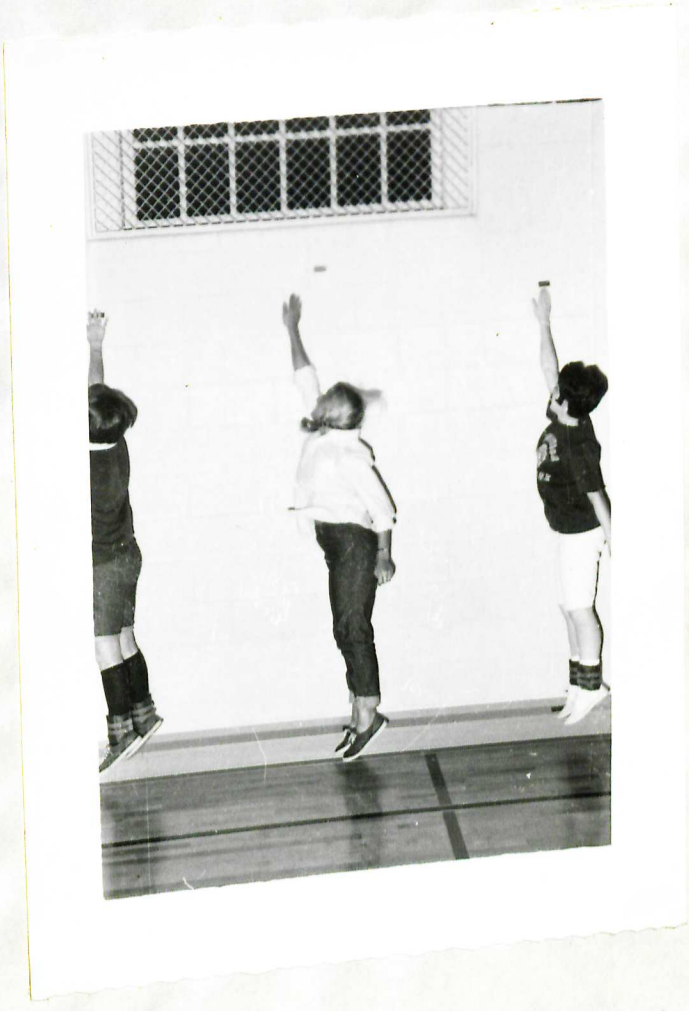

Figure 8. Subjects Performing Vertical Jumps.

Figure 9. Subjects Performing Vertical Jumps.

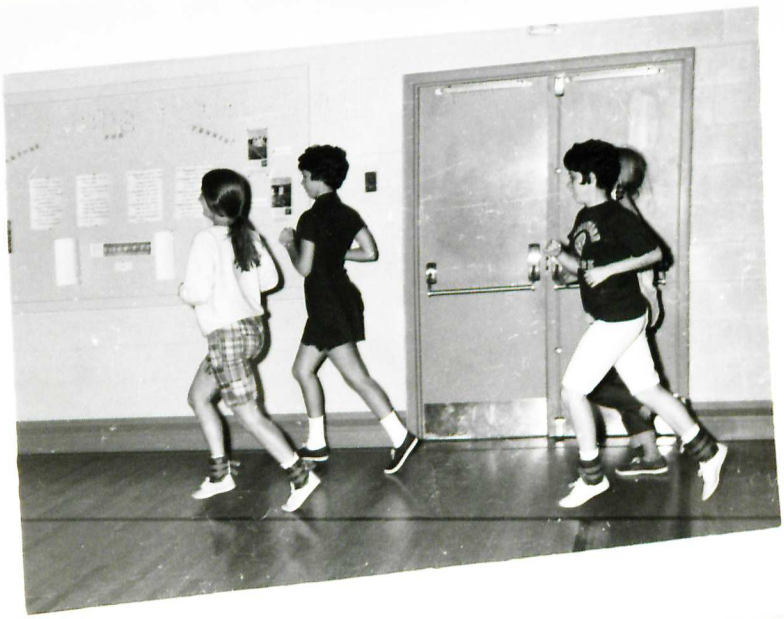

Figure 10. Paired Subjects Running Laps.

Figure 11. Paired Subjects Running Laps.

APPENDIX F

SUBJECT ATTENDENCE CHART

Subject	Sept. 27	29	4	6	Oct. 11	13	18	20	25	27	Nov. 1	3	8	10	15	17	22	29	Dec. 1	6	8
1								A						A		A					
2																			A		
3																					
4																					
5																					
6					A												A				
7														A			A				
8												A		A							
9																					
10																	A				
11												A									
12														A							
13														A							
14										A					A		A	A			
15												A							A		
16																	A				A
17													A		A						
18					A		A							A			A				A

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