

AN INVESTIGATION OF THE EFFECT OF ISOMETRIC AND ISOTONIC
MUSCULAR CONTRACTIONS ON THE PHYSICAL PERFORMANCE
SCORES OF HIGH SCHOOL GIRLS

A Thesis

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of the Requirements for the Degree
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by

Nancy Lou Curry

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Statement of the author

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The need for increased physical fitness
established. is mostly the
the citizen, and the student, and the
business man who are engaged in the

Physical Fitness

Physical education programs have been and
are being developed to attain this objective. Some of these
programs include a well-rounded program of sports
and of instruction in physical education prior to
the onset of industrial or military service.

John F. Kennedy, President's Council on Physical
Fitness, U. S. Department of Health, Education and Welfare
Commerce Publishing Company, 1961, p. 1.

CHAPTER I

THE PROBLEM AND DESIGN FOR STUDY

Through the promotion of physical fitness programs by the late President John F. Kennedy, the nation's people are cognizant of the word fitness and its implications.

Ours is not a regimented society where men are forced to live lives in the interest of the state. We are, all of us, as free to direct the activities of our bodies as we are to pursue the objectives of our thoughts. But if we are to retain this freedom, for ourselves and for generations yet to come, then we must be willing to work for those physical qualities upon which the courage and intelligence and skill of man so largely depend. . . .

The need for increased physical fitness is clearly established. . . . A nation is merely the sum of all its citizens, and its strength, energy and resourcefulness can be no greater than theirs.¹

Physical fitness is one of the major objectives of physical education programs. Various methods have been and are being employed to attain this objective. Some of these methods include: a well-rounded program of sports and games, a program of isotonic contractions prior to sports and games, a program of isometric contractions preceding the sports and games.

¹ John F. Kennedy, President's Council on Physical Fitness, U. S. Official Physical Fitness Program (Chicago: John Dienhart Publishing Company, 1961), p. 1.

I. THE PROBLEM

Statement of the problem. The purpose of this study was to investigate the effect of isotonic and isometric muscle contractions on physical performance scores of high school sophomore girls. The following questions were to be answered:

1. Will the girls who were not exposed to either a program of isotonic or isometric muscle contractions improve their performance scores?
2. Will the girls who experienced the program of isometric contractions improve their performance scores?
3. Will the girls who experienced the program of isotonic contractions improve their performance scores?
4. Will any one of the three groups improve significantly more than the others?

Importance of the study. To ascertain individual and group progress, methods of continual and effective evaluation are needed. Through the utilization of performance testing, the physical educator can determine the exact area or areas of weakness and then apply proper corrective methods or rehabilitative techniques. Only through this continual testing and evaluation can the physical educator hope to achieve the goal of fitness for his students.

Limitations of the study. This study is limited to thirty-five sophomore girls who are presently enrolled in Emporia High School, Emporia, Kansas.

Only those test items in the California Physical Performance Test² applicable to high school girls will be utilized.

II. DEFINITIONS OF TERMS USED

Isometric contractions. "Isometric contraction is a muscular contraction in which the subject exerts force against a resistance that does not move."³

Isotonic contraction. "An isotonic contraction is one in which the subject exerts muscular force against a resistance that does move."⁴

Regularly scheduled program of sports and games. This term was used to refer to physical education classes which met daily and offered physical activity through the media of sports and games.

²Appendix A, p. 24.

³M. Gladys Scott, Analysis of Human Motion, A Textbook in Kinesiology (New York: Appleton-Century-Crofts, 1963), p. 435.

⁴Ibid.

III. METHOD OF STUDY

Thirty-five sophomore girls from Emporia High School, Emporia, Kansas, were chosen from a combination of two physical education classes to participate in this study. The plan of this study was (a) to secure three equated groups of girls regularly enrolled in a daily program of physical education; (b) to administer the California Physical Performance Test to all girls participating in the study; (c) to present a program of isotonic and isometric muscle contractions to the experimental groups A and B, respectively; (d) to administer the California Physical Performance Test at the end of the six weeks period; (e) to evaluate the three groups with regard to their test scores and note improvement, if any, in their physical performance scores.

Classification of test groups. The McCloy Classification Index $I^5 [(20 \times \text{age}) + (6 \times \text{height}) + (\text{weight})]$ was employed to equate the three groups. This method of classification was selected because of its proven effectiveness and ease of indexing. The score for each girl was computed and placed in rank order. Utilizing rank distribution, the scores were placed into three groups. The mean score was

⁵ Appendix B, p. 29.

established for each group to check group equation. The control group with a mean score of 807., experienced a daily program of regularly scheduled sports and games. Experimental group A with a mean score of 808., experienced a program of isotonic muscular contractions daily in addition to the regularly scheduled sports and games. Experimental group B with a mean score of 808. experienced a program of isometric muscle contractions daily in addition to the regularly scheduled program of sports and games.

The California Physical Performance Test. The California Physical Performance Test was selected because of its design to measure fitness. The events contained in the test measure muscle power, coordination, strength, flexibility, speed, agility, and body control.

The test was administered by the author. Two class periods of forty minutes each were needed to complete the test. All three groups were tested at the beginning of the six weeks period and again at the end of the experimental period. Only those test items applicable to high school girls were used.

Presentation of contractions. The isotonic⁶ and isometric⁷ contractions used in this study were selected from those suggested by the President's Council on Fitness.⁸ They were selected because of their relation to the development of certain areas of the body: the arms, the shoulders, the back, the abdomen, and the legs.

The daily physical education classes were conducted by the girls' physical education instructor at Emporia High School. All three groups were exposed to a daily program of sports and games. The control group was composed of eleven girls from first and fourth hour physical education classes. In their respective hours, they reported to the gymnasium and participated only in a program of sports and games.

Experimental group A, composed of twelve girls in first hour class, remained in the locker room fifteen minutes each day and experienced a program of isotonic muscle contractions. The isotonic contractions were demonstrated, explained and were conducted under direction. The students began by doing each isotonic contraction six times daily for a period of two weeks. The number of contractions was then

⁶ Appendix C, p. 31.

⁷ Appendix D, p. 34.

⁸ President's Council on Fitness, op. cit., p. 1.

increased to eight daily through the third and fourth weeks of the study. During the fifth and sixth weeks of the study, the contractions were increased to ten daily. Each day after completing the series of contractions, the subjects reported immediately to the gymnasium and joined the control group in sports and games.

The experimental group B, composed of twelve girls from fourth hour physical education class, remained in the locker room fifteen minutes each day and experienced a program of isometric contractions. The isometric contractions were demonstrated, explained and directed. Through the first and second weeks of the study the students did each contraction for six counts. During the third and fourth weeks, the counts per contraction were increased to eight. In the fifth and sixth weeks the counts were increased to ten per day or meeting. Following the daily program of contractions, the subjects reported to the gymnasium and joined the control group in sports and games.

The number of contractions was increased for the explicit purpose of observing any relative change in the strength of the subjects.⁹

⁹Eleanor Metheny, Body Dynamics (New York: McGraw-Hill Book Company, Inc., 1952), p. 41.

At the end of the six-week period of experimentation, the California Physical Performance Test was again administered to the three groups. The initial test scores of each group were evaluated by comparison with the final test scores to note if any improvements were made. Progress of isometric and dynamic systems of exercise is the development of muscular strength and muscular body. This system also reveals the effectiveness and ability of exercise.

I. LIMITATIONS ON ISOMETRIC CONTRACTIONS

The idea of isometrics is to exercise a muscle by pulling or pushing against a fixed point. The basic principle of exercise is that a muscle required to perform work beyond its usual intensity will grow in strength. This is the basic principle of exercise.

However, it is stated that exercise will increase the strength of a muscle only if: (1) it is intense enough to cause the muscle to work at its maximum capacity, and (2) it is repeated persistently over a period of time.

CHAPTER II

REVIEW OF THE LITERATURE

A number of studies have been completed in the last fifteen years to determine the relative effectiveness of isometric and isotonic systems of exercise in the development of muscular strength and muscular endurance. The literature reveals the effectiveness and limitations of both systems of exercise.

I. LITERATURE ON ISOMETRIC CONTRACTIONS

The idea of isometrics is to exercise a muscle by pushing or pulling against an immovable object such as a wall, or by putting the muscle against the opposition of another muscle. "The basis is the overload principle of exercise physiology, which states that a muscle required to perform work beyond the usual intensity will grow in strength."¹⁰

Metheny¹¹ states that "exercise will increase strength of a muscle only if: (1) it is intense enough to cause the muscle to work at its maximum level of ability; (2) it is repeated persistently over a period of time; and (3) its

¹⁰President's Council on Physical Fitness, op. cit., p. 57.

¹¹Metheny, loc. cit.

demand on the muscle is gradually increased by increasing the number of times the movement is performed, the speed with which the movement is performed." Bender, Kaplan, and Johnson concluded in a recent study:

Isometrics can develop strength and should be an integral part of any physical activity program, but they must be used properly if strength is to be developed where it is needed. To be conducted properly, there must be some form of evaluation, either through success in an activity or by appropriate testing.¹²

II. LITERATURE ON ISOTONIC CONTRACTIONS

According to a study by Dennison, Howell, and Morford,¹³ both isometric and isotonic exercise increased muscular endurance significantly following eight weeks of activity, twice a week. Arm strength, the area of concentration in the study, increased more in those individuals who experienced a program of isotonics in comparison to those who experienced isometrics.

¹²Jay Bender, Harold M. Kaplan, and Alex J. Johnson, "Isometrics, A Critique of Paddism Versus Facts," Journal of Health, Physical Education and Recreation, 34:5, May, 1963, p. 66.

¹³J. D. Dennison, M. L. Howell, and M. R. Morford, "Effect of Isometric and Isotonic Exercise Programs Upon Muscular Endurance," Research Quarterly, 34:348-352, October, 1961.

Clarke¹⁴ states, "The effects of isotonic exercise favor the improvement of muscular endurance and the retention of muscular strength following the cessation of exercise." This study revealed certain restrictions were present in the development of muscular endurance when training with isometric exercises:

1. Isometric contractions restrict blood circulation to a greater extent than do isotonic contractions.
2. The amount of oxygen, oxygen debt, and total oxygen requirements increase linearly in proportion to the size of the load.
3. This constriction of circulation with attendant effects on oxygen supply to muscles, locally restricts the development of muscular endurance when training with isometric contractions.¹⁵

Bender¹⁶ and others concluded in one study that isometric exercises were of great significance for development of strength, but for overall results with regard to fitness they should be followed by appropriate adjunctive isotonic and stretching exercises.

Clarke¹⁷ points out "in comparing isometric and isotonic exercise training methods, the results of the

¹⁴H. Harrison Clarke, "Development of Volitional Muscle Strength As Related to Fitness," Exercise and Fitness (Chicago: Athletic Institute, 1959), p. 210.

¹⁵Ibid., p. 205.

¹⁶Bender, et. al., loc. cit.

¹⁷Clarke, loc. cit.

studies were somewhat contradictory. In two studies, the subjects who engaged in the isotonic exercises gained significantly more strength; and in one study, the isometric exercise group made definitely greater strength gains."

While many questions pertaining to these two systems of exercise remain unanswered, the following summation may be offered: (1) increases in muscular endurance may be effected by certain programs of isometric contractions, as well as by isotonic exercises; (2) "Both isometric and isotonic forms of exercise improve muscular strength. However, the evidence shows little if any difference in the effectiveness of the two forms in achieving strength increase. Variations in individual strength improvement exists for both forms of exercise;"¹⁸ (3) the amount of tension developed in a muscle is a major factor in determining strength improvement.

It appears that more scientific research is warranted before the total effectiveness of the two systems of exercise may be determined. However, it seems evident that the prime factors, strength and endurance involved in both

¹⁸The University of Illinois College of Physical Education and The Athletic Institute, Exercise and Fitness, A Collection of Papers Presented at the Colloquium on Exercise and Fitness (Illinois: Robert Allerton Park, 1959), p. 205.

isometric and isotonic contractions, are applicable to physical performance as related to the California Physical Performance Test.

The statistical computation of the data was done by an electronic computer (IBM) at Santa Clara University. The program used was "analysis of variance." The purpose of the "analysis of variance" was to determine any significant differences between the test scores and the final test scores of the groups.

Mean scores were computed for the two scores¹⁹ of the initial California Physical Performance Test for the control group, 25.25; the experimental group 1, 25.71; the mean score was also computed for the two scores²⁰ of the final test of all three groups: the mean score of the control group 25.29; the mean score of the experimental group 1, 25.58; the mean score of the experimental group 2, 25.58. Comparing the initial and the final mean scores for each group, the analysis of variance exhibited no significant differences in the mean scores. There was no significant improvement in the physical performance of any of the groups.

¹⁹ Appendix A, B, C, pp. 37-39.

²⁰ Ibid.

DISCUSSION AND INTERPRETATION OF DATA

The statistical computation of the data was done by an electronic computer (IBM) at Kansas State Teachers College, Emporia, Kansas. The program used was "analysis of variance." The purpose of the "analysis of variance" was to determine any significant difference in the means of the initial test scores and the final test scores of all three groups.

Mean scores were computed for the raw scores¹⁹ of the initial California Physical Performance Test for the control group, 25.23; experimental group A, 24.60; experimental group B, 25.71. The mean score was then established from the raw scores²⁰ of the final test of all three groups: the mean score of the control group 25.20; the mean score of the experimental group A, 24.31; the experimental group B, 25.52. In comparing the initial and the final mean scores for each group, the analysis of variance exhibited no significant difference in the mean scores. Therefore, considering group improvement in the physical performance score, there appeared

¹⁹ Appendixes E, F, G, pp. 37-39.

²⁰ Ibid.

to be no improvement. In all cases the mean scores for the final test were slightly lower than those of the initial test.

TABLE I
COMPARISON OF INITIAL TEST AND FINAL TEST MEANS
FOR ALL GROUPS

Group	Initial mean	Final mean
Control group	25.23	25.20
Experimental A	24.60	24.31
Experimental B	25.74	25.52

In analyzing the scores for the specific events of the California Physical Performance Test, the means of the final scores for some events were somewhat higher than the means of the initial score as shown in Table I.

Analysis of the mean scores of the push-up showed the control group, which experienced only a program of sports and games, had improved their mean score 2.45 on the final test; the experimental group A, which was exposed to a program of isotonic contractions, improved their mean score 3.25 on the final test; the experimental group B, which experienced the isometric contractions, improved their mean score 8.59 on the final test.

The analysis of the sit-up indicated improvement of the mean scores in all three groups of the study. The control group did 3.81 more, the experimental group A had the

largest increase of 9.08, and the experimental group B improved with 5.34 more sit-ups.

The change of the mean scores on the shuttle race varied with each group. The control group improved their mean score by .12 second, while the mean score of the experimental group A and experimental group B became slower by .04 seconds and .46 seconds, respectively.

The mean scores of all groups showed a decrease in performance scores for the broad jump and the basketball throw. The final mean score of the control group for the broad jump decreased .04 inch, the experimental group A decreased .84 inch, the experimental group B decreased 2.56 inches. The mean scores for the basketball throw decreased 26.57 inches for the control group and 16.92 inches for the experimental group A. The final mean score for the experimental group B remained constant for both the initial and final test.

The "analysis of variance" used to compute the significance difference of the means for the initial and final test scores of all groups showed no significance at the 5 per cent level of confidence.

Although there was improvement on certain events by all groups, the improvement was not enough to be significant.

The following results were based on data obtained from the study: (1) none of the group mean scores improved on the

TABLE II

COMPARISON OF INITIAL MEAN SCORES WITH FINAL MEAN SCORES FOR ALL
EVENTS OF THE CALIFORNIA PHYSICAL PERFORMANCE TEST

Group	Push-up			Sit-up			Shuttle Race			Broad Jump			Basketball Throw		
	Mean	Score		Mean	Score		Mean	Score (Sec.)		Mean	Score (in.)		Mean	Score (in.)	
	I*	F**	Ch.***	I	F	Ch.	I	F	Ch.	I	F	Ch.	I	F	Ch.
Control	23.82	26.27	+2.45	23.10	26.91	+3.81	13.01	12.91	+.12	62.09	62.05	-.04	488.48	461.91	-26.57
Experi- mental Group A	27.00	30.25	+3.25	27.92	37.00	+9.08	12.69	12.73	-.04	59.83	58.98	-.85	541.00	524.08	-16.92
Experi- mental Group B	25.83	34.42	+8.59	25.33	30.67	+5.34	12.78	13.24	-.46	61.75	59.19	-2.56	469.25	469.25	0

I* - Initial Test Score

F** - Final Test Score

Ch.*** - Change

final test; (2) there was improvement by all groups on specific test items such as the sit-up and push-up; (3) the experimental group B, which was exposed to the program of isometric contractions, improved their final mean scores in the push-up event more than the other two groups involved in the study; (4) the groups which experienced the isotonic and isometric contractions improved their mean scores to a greater degree than the control group in two of the events which involved strength and endurance, the sit-up and push-up; (5) the isotonic and isometric contractions did nothing to increase speed and agility.

IV. CONCLUSIONS

The following conclusions are based on the data obtained from this study: (1) the isotonic and isometric contractions improved muscular strength and endurance in such events as the push-up and sit-up; (2) events which

CHAPTER IV

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

The McCloy Classification Index I was used as a means of establishing three equated groups for the study. The analysis of variance proved that there was no significant difference in the mean scores of the groups. The California Physical Performance Test was administered to each group prior to the experimentation and again following the six week study. During this six week period the experimental group A and experimental group B experienced a program of isotonic and isometric exercises, respectively, in addition to a regularly scheduled program of sports and games. The control group experienced only a program of sports and games. The purpose of the study was to ascertain any improvement on the final physical performance scores as compared to the initial test scores.

II. CONCLUSIONS

The following conclusions are based on the data obtained from this study: (1) the isometric and isotonic contractions improved muscular strength and endurance in events such as the push-up and sit-up; (2) events which

involved agility and over-all body coordination in addition to strength and endurance, such as the broad jump, shuttle race and basketball throw, showed no improvement through the isolated use of isometric and isotonic contractions; (3) none of the groups improved their mean scores; (4) all groups showed a decrease in their mean score on the final test. Bender²¹ concluded in one study that isometric exercises were of great significance for development of strength, but for over-all fitness, they should be followed by appropriate adjunctive isotonic and stretching exercises.

III. RECOMMENDATIONS

As a result of this study the author wishes to recommend the following: (1) repetition of this study or a similar one in other schools and at different age levels; (2) exposure of experimental groups to programs of contractions over a period of months; (3) a combination of isotonic and isometric exercises for a group should be compared with the groups used in this study.

²¹ Bender, et.al., op. cit., p. 59.

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APPENDIX A

CALIFORNIA PHYSICAL PERFORMANCE TESTS

PURPOSE

The test is designed to measure the present status of physical fitness.

The test involves the use of five groups of exercises. The groups in which groups are of such nature that particular physical fitness are involved in their performance. The other abilities to be measured are estimated by group II tests given as follows:

Group I: Tests in which power, together with endurance, strength, flexibility of arms and body, and balance is involved: standing, broad jump

Group II: Tests in which additional strength and endurance is involved: sit-up

APPENDIXES

Group III: Tests in which strength, endurance, and speed is involved: 100 yard dash, 200 yard dash, 400 yard dash, 800 yard dash, 1600 yard dash, 3200 yard dash, 6400 yard dash, 12800 yard dash, 25600 yard dash, 51200 yard dash, 102400 yard dash, 204800 yard dash, 409600 yard dash, 819200 yard dash, 1638400 yard dash, 3276800 yard dash, 6553600 yard dash, 13107200 yard dash, 26214400 yard dash, 52428800 yard dash, 104857600 yard dash, 209715200 yard dash, 419430400 yard dash, 838860800 yard dash, 1677721600 yard dash, 3355443200 yard dash, 6710886400 yard dash, 13421772800 yard dash, 26843545600 yard dash, 53687091200 yard dash, 107374182400 yard dash, 214748364800 yard dash, 429496729600 yard dash, 858993459200 yard dash, 1717986918400 yard dash, 3435973836800 yard dash, 6871947673600 yard dash, 13743895347200 yard dash, 27487790694400 yard dash, 54975581388800 yard dash, 109951162777600 yard dash, 219902325555200 yard dash, 439804651110400 yard dash, 879609302220800 yard dash, 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APPENDIX A

CALIFORNIA PHYSICAL PERFORMANCE TEST*

PURPOSE

The test is designed to measure the present status of physical fitness.

The test involves the use of five groups of events. The events in each group are of such nature that particular phases of physical fitness are involved in their performance. The motor abilities to be measured are enumerated for events in each group as follows:

- Group I Event in which power, together with coordination, strength, flexibility of legs and body, and balance is involved: standing broad jump
- Group II Event in which abdominal strength and endurance is involved: sit-up
- Group III Event in which muscular strength, endurance of arms, and strength of shoulder girdle is involved: push-up (knee)
- Group IV Event in which speed and endurance is involved: shuttle race
- Group V Event in which agility, coordination, body control, and strength is involved: basketball throw

SEX AND AGE LEVEL

High school girls.

*California State Department of Education, California Physical Performance Test (Sacramento: Bureau of Health Education, Physical Education, and Recreation, 1957).

TEST ITEMS AND EQUIPMENT

A clean smooth surfaced floor; a tumbling mat at least 8 feet in length; 30 feet of straight unobstructed running surface; two blocks of wood, each 2 inches x 2 inches x 4 inches; a stop watch; two parallel lines drawn on the floor 30 feet apart and numbered as one and two; a basketball; two lines drawn parallel and 6 feet apart; an unobstructed area 20 feet high and 75 feet long; chalk; tape measure.

TIME REQUIREMENTS AND NUMBERS THAT CAN BE TESTED

Approximately 35 to 40 subjects can be measured in two 40-minute periods.

INSTRUCTIONS TO BE READ TO SUBJECTS

This is a test designed to measure your present status in physical fitness. The test is divided into five parts: the standing broad jump; modified push-up from the knees; sit-up; shuttle race; basketball throw.

The first test we will be taking is the standing broad jump. The pupil stands with feet several inches apart and with toes just back of the take-off line. The take-off is made from both feet and the pupil jumps forward as far as possible, landing on both feet. Free swinging of the arms and bending of the knees is permissible, but during this action of arms and legs the feet must not leave the floor or take-off line until the jump is made.

Each pupil will have three fair trials (not including fouls) and the best of the three will be recorded. Violation of any of points listed in the test will constitute a foul.

Line up in alphabetical order and step to the take-off line when your name is called.

ADMINISTERING OF STANDING BROAD JUMP

Each student will do the standing broad jump and their scores will be recorded.

INSTRUCTIONS TO BE READ TO SUBJECTS

The next test item will be the modified push-up. The pupil gets into position to perform a knee push-up by lying

face down on the floor with the body straight and legs together. Next, she raises her feet and bends her knees until her legs form right angles and the soles of her feet point directly upward; she bends her elbows and places her palms downward on the floor at points even with her shoulders. To perform a knee push-up, the pupil pushes with her arm and shoulder muscles until the arms are straight and the body is elevated diagonally and is supported by the hands and knees. The test is continued by bending her arms and lowering her body until the chest, and chest only, touches the floor. The exercise is repeated with no resting between push-ups. No push-up shall be counted in which the pupil fails to (a) keep the body straight from head to knees; (b) come to full extension of arms; (c) touch the chest and only the chest to the floor. The pupil's performance shall be recorded as the number of correctly executed knee push-ups she is able to do. Those push-ups not done correctly will not count.

Get a partner and line up across the width of the gymnasium. The girls on the east side of the line will do the push-ups first and the girls on the west side of the line will count them. After the first group has completed their push-ups the second group will do them.

ADMINISTERING OF PUSH-UPS (KNEE)

The students will do the push-ups with their partner counting. After the first group has completed their push-ups the scores will be recorded and the second group will do their push-ups with the first group counting.

INSTRUCTIONS TO BE READ TO SUBJECTS

The next test item will be the shuttle race. The blocks are placed about a foot apart, just beyond the line designated as line two. The pupil stands back of the block-free line designated as line one and faces line two. On the words "Are you ready?" the pupil gets ready to run, and on the starting signal "Go!" she runs to line two, picks up one block of wood, runs back to line one and PLACES, not throws, the block behind the line; she then runs back to line two, picks up the second block of wood and runs back to line one, finishing as she crosses the line with the block in her hand. Two trials shall be given each runner with a rest period between each trial. The time will be recorded from the starting signal until the runner crosses the line

on her second round trip. The better time of two trials will be recorded.

Line up in alphabetical order and step to line one when your name is called.

ADMINISTERING THE SHUTTLE RACE

The test will be administered to each girl twice, allowing for a rest period between two trials. The better of the two trials will be recorded.

INSTRUCTIONS TO BE READ TO SUBJECTS

The next test will be the sit-ups. The pupil lies on her back on the floor with her legs straight and her feet placed about two feet apart. She puts her hands on the back of her neck with either the fingertips touching or the fingers clasped. She keeps her elbows squarely on the floor. Her partner holds the pupil's ankles to keep her heels in contact with the mat at all times. To perform a sit-up, the pupil raises her trunk until she reaches a sitting position; she turns her trunk to the left to touch the right elbow to the left knee; she returns to the starting position, then immediately raises her body forward again and turns her trunk to the right to touch her left elbow to her right knee. Her back should be rounded as the head and elbows are brought forward. This movement is also called a "curl-up." No resting will be permitted between sit-ups and only one trial will be given. No sit-up will be counted if the pupil fails to (a) keep the fingers in contact behind her neck; (b) keep the knees on the floor during the sit-up; however, knees may be bent slightly when touching elbow to knee; (c) bring both elbows forward in starting to sit up; pushing off the floor with an elbow is not permitted; and (d) return to starting position with elbows flat on mat before sitting up again. The pupil's performance shall be recorded as the number of correctly executed sit-ups he is able to do.

Get a partner and line up across the width of the gymnasium. The girls on the east side of the line will do the sit-ups first and the girls on the west side of the line will hold your feet and count. After completing the sit-ups the girl on the west side of the line will do them and the girl on the east side of the line will hold her feet and count.

ADMINISTERING OF SIT-UPS

The students will do the sit-ups with their partner holding their feet and counting. When the first group has completed their sit-ups they will hold the feet and count for their partner in the second group. The total number of sit-ups done correctly will be recorded.

INSTRUCTIONS TO BE READ TO SUBJECTS

The final test item will be the basketball throw. The object of this test is to throw the basketball as far as possible without stepping over the restraining line. The pupil may take one or more steps providing she does not cross the restraining line. An overhand throw must be used in performing this test. Three trials shall be taken with no rest between trials and the best of these trials will be recorded. The distance will be measured from the point where the ball first lands to the restraining line. Line up in alphabetical order.

ADMINISTERING THE BASKETBALL THROW

The students will be in alphabetical order and will step to the line when their name is called. The best distance of the three trials will be recorded.

Distich	44.0"	130	814
Reino	46.0"	130	815
Lowell	47.0"	130	816
Nelson	48.0"	130	817
Kumler	49.0"	130	818
Crump	50.0"	130	819
Phillips	51.0"	130	820
Clark	52.0"	130	821
Wright	53.0"	130	822
Gray	54.0"	130	823

APPENDIX B

McCLOY CLASSIFICATION INDEX I*
 FORMULA = (20xAGE) + (6xHEIGHT) + WEIGHT

Name	Age	Height	Weight	Formulated total
CONTROL GROUP				
Batson	15	64.0"	130	838
Fowler	15	65.0"	125	815
Graham	15	62.0"	112	784
Grimmet	15	64.0"	105	789
Guerrez	16	62.0"	102	794
Gueterra	15	65.0"	118	808
Hollar	15	64.5"	120	807
Kidwell	15	64.0"	120	804
Krueger, L.	15	65.0"	150	840
McGlenny	15	54.5"	118	745
Parker	15	65.5"	175	868
EXPERIMENTAL GROUP A				
Corbin	15	68.0"	100	808
Harry	15	68.0"	140	848
Judd	15	62.0"	105	777
Kittle	15	63.0"	120	778
Krueger, R.	15	66.0"	150	846
McAlister	15	63.0"	103	781
Messinger	15	67.0"	145	847
O'Daniel	15	62.5"	106	781
Painter	15	67.0"	135	737
Schroeder	15	65.0"	145	835
Stow	15	62.5"	155	830
Swanner	15	65.0"	140	830
EXPERIMENTAL GROUP B				
Dietrich	15	64.0"	130	814
Heins	15	66.0"	120	816
Lewallen	16	63.0"	108	806
Melton	15	65.0"	116	806
Mounkes	15	59.5"	100	767
Owens	15	63.5"	95	776
Phillips	15	64.5"	120	807
Schade	15	65.5"	150	843
Stanton	15	64.0"	108	792
Starr	16	63.0"	155	865

APPENDIX B (continued)

Name	Age	Height	Weight	Formulated total
Wyatt	15	63.0"	110	788
Young	15	65.5"	112	805

*H. Harrison Clark, Application of Measurement to Health and Physical Education (Englewood Cliffs: Prentice-Hall, Inc.), p. 305.



Figure 1. Arm position.

Exercise 1: Arm Position
 Stand in a relaxed position with arms extended sideways from shoulders, palms down. Breathe small circles with both arms extended forward, moving arms slightly forward, upward, backward, and downward, maintaining movement in circular path.



Figure 2. Arm position.

*President's Council on Physical Fitness, Physical Education Program (Chicago: John Wiley & Sons Company, 1957), p. 100.

APPENDIX C

The exercises which represent the isotonic muscle contractions were:*

1. Long Stride, Run In Place

Starting position. Forward lunge position with left foot forward, head and chest parallel to floor, palms of hands placed on floor directly under shoulders.

Analysis. Jump, exchanging positions of feet, forward foot replacing back foot, transferring weight to hands on exchange of feet. Count: 1.

Note. (a) Balls of both feet are on the floor with toes pointing straight ahead, knee of back leg off floor. (b) The hips and back should remain close to and parallel with floor in exchanging position of feet.

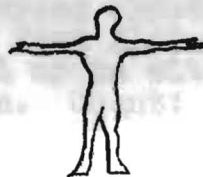


Starting Position

2. Extended Arm Circling

Starting position. Good standing position with arms extended sideward from shoulders, palms down.

Analysis. Describe small circles with both arms extended sideward, moving arms slightly forward, upward, backward, and downward, confining movement to shoulder joint. Count: 1.



Starting Position

*President's Council on Physical Fitness, U. S. Official Physical Fitness Program (Chicago: John Dienhart Publishing Company, 1961), p. 19-31.

3. Alternate Leg Lifting and Lowering

Starting position. Back lying position.

Analysis. Raise left leg upward slowly to form right angle with hip, keeping both legs straight and right leg in position on floor. Lower left leg slowly to starting position. Count: 4.

Return to starting position. Return to starting position. Count: 4.



Starting Position

4. Double Leg Lifting and Lowering

Starting position. Back lying position.

Analysis. Lift both legs upward slowly from floor to form right angle with hips, keeping legs straight and together, toes pointed. Lower both legs slowly to floor, ankles flexed and heel leading. Count: 4.

Note. Abdominal muscles would be strongly contracted to prevent hyperextension of spine.



Starting Position

5. Sit up (Arms Crossed, Knees Bent)

Starting position. Lie on back, arms crossed on chest, hands grasping opposite shoulders, knees bent at right angles, feet flat on floor.

Analysis. Curl up to sitting position. Return to starting position. Count: 4.

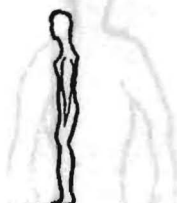


Starting Position

6. Squat Thrust

Starting position. Pupil stands at attention.

Analysis. Bend knees and place hands on floor in front of feet. Arms may be between, outside, or in front of the bent knees. Thrust the legs back far enough so that the body is perfectly straight from shoulders to feet (the push-up position). Return to squat position. Return to erect position.
Count: 4.



Starting Position

7. Push-up Stand, facing wall, hands at shoulder level, feet against wall.
Push up, keeping hands forward against wall keeping arms straight.



Starting Position

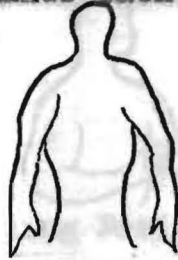
APPENDIX D

The isometric contractions used in the study were:*

1. Upper Body

Starting position. Stand, back to wall, hands at sides, palms toward wall.

Action. Press hands backward against wall, keeping arms straight.

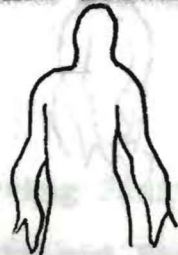


Starting Position

2. Upper Body

Starting position. Stand, facing wall, hands at sides, palms toward wall.

Action. Press hands forward against wall keeping arms straight.



Starting Position

*President's Council on Physical Fitness, U. S. Official Physical Fitness Program (Chicago: John Dlenhart Publishing Company, 1961), pp. 58-59.

3. Arms

Starting position. Stand with feet slightly apart. Flex right elbow close to body, palm up. Place left hand over right.

Action. Forcibly attempt to curl right arm upward, while giving equally strong resistance with the left hand. Repeat with the left arm.



Starting Position

4. Abdominal

Starting position. Stand, knees slightly flexed, hands resting on knees.

Action. Contract abdominal muscles.

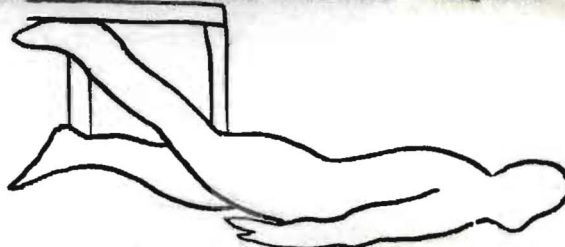


Starting Position

5. Lower Back, Buttocks and Back of THIGHS

Starting position. Lie face down, arms at sides, palms up, legs placed under heavy object.

Action. With both hips flat on floor, raise one leg, keeping knee straight so that heel pushes hard against the resistance above. Repeat with opposite leg.



Starting Position

6. Legs

Starting position. Sit on chair with left ankle crossed over right, feet resting on floor, legs bent at ninety degree angle.

Action. Forcibly attempt to straighten right leg while resisting with left. Repeat with opposite leg.

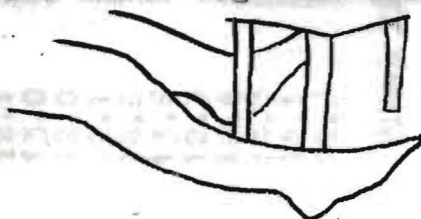


Starting Position

7. Inner and Outer Thighs

Starting position. Sit, legs extended with each ankle pressed against the outside of sturdy chair legs.

Action. Keep legs straight and pull toward one another firmly. For outer thigh muscles, place ankles inside chair legs and exert pressure outward.



Starting Position

APPENDIX E

RAW SCORES ON INITIAL TEST AND FINAL TEST FOR CONTROL GROUP

Name	Push-up	Sit-up	Shuttle race (seconds)	Standing broad jump (inches)	Basketball throw (inches)
INITIAL TEST					
Batson	23	29	12.1	63.00	649.00
Fowler	40	30	13.0	71.50	551.50
Graham	31	30	12.0	71.75	513.00
Grimmet	21	25	12.1	71.00	443.50
Guerrez	25	30	14.8	48.50	397.75
Gueterra	13	10	13.6	63.00	317.00
Hollar	25	34	12.3	63.50	533.50
Kidwell	25	11	12.4	62.25	417.00
Krueger, L.	23	20	14.0	50.50	454.00
McClenny	22	17	14.1	59.00	637.00
Parker	10	18	12.9	59.00	460.00
FINAL TEST					
Batson	25	32	12.6	71.00	520.00
Fowler	50	35	11.4	70.75	497.00
Graham	22	28	12.6	59.00	507.00
Grimmet	21	28	12.4	58.25	417.00
Guerrez	24	35	13.7	58.00	366.00
Gueterra	26	23	12.2	65.75	420.00
Hollar	30	35	12.3	68.50	480.00
Kidwell	21	11	13.4	59.25	390.00
Krueger, L.	29	30	14.3	49.75	440.00
McClenny	26	23	13.5	63.50	568.00
Parker	15	16	13.6	58.75	476.00

Mean score on initial test: 25.23; standard deviation: 54.35

Mean score on final test: 25.20; standard deviation: 54.29

APPENDIX F

RAW SCORES ON INITIAL TEST AND FINAL TEST FOR EXPERIMENTAL GROUP A

Name	Push-up	Sit-up	Shuttle race (seconds)	Standing broad jump (inches)	Basketball throw (inches)
INITIAL TEST					
Corbin	31	20	13.7	59.60	464.00
Harry	29	30	12.5	63.50	437.00
Judd	25	21	12.3	55.00	493.00
Kittle	31	40	12.1	64.25	510.00
Krueger, R.	25	27	13.5	55.00	597.00
McAlister	25	50	12.0	68.50	675.00
Messinger	16	16	13.6	53.50	487.00
O'Daniel	35	22	12.0	57.25	415.00
Painter	36	40	12.1	57.00	704.00
Schroeder	23	27	12.1	62.25	671.00
Stow	28	30	13.1	65.25	684.00
Swanner	20	12	13.3	57.50	355.00
FINAL TEST					
Corbin	30	35	13.2	56.00	477.00
Harry	31	40	11.8	65.00	447.00
Judd	30	31	12.2	59.00	449.00
Kittle	31	40	12.0	59.00	459.00
Krueger, R.	23	42	12.9	50.25	593.00
McAlister	30	75	14.2	66.50	596.00
Messinger	26	30	14.5	54.00	432.00
O'Daniel	35	23	12.5	59.50	470.00
Painter	32	48	12.0	53.50	682.00
Schroeder	35	30	11.6	62.75	624.00
Stow	30	30	12.7	63.75	672.00
Swanner	30	20	13.2	58.50	388.00

Mean score on initial test: 24.60; standard deviation: 54.42

Mean score on final test: 24.31; standard deviation: 54.34

APPENDIX G

RAW SCORES ON INITIAL TEST AND FINAL TEST FOR EXPERIMENTAL GROUP B

Name	Push-up	Sit-up	Shuttle race (seconds)	Standing broad jump (inches)	Basketball throw (inches)
INITIAL TEST					
Dietrich	12	21	13.0	45.00	518.00
Heins	26	15	13.6	66.50	403.00
Lewallen	9	10	13.2	68.00	483.50
Melton	47	30	12.1	65.75	517.50
Mounkes	25	20	13.1	62.00	373.00
Owens	35	41	12.5	61.50	382.75
Phillips	52	40	11.7	65.25	418.50
Schade	12	32	12.7	63.00	451.25
Stanton	9	12	13.0	56.00	456.50
Starr	24	17	13.3	47.00	626.00
Wyatt	40	42	13.3	71.50	540.00
Young	19	24	11.9	69.50	461.00
FINAL TEST					
Dietrich	20	25	13.4	42.00	424.00
Heins	30	12	14.5	63.25	441.00
Lewallen	9	12	14.3	65.50	450.00
Melton	70	40	12.4	68.00	468.00
Mounkes	35	32	13.7	62.00	376.00
Owens	60	40	12.5	59.25	605.00
Phillips	70	40	12.0	65.00	403.00
Schade	24	50	13.0	62.50	539.00
Stanton	12	30	13.9	52.25	438.50
Starr	26	30	14.2	43.75	579.00
Wyatt	40	30	12.5	68.25	459.00
Young	17	27	12.5	60.50	449.00

Mean score on initial test: 25.74; standard deviation: 54.29

Mean score on final test: 25.52; standard deviation: 54.35