A COMPARISON OF THREE SELECTED EXERCISES IN BUILDING ABDOMINAL STRENGTH AND ENDURANCE IN UPPER ELEMENTARY SCHOOL GIRLS

THESIS

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This study compares the effectiveness of three selected exercises (curl-up, conventional hook sit-up and modified hook sit-up) in building abdominal strength and endurance in upper elementary school girls. Ninety-nine subjects were randomly divided into four groups.

The study was designed to determine (1) whether an eight week exercise program can increase abdominal strength and endurance; (2) the most effective exercise; (3) if muscle action intensity affects the results.

A cable tensiometer measured abdominal strength and a timed sit-up measured abdominal endurance. An analysis of covariance determined significance.

Significant gains in abdominal strength and endurance were shown by the conventional hook sit-up.

Further study on the relationship between muscle development and maturation in young children is recommended.

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CHAPTER I

INTRODUCTION

The physical fitness of the American people, young and old alike, has become a major concern in our country today (15). Numerous programs have been instigated by educational, professional and governmental bodies in an effort to raise the fitness level of the people, particularly the youth (2).

One notable example of these programs was the creation of the President's Council on Youth Fitness in 1957 which publicized the values of physical fitness and encouraged programs in this area (7; 13, p. 1). The Youth Fitness Test Project was developed in conjunction with the President's Council. The battery of tests developed by the project was the first ever created by the physical education profession in which national norms were established. These norms were determined in 1957, and updated in 1965. In 1975 the test was modified by eliminating the softball throw and by substituting the flexed knee sit-up for the straight leg sit-up which minimizes the action of the hip flexors in performing the exercise. A revision of the norms was also established (2).

However, the 1975 revision of the national norms for the Youth Fitness Test is a cause of great concern among those associated with the physical education profession.

In the eight years from 1957 to 1965, significant gains were recorded for both boys and girls in all seven events. The results of the 1975 update of the national norms showed there was no significant overall improvement in the fitness of American boys or girls since 1965 (2).

Activities associated with sports, games and rhythms found in many physical education programs are usually not sufficient or specific enough to stimulate all-around development; therefore, it is necessary to supplement skill instruction with a well-conceived program of developmental exercise (10, 20).

Muscular strength is one of the basic components of physical fitness. It is recognized by many as one of the most important elements in improving motor skills and in acquiring endurance to perform these skills(12, 20). Moreover, inadequate strength results in more rapid onset of muscular fatigue (19). There is a strong relationship between muscular strength and social adjustment, general learning ability and appearance (1; 7, p. 2; 19). Strong muscles are also a deterrent against certain orthopedic deficiencies and chronic illnesses (19).

Abdominal strength plays a major role in physical activities of various kinds. It is a primary factor in developing sport proficiency and enjoyment for both athletic and recreational activities (9). Wallis and Logan (20) believe that strong abdominal muscles are essential

in maintaining good posture, and are best developed in childhood. Mathews (19) emphasized that 80 per cent of low back pain is caused by weak abdominal muscles. He suggested that bent leg sit-up exercises are an effective way to strengthen these muscles.

The measurement of human strength has interested scientists for over 250 years (18). They have used many different methods for studying this aspect of physical fitness. One of the most recent and important tools used in muscular research is the study of muscle action potentials through the use of electromyography (11, p. 22).

Numerous researchers have done studies on the action potential of muscles participating in exercises used to test and to develop the strength and endurance of the abdominal muscles (14, 16, 21).

Bernard Gutin and Stanley Lipetz recorded the muscle action potential of ten abdominal exercises and then ranked them in order of electromyographic intensity. The exercises were then grouped into four groups with each group showing a significant difference at the .05 level of significance from each of the other groups. For this study on comparing three selected exercises in building abdominal strength in upper elementary school girls, an exercise was selected from three of the four groups. The exercises selected to be tested for training effectiveness were the modified hook sit-up, the conventional hook sit-up and the curl-up.

The sit-up has been considered by many as the best exercise for testing and developing abdominal muscles (12). Many variations in the arm position, angle of knee flexion and slant of the body has been developed.

In 1956, Wedemeyer (22) used the straight leg sit-up in a two months training program with senior high school boys. Through this study he found that the boys who were weaker to begin with showed the most improvement in the number of sit-ups performed following the training program. However, these same boys did not show the greatest improvement in sit-up strength. He concluded, therefore, that after strength reached a certain level of improvement, the strength factor remained stable and the endurance factor showed the greatest improvement. Wedemeyer also concluded that sit-ups measure a combination of strength and endurance of the abdominal and thigh-flexor muscles.

Beyer (5) conducted a study in 1966 comparing the results of a sit-up test with a two minute time limit and a test with no time limit. He concluded that the two minute time limit was as effective as the no time limit in measuring abdominal strength.

Craven (9) followed with a study in 1968 in which he compared the effectiveness of the straight leg sit-up with the bent knee sit-up using both with a one minute time limit and with no limit in exercising time. From the results of this study, Craven feels that both leg positions are equally

adequate in measuring abdominal strength and there is no significant difference between the one minute time limit and the no time limit. He stated that the study would infer that each exercise would also be of equal importance in developing the abdominal muscles.

Most training programs use adults or older youth as subjects. There is doubt whether comparable training effect can be shown in children since strength closely parallels physical maturity (17, p. 32). Asmussen (3) and Cureton (10) believe strength can be accelerated in children with a systematic training program.

Since most studies have used young adults as subjects, it is not known what effect different abdominal exercises might have upon strength development among children. Moreover, the order effect of muscle action potentials, suggesting greater trainability for the higher intensity exercises has not been tested to date. It seemed that a study to test the theory of muscle action potential production and subsequent strength gains was needed, especially among a young population.

Statement of the Problem

The problem in this study was to compare the effectiveness of three selected exercises in building abdominal strength and endurance in upper elementary school girls.

Purposes of the Study

The following purposes were formulated to further clarify and identify the problem:

1. To test the effectiveness of an eight weeks exercise program on building abdominal strength and endurance in upper elementary school girls;

2. To compare the results of three different types of exercises in building abdominal strength and endurance;

3. To test whether exercises with greater intensity in muscle action potential develop greater abdominal strength and/or endurance.

Hypotheses

Consistent with the purposes stated above, this study was designed to test the following hypotheses:

1. There will be no significant difference in the abdominal strength and endurance of upper elementary school girls following an eight weeks exercise program;

2. There will be no significant difference between the results of the three exercises;

3. An exercise program based on an exercise with a greater muscle action potential will not show greater strength improvement than a program based on an exercise with lesser muscle action potential.

The above hypotheses were tested at the .05 level of significance.

Delimitations

In order to incorporate this study in an elementary school physical education program, the following delimitations were established:

1. The fourth and fifth grade girls of Armstrong Elementary School in Highland Park, Dallas, Texas were used as subjects;

2. The study was limited to three exercises;

3. The testing was done with a cable tensiometer and a one-minute bent knee sit-up test;

4. The exercises were done in the Fall of 1977;

5. The exercise programs lasted for eight weeks;

6. The testing involved only the abdominal muscles.

Limitations

The following limitations were in this study:

1. Absences from school and excuses from activity may have affected training benefits;

2. The hip flexors, which are also involved in sit-ups, were not tested.

Definition of Terms

Basket hang.--"The performer is suspended from a horizontal bar with the palms supinated and legs extended. Knees are drawn up to the chest until the pelvis tilts up and back. Subject then uncurls to the extended position" (16, p. 257).

Conventional hook sit-up.--"From the hook lying position with the knees at 65 degrees and the legs not anchored to the floor, the subject sits up until the chest touches the quadriceps. The hands are clasped behind the neck and the elbows are held forward throughout, in order to prevent a whipping action with the arms" (16, p. 257).

Curl-up.--"From the supine position, the subject curls up until the finger-tips reach the level of the knee joint. Arms are extended throughout and legs are not anchored to the floor. The curling action is initiated when the chin is brought to the chest" (16, p. 257).

Isometric contraction.--Static muscular contraction in which the muscle maintains a fixed length (7).

Isotonic contraction.--Dynamic muscular contraction in which the muscles continue to raise and lower a submaximal load. Muscles alternately shorten and lengthen (7).

Modified hook sit-up.--The lower legs rest across the top of the bench 14 inches high with the back of the knee in contact with the corner of the bench. The hands are clasped behind the neck and the elbows are held forward throughout. Subject sits up until the chest touches the quadriceps (16).

Muscular endurance.--The ability of muscles to continue work (6).

Muscular strength.--Capacity to exert a force against some resistance (7). The tension muscles can apply in a single maximum contraction (6).

Tensiometer.--A strength measurement device which has a special calibration for an "up-pull" on the cable and a maximum pointer to facilitate reading the subject's score (7).

Significance of the Study

School physical education programs too often fail to concentrate on the physical development of all children. A short conditioning program of vigorous exercises at the start of every physical education period is considered of utmost importance (10, 20).

If a short exercise period three times a week spent on specific exercises would show a significant gain in abdominal strength, and if one exercise could be shown to be superior to the other two, the following benefits would be derived:

1. Abdominal strength in upper elementary school girls could be increased within the frame-work of a physical education program;

2. Utilization of the superior exercise would decrease time spent on exercise but would increase the results;

3. This study could serve as a guide in formulating a program for building abdominal strength in upper elementary school children.

CHAPTER BIBLIOGRAPHY

1. American Association for Health, Physical Education and Recreation Youth Fitness Project, Your Child Can't Sit and Keep Fit, Washington, D. C., AAHPER Publication.

2. American Alliance for Health, Physical Education and Recreation, Youth Fitness Test Manual, Revised 1976 Edition, Washington, D. C., AAHPER Publication, 1976.

3. Asmussen, Erling, "Neuromuscular System and Exercise," Exercise Physiology, edited by Harold B. Falls, New York, Academic Press, 1968.

4. Astrand, Per-Olof and Kaare Rodahl, Textbook of Work Physiology, New York, McGraw-Hill Book Co., 1970.

5. Beyer, Richard A., "Evaluation of the 2-Minute Sit-Up Test as a Measure of Muscular Endurance and Strength," Journal of Association of Physical and Mental Rehabilitation, 20 (July-August, 1966), 140.

6. Clarke, H. H., Muscular Strength and Endurance in Man, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

7. _____, "Development of Volitional Muscle Strength as Related to Fitness," Exercise and Fitness, Chicago, Illinois, The Athletic Institute, 1960, pp. 200-213.

8. Coleman, Alfred E., "Comparison of Weekly Strength Changes Following Isometric and Isotonic Training," Journal of Sports Medicine and Physical Fitness, 12 (1972), 26-29.

9. Craven, Charles W., "An Evaluation of Methods of Administering the Sit-Up Test," unpublished master's thesis, Department of Education, University of Texas at Austin, Austin, Texas, 1968.

10. Cureton, T. K., Improving the Physical Fitness of Youth, Monogr. Soc. Res. in Child Development, No. 4 (Serial No. 95), 1964.

11. deVries, Herbert A., Physiology of Exercise for Physical Education and Athletics, 2nd Edition, Dubuque, Iowa, W. C. Brown, Co., Inc., 1974.

12. Falls, H. B., E. J. Wallis, and G. A. Logan, Foundations of Conditioning, New York, Academic Press, 1970.

13. Fleishman, E. A., The Structure and Measurement of Physical Fitness, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1964.

14. Flint, M. Marilyn and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, 26 (March, 1965), 29-37.

15. Gawer, Herman and Herbert Michelman, Body Control and Physical Fitness, New York, Gramercy Publishing Co., 1970.

16. Gutin, Bernard and Stanley Lipetz, "An Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, 42 (October, 1971), 256-263.

17. Hettinger, Theodore, Physiology of Strength, Springfield, Illinois, Charles C. Thomas, 1961.

18. Hunsicker, Paul A. and Richard L. Donnelly, "Instrument to Measure Strength," Research Quarterly, 26 (December, 1955), 408-420.

19. Mathews, Donald K., Measurement in Physical Education, 4th Edition, Philadelphia, Pennsylvania, W. B. Saunders Co., 1973.

20. Wallis, Earl L. and Gene A. Logan, Exercise for Children, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

21. Walters, C. Etta and Mariam J. Partridge, "Electromyographic Study of the Differential Action of the Abdominal Muscles During Exercise," American Journal of Physical Medicine, 36 (October, 1957), 259-268.

22. Wedemeyer, Ross, "A Differential Analysis of Sit-Ups for Strength and Muscular Endurance," Research Quarterly, 17 (March, 1946), 40.

CHAPTER II

REVIEW OF RELATED MATERIAL

Physical Fitness of Children

The present physical fitness level of American children is of great concern to many physical educators. In several carefully conducted studies between our youth and the youth of other countries, it was found that our children did not compare well in several basic areas of physical fitness (10, 22, 23) even though they do compare favorably when trained and challenged in various competitive athletics (22).

In a comparison of American children and British children on the AAHPER test, the U. S. children averaged in the fiftieth percentile and the British in the sixty-fourth percentile. If the softball throw were discounted, the British children would have ranked in the seventieth percentile (22).

In a minimum fitness test, 58 per cent of the American children failed while only 9 per cent of the Austrian, Italian and Swiss children failed (23).

The typical physical education program based on games, dances and sports rather than on conditioning exercises and gymnastics may be largely responsible for the apparent lack of strength in American youth (10). Another major contributing factor may be the fact that 95 per cent of the average American child's waking hours are spent sitting down (2).

Quite often exercise programs for children are not strenuous enough to show any real improvement in strength (31). Few of their activities reach the organic level that can be considered conditioning or training (10). Although muscular strength develops throughout the growing years naturally, Asmussen and Cureton believe that it is possible to accelerate this growth of strength by systematic training (3, p. 78; 10).

In our modern society most of the basic tasks can be done with only minimal exertion and this is conducive to a weak musculature (7, p. 1).

Hettinger found a close relationship exists between a child's biological maturity and his ability to be trained. Some boys and girls are trainable while others show little or no improvement following an extensive conditioning program (21, p. 32).

Strength Training Principles

There is no easy way to develop strong muscles (20, p. 371). An adequate program must be built on the overload principle and the rate of improvement will depend on the degree to which a person will exert the additional effort (20; 28, p. 230). The muscular system must be pushed beyond previous demands (12, 21). This can be done either by moving a light load rapidly or a heavy load slowly (11).

There are two approaches to muscular strength training. One approach is to build a program around high resistance exercises in which the load to be moved is maximal or near maximal. The number of repetitions is low, and they are usually in a fixed number of sets. The number of sets remain constant but the load is progressively increased. This type of training is most frequently used in weight training.

The second approach to building muscular strength is in the use of isotonic exercises. The load is a lighter, submaximal one and the number of repetitions is high. This allows a full range of motion and is conducive to endurance training in conjunction with strength training (4, 9, 11, 12).

Falls (14) considers the isometric exercises as the most efficient way to gain strength, but recognizes the fact that the isotonic exercise is the one most widely used in high level strength development programs. Coleman (9) indicates that similar results are obtained through isometric and isotonic training. Isometric contractions are found within isotonic exercises at the points of greated intensity (21).

Isotonic or dynamic exercises have several advantages. One advantage is that it is more functional. It can cover the entire range of motion in one contraction. It would take several isometric contractions to benefit the same area. Another advantage is a psychological one. The exerciser has the satisfaction of seeing the work done in overcoming a fixed resistance (12, p. 307).

In the isotonic type of exercise the load is submaximal but several physiologists feel that the heavier the load and the more often it is applied, the greater the strength development (4, 11). Morehouse believes that the main factor influencing training is the intensity of the muscle tension and that the frequency and duration of time is of lesser importance (28, p. 234). According to Hettinger (21, p. 20), the intensity of training stimulus must be increased at least every two weeks to gain the desired results. However, the fatigue factor must be considered because a tired muscle reduces its tension and thus loses its training effect (7, p. 203; 28, p. 249).

In a conditioning program, the muscle goes through three stages of development. First, there is hypertrophy of the muscle, followed by an increase in explosive strength. This in turn is followed by the development of muscular endurance (28).

Strength Training Programs

Providing that there is no pathological condition present, a systematic approach to overloading a muscle or group of muscles will produce stronger muscles (27). The rate of gain is a highly individual matter (14). The expected gain depends largely on the beginning level of strength--with the gain slowing as the muscle approaches its maximum development. Greatest gains are obtained at the beginning of a program and

by those in the poorest physical condition (9; 12; 28, p. 234). The training potential of girls nine and ten years of age is 10 - 15 per cent less than that of boys of the same age (21, p. 40).

In formulating a training program for elementary school children there seems to be little concrete guidance. Physiologists generally agree that good programs can show significant improvement in the strength of youngsters. However, there appears to be no agreement on the recommended intensity, frequency or duration of time to spend on such a program. Falls (14) states that significant gains in strength can be noted after three or four weeks with five exercise periods a week. Hettinger (21) has obtained an 80 per cent increase in strength in a six weeks program with exercise sessions three times a week and Mathews (27, p. 143) recommends six or seven weeks of three times a week training bouts. Asmussin conducted a successful training program in increasing the ability of children to chin the bar in eight weeks of exercise, three times a day on three days a week. The increase was 100 per cent over beginning strength (4). Logan (26, p. 230) suggests that daily exercise periods are best and Clarke believes that a conditioning program should have not less than three nor more than five days a week spent in exercising (6). deVries (12) feels that three or four sessions a week are most desirable with only one of these sessions reaching an exhaustive state.

Morehouse gives three ways an exercise can overload a muscle group: (1) the speed or rate of movement can be increased, (2) the duration can be increased, (3) and the frequency of exercise sessions can be increased (28).

Exercises for the Abdominal Muscles

Physical educators, athletic coaches and trainers as well as physical and corrective therapists have a special interest in different methods of strengthening the abdominal muscles (26) although a difference of opinion exists as to which exercises are the most desirable and the most effective (1, 17). Flint (17) and Soderberg (30) believe that the trunk curl is far superior to the sit-up. Wedemeyer (33) and De Witt (13) feel that there is no significant relationship between the sit-up and abdominal strength and endurance. Fleishman (15) has stated that the leg-lifts are much better than the sit-up for measuring trunk strength.

Despite the search for a new or better abdominal strengthening exercise, the bent-knee sit-up remains a popular exercise with many physical educators and is included in many test batteries. Many variations have been developed. These variations consist mainly of different angles for knee flexion, different arm positions and whether the feet are supported (29).

Exercises in which the abdominal muscles are the prime movers instead of the stabilizers are considered by many to

be the most effective although there is no objective evidence of this (34, p. 462). The abdominal muscles and the hip flexors are the two sets of muscles involved in the sit-ups (29). This study was concerned with the muscles of the abdominal wall which include the rectus abdominus, external oblique, the internal oblique, and the transversalis (34, p. 462).

Electromyography

The contraction of a muscle is accompanied by an electrical change that can be recorded and measured. This electrical change is called a muscle action potential (MAP) and its recording is called electromyography (5, p. 53; 12, p. 22). The intensity of a muscle's participation in a specific movement shows a linear relationship with the force of contraction (25) and this provides a workable estimation of muscular strength (12, p. 190).

EMG Studies of Abdominal Muscles

Studies of Walters and Partridge are pertinent in analyzing muscle group participation in a series of exercises. They found that in all forms of sit-up exercises from the hook-lying position in which the feet were held down, the hip flexors played a greater part than did the abdominals. They concluded that the sit-up type of exercise was one of the most effective types of exercise for all of the abdominal muscles (32).

Flint made a MAP study of the use of the abdominal muscles in seventeen exercises (18). She followed this study with another study in which she compared the functions of the rectus abdominis and the external oblique during the performance of ten variations of the sit-up (16). She concluded that the three favored exercises for the abdominals are (1) the trunk curl with knees flexed at a 45 degree angle with a body twist, with either the feet supported or not supported, (2) the trunk curl with knees flexed at a 45 degree angle, with feet supported, and (3) the sit-up with knees flexed at a 45 degree angle and with the feet supported.

In 1970, Lipetz and Gutin (24) did an electromyographic study of four abdominal exercises designed to determine the intensity and duration of MAPS in the upper and lower segment of the rectus abdominis (RA) during the performance of these exercises. The four exercises were the conventional sit-up, the hook sit-up, the arched back sit-up and the double leg raise. They found all four exercises would be effective in the development of abdominal strength and endurance. This study was followed by another study entitled "An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises" (19). This study provided the basis for this thesis.

An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises

In this study, Gutin and Liptez (19) tested ten abdominal exercises and then ranked them in order of MAP intensity. They bracketed those exercises showing similar intensities within a .05 level of significance. The brackets were different in ranking the upper RA and the lower RA. The ten exercises tested in descending order of MAP intensity in the upper RA were basket hang, modified hook sit-up, conventional hook sit-up, inclined sit-up, hook arm across chest, arched back sit-up, conventional sit-up, curl-up, V-sit and the controlled backward lean.

In the lower RA, the basket hand and the modified hook sit-up also showed the greatest intensity. The hook arms across chest was elevated above the conventional hook sit-up and the inclined sit-up dropped below the curl up.

In the selection of the exercises to be used in this study in comparing three abdominal exercises, an attempt was made to select an exercise from the three top groups that would be representative of the ranking order of both the upper RA and the lower RA.

Flint and Gudgell (18) also found the basket hang to have the highest degree of intensity. However, the two studies disagreed on the relative intensity of the backward lean and the V-sit -- with Flint and Gudgell giving them a much higher rating. The similar intensities elicited by the curl-up and the conventional sit-up confirmed the

findings of Walters and Partridge (32). Therefore, it can be theorized that for the purpose of developing abdominal strength, the curl-up with its limited movement is as effective as the full sit-up (19).

Strength Testing Instruments

Strength tests provide us with one of the most objective practical measures to evaluate the fitness of youngsters in school. "A strength test is one in which a subject applies a force that is measured by some type of scale or dynamometer" (27). Other instruments used in testing strength are cable tensiometers, strain gauges and spring scales (35). Dynamometric and cable-tension tests are used primarily to measure gross strength (8). The simplest and most widely used is Clarke's cable tension testing method (12, p. 311).

Clarke and his associates originally developed the cable tension test to measure the strength of muscles weakened by orthopedic disabilities. The possibilities for measuring strength in normal muscles was quickly realized and this method became one of the principle strength measuring devices. In 1964, Clarke used the cable tensiometer in a battery of tests designed to measure the strength of Oregon boys and girls from the fourth grade through college. National norms were established in this test (8).

The cable tensiometer was one measuring instrument used in this study to determine abdominal strength.

Summary

The fitness of our children depends on the intensity of their activities. Physical education programs and recreational activities are often insufficient in providing the vigorous, sustained exercise that is needed for improvement in muscular strength and endurance.

From the review of literature, it is affirmed that strength can be built through a systematic program of overloading the muscle. Most training programs are conducted using adults and older youth as subjects. It is the belief of many physical educators that similar training results can be obtained from children although there exists a close relationship between muscular strength and physical maturity.

It has been shown that different exercises record differing degrees of MAP. Physiologists assert that the amount and the duration of tension applied to the muscle is a major determining factor in strength development. Another major factor is the frequency of exercise bouts.

Gutin and Lipetz ranked ten abdominal exercises in the order of muscle participation. This hierarchy of exercises supplied the basis for the study comparing three selected abdominal exercises.

CHAPTER BIBLIOGRAPHY

1. Allsop, Kent, "Potential Hazards of Abdominal Exercises," Journal of Health, Physical Education and Recreation, 42 (January, 1971), 89.

2. American Association for Health, Physical Education and Recreation Youth Fitness Project, Your Child Can't Sit and Keep Fit, Washington, D. C., AAHPER Publications.

3. Asmussen, Erling, "Growth in Muscular Strength and Power," Physical Activity, edited by G. Lawrence Rarick, New York, Academic Press, 1968.

4. _____, "Neuromuscular System and Exercise," Exercise Physiology, edited by Harold B. Falls, New York, Academic Press, 1968.

5. Astrand, Per-Olof and Kaare Rodahl, Textbook of Work Physiology, New York, McGraw-Hill Book Company, 1970.

6. Clarke, H. H. and D. H. Clarke, Developmental and Adapted Physical Education, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1963.

7. Clarke, H. Harrison, Muscular Strength and Endurance in Man, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

8. Clarke, H. H. and Richard A. Munroe, Oregon Cable-Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College, Eugene, Oregon, Microform Publications, University of Oregon, 1970.

9. Coleman, Alfred E., "Comparison of Weekly Strength Changes Following Isometric and Isotonic Training," Journal of Sports Medicine and Physical Fitness, 12 (1972), 26-29.

10. Cureton, T. K., "Improving the Physical Fitness of Youth," Monograph of Social Research in Child Development, 29 (Serial No. 15), 1964.

11. DeLorme, T. L. and A. L. Watkins, Progressive Resistance Exercise: Technique and Application, New York, Appleton-Century-Crofts, Inc., 1951.

12. deVries, Herbert A., Physiology of Exercise for Physical Education and Athletics, 2nd edition, Dubuque, Iowa, W. C. Brown, Co., Inc., 1974.

13. DeWitt, R. J., "A Study of the Sit-Up Type of Test, as a Means of Measuring Strength and Endurance of the Abdominal Muscles," Research Quarterly, 15 (March, 1944), 60.

14. Falls, H. B., E. J. Wallis and G. A. Logan, Foundations of Conditioning, New York, Academic Press, Inc., 1970.

15. Fleishman, E. A., The Structure and Measurement of Physical Fitness, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1964.

16. Flint, M. Marilyn,"Abdominal Muscle Involvement During the Performance of Various Forms of Sit-Up Exercises," American Journal of Physical Medicine, 44 (October, 1965), 224.

17. _____, "Selecting Exercises," Journal of Health, Physical Education and Recreation, 35 (February, 1964), 19.

18. Flint, M. Marilyn and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, 36 (March, 1965), 29-37.

19. Gutin, Bernard and Stanley Lipetz, "An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises," Research Quarterly, 42 (October, 1971), 256-263.

20. Hellebrandt, F. A. and Sara Jane Houtz, "Mechanisms of Muscle Training in Man: Experimental Demonstration of the Overload Principle," Physical Therapy Review, 36 (June, 1956), 371.

21. Hettinger, Theodore, Physiology of Strength, Springfield, Illinois, Charles C. Thomas, 1961.

22. Hunsicker, Paul A. and Richard L. Donnelly, "Instruments to Measure Strength," Research Quarterly, 26 (December, 1955), 408-420.

23. Kraus, Hans and Ruth P. Hirschland, "Minimum Muscular Fitness Tests in School Children," Research Quarterly, 25 (May, 1954), 178.

24. Lipetz, Stanley and Bernard Gutin, "An Electromyographic Study of Four Abdominal Exercises," Medicine and Science in Sports, 2 (Spring, 1970), 35.

25. Lippold, O. C. J., "The Relation Between Integrated Action Potentials in a Human Muscle and Its Isometric Tension," Journal of Physiology, 117 (1952), 492.

26. Logan, Gene A. and Wayne C. McKinney, Kinesiology, USA W. C. Brown, Co., Inc., 1970.

27. Mathews, Donald K., Measurement in Physical Education, 4th edition, Philadelphia, Pennsylvania, W. B. Saunders, Co., 1973.

28. Morehouse, Laurence E. and Augustus T. Miller, Jr., Physiology of Exercise, 7th edition, Saint Louis, C. V. Mosby, Co., 1976.

29. Physical Fitness Research Digest, President's Council on Physical Fitness and Sports, Washington, D. C., edited by H. Harrison Clarke, Series 6, No. 3, July, 1976.

30. Soderberg, Gary L., "Exercise for the Abdominal Muscles," Journal of Health, Physical Education and Recreation, 37 (September, 1966), 67.

31. Wallis, Earl L. and Gene A. Logan, Exercise for Children, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

32. Walters, C. Etta and Mariam J. Patridge, "Electromyographic Study of the Differential Action of the Abdominal Muscles During Exercise," American Journal of Physical Medicine, 36 (October, 1957), 259.

33. Wedemeyer, Ross, "A Differential Analysis of Sit-Ups for Strength and Muscular Endurance," Research Quarterly, 17 (March, 1946), 40.

34. Wells, Katharine F., Kinesiology, 3rd edition, Philadelphia, Pennsylvania, W. B. Saunders, Co., 1960.

35. Wilmore, Jack H. and Jack F. Keogh, editors, Exercise and Sport Sciences Reviews, Vol. 3, New York, Academic Press, 1975.

CHAPTER III

PROCEDURE

Introduction

This study was designed to test two theories. The first theory was that upper elementary school girls would show an increase in abdominal strength and endurance with an eight week conditioning program based upon the overload principle of strength development using three different types of sit-ups as the conditioning exercises. The second theory was that exercises with greater muscle action potential would show a greater training effect. The selection of exercises was based upon the study of Gutin and Lipetz (4) in which they established a hierarchy of abdominal exercises ranked in order of intensity of the muscle participation. The exercise selected with the greatest intensity was the modified hook sit-up. The second exercise selected in descending order of intensity was the conventional hook sit-up. The curl-up was selected as the third exercise for a specific reason. Gutin and Lipetz (4) ranked it low, but Flint and Gudgell (3) ranked it very high. The results of this study may help to confirm the relative merit of the curl-up.

The subjects were the fourth and fifth grade girls from Armstrong Elementary School in Highland Park, an upper middle class suburb of Dallas, Texas.

The testing procedures to determine static abdominal strength followed those prescribed by Clarke in his Oregon strength test battery study using the cable tensiometer as the measuring instrument (1). A pretest and a posttest was given.

The measurement for testing abdominal endurance was provided by a one-minute timed bent knee sit-up test in which the feet were supported. This is the test found in many fitness test batteries to test abdominal strength and endurance.

The conditioning program had three exercise sessions a week for seven weeks and five exercise sessions during the eighth week. The subjects performed the exercise assigned to them to the best of their ability for the specified time limit. The duration of exercise bouts progressed from one minute to two minutes.

The data from the pretest and the posttest were analyzed and processed through the North Texas State University Computer Center.

Subjects

Each fourth and fifth grade class was divided into four groups, using a random selection chart. Group I, II, and III were each assigned an abdominal exercise to perform three days a week in addition to the regular activities of the physical education program. Group IV was given mild,

generalized exercises to do and served as the control group. An individual chart was kept on each girl. Information on the chart included age, weight, height, number of exercise repetitions performed each session, the number of absences, and any special information which might pertain to the exercise program. (A copy of this chart is found in Appendix A.)

Instrument of Measurement

A 10-200 pound pull cable tensiometer with a one-sixteenth inch cable was used. A test of reliability conducted in the Spring of 1977 by the examiner showed a reliability coefficient of .952 which indicates a very satisfactory degree of testing reliability. Care was taken to obtain uniform tautness on the cable before the pull in order to assure the reliability of the procedure.

The tensiometer was calibrated prior to and following the pretest and the posttest to assure accurate tabulation of the cable tensiometer strength data.

Testing Procedure

The administration of the cable tension strength test required the examiner and an assistant.

The following procedure was established by Clarke (1) and was followed in this study.

1. Subject was placed in supine lying position with the upper back over a slit in the table. Legs were straight and together.

2. A trunk strap was placed around the chest, close under the arm pits. The pulling assembly was hooked beneath the subject, maintaining a 90 degree angle of pull.

3. The assistant braced the thighs of the subject by reaching across the table and pressing the thighs to the table.

4. Each test was begun with sufficient tension to maintain tautness of the cable. The pull must be steady, not jerky.

5. One pull per subject was permitted on each test.

6. The raw score of the pull was recorded on the subject's individual chart. The raw score was converted into pounds of pull at a later time.

The pretest was given the week prior to the introduction of the exercises. The posttest was given the week following the completion of the eight-week exercise program.

Treatment Period

Following the administration of the strength test, the fourth and fifth grade girls were divided randomly into four groups--three exercise groups and a control group for each grade.

Each group was carefully instructed as to the correct method of performing the exercise. If the exercise was too difficult for the girl to do properly, she was instructed to do it to the best of her ability. Each girl was instructed to do as many exercises as possible in the specified time

limit. The following schedule based upon the recommendations for overloading by Morehouse (5, p. 234) was adhered to:

Week	Time Limit	Frequency
First week	one minute	three times a week
Second week	one minute, 10 sec.	three times a week
Third week	one minute, 20 sec.	three times a week
Fourth week	one minute, 30 sec.	three times a week
Fifth week	one minute, 40 sec.	three times a week
Sixth week	one minute, 50 sec.	three times a week
Seventh week	two minutes	three times a week
Eighth week	two minutes	five times a week

According to Beyer, the two minute sit-up tests are comparable to the sit-up test with no time limit in assessing the strength of abdominal muscles (6).

The girls were encouraged to increase the number of repetitions each time by verbal encouragement, interested observation and ego-involvement in which a chart was kept on each girl to record the number of repetitions each time. These motivating devices were suggested by Clarke in Muscular Strength and Endurance in Man (2).

Data Analysis

At the outset of this study a single and two factor analysis of variance with repeated measures was proposed. Following the drawing of the samples, it was found that the four groups were markedly different in pretest scores in both the cable tensiometer test and the timed sit-up test. Therefore, the ANOVA design was abandoned in favor of two, one-way analyses of covariance; one for the tensiometer measurement and one for the timed sit-ups.

All data were analyzed at the North Texas State University Computing Center under program STO14. The .05 level of significance was selected as the criterion for accepting or rejecting the hypotheses.

CHAPTER BIBLIOGRAPHY

1. Clarke, H. Harrison and Richard A. Munroe, Oregon Cable Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College, Eugene, Oregon, Microform Publications, University of Oregon, 1970.

2. Clarke, H. Harrison, Muscular Strength and Endurance in Man, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

3. Flint, M. Marilyn and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, 36 (March, 1965), 29-37.

4. Gutin, Bernard and Stanley Lipetz, "An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises," Research Quarterly, 42 (October, 1971), 256-263.

5. Morehouse, Laurence E. and Augustus T. Miller, Jr., Physiology of Exercise, 7th edition, Saint Louis, C. V. Mosby, Co., 1976.

6. Beyer, Richard A., "Evaluation of the 2-Minute Sit-Up, Test as a Measure of Muscular Endurance and Strength," Journal of Association for Physical and Mental Rehabilitation, 20 (July-August), 140.

CHAPTER IV

RESULTS OF THE STUDY

It was the purpose of this study to investiage the possible effects of an eight week exercise program upon the abdominal strenght of fourth and fifth grade girls. It was also the purpose to find out if an exercise with a higher muscle action potential would produce a greater strength gain than an exercise with lesser intensity in the muscle contraction. Data were collected from ninety-nine fourth and fifth grade girls from Armstrong Elementary School in Highland Park, Texas. Each subject was tested with a cable tensiometer as suggested by Clarke (2) and on a one minute timed sit-up test as prescribed by the AAHPER Youth Fitness Test (1). The subjects were then grouped into four groups through the use of a random sampling chart. Each group was assigned an exercise to do three times a week for eight weeks. The time limits for the exercises increased from one minute to two minutes through the eight weeks. Three of the exercises were designed to provide an overload on the abdominal muscles. The fourth group did generalized exercises selected to employ the use of the abdominal muscles as little as possible. This group served as the control group. Following the eight weeks exercise program, the cable tensiometer test

and the timed sit-up tests were again administered to the ninety-nine girls. The data obtained in these tests served as the basis for the findings in this study. Since no attempt beyond randomization was made to equate the four groups by age or original abdominal strength, an analysis of covariance was considered the most appropriate statistical tool to use in analyzing the data for this project. This was done through two analyses of covariance with a one-way design at the Computer Center at North Texas State University.

Analysis of Data

Cable Tensiometer Data

The results of the study are presented in Table I through Table VI. Tables I and II report the data obtained from the tests given on the cable tensiometer. Table I depicts the computation of the unadjusted group means, the standard deviations and the adjusted group means derived from the pretest and the posttest scores of the four exercise groups. There was a marked difference between the pretest unadjusted group means which provided the basis for correlational analysis of scores and resulted in the use of covariance analysis. This served to eliminate the effect of the initial strength difference among subjects in all of the groups. The resulting F ratio in the analysis of covariance technique was found to be 3.55. This value was significant at the .05 level of significance. Since visual inspection alone would

not provide the specific location of the intergroup comparisons, a multiple comparison analysis of the group means was performed.

TABLE I

DESCRIPTIVE STATISTICS FOR THE CABLE TENSIOMETER

Group	Number	Test	Unadjusted Mean	Standard Deviation	Adjusted Mean
Group I (Curl-Up)	25	Pretest	38.96	13.88	
		Posttest	43.68	15.59	43.03
Group II (Conventional Hook Sit-Up)	24	Pretest	37.46	9.75	
		Posttest	48.38	14.91	48.66
Group III (Modified Hook Sit-Up)	26	Pretest	35.31	14.50	
		Posttest	41.46	9.24	43.08
Group IV (Generalized Exercises)	24	Pretest	40.08	13.19	
		Posttest	39.96	12.96	38.61

Table II shows the results of the comparison among the adjusted group means. A Tukey's Test chart was used to determine that a value of 2.92 was needed to show a significant difference at the .05 level of significance.

This study was designed to determine if three different types of sit-up exercises performed three times a week for eight weeks would increase the abdominal strength of upper elementary school girls. It was also designed to see if one exercise could be shown to be superior to the other two exercises. Table II shows that in strength gains as

registered by a cable tensiometer there was a significant difference between Exercise Group II which did the conventional hook sit-up and Group IV which was the control group doing mild generalized exercises. Therefore, the conventional hook sit-up is shown to be an effective exercise

TABLE II

COMPARISON OF GROUP MEANS USING THE TUKEY (HSD) METHOD FOR THE CABLE TENSIOMETER

Group	I	II	III	IV
I	0.0	-2.6112	-0.0244	2.0505
II	2.6112	0.0	2.5868	4.6618*
III	0.0244	-2.5868	0.0	2.0749
IV	-2.0505	-4.6618	-2.0749	0.0

*Value of 2.92 is necessary for significance at the .05 level of significance

to use in increasing the abdominal strength in fourth and fifth grade girls. However, no significant difference can be shown between the three abdominal exercises performed by Groups I, II, and III.

Timed Sit-Up Data

Tables III and IV report the data obtained from the timed sit-up pretests and posttests. Table III gives a presentation of the unadjusted group means, standard deviations and adjusted group means derived from the raw scores. The variations in pretest unadjusted group means

supplied the basis for correlational analysis of scores which resulted in the use of an analysis of covariance to equate the subjects within the groups in order for a true comparison between the groups to be made. The resulting F ratio in the analysis of covariance was found to be 3.49. This value was significant at the .05 level of significance. To determine the specific location of significance between the groups a multiple comparison analysis of the adjusted group means was executed.

TABLE III

DESCRIPTIVE STATISTICS FOR THE TIMED SIT-UPS

	Number	Test	Unadjusted Mean	Standard Deviation	Adjusted Mean
Group I (Curl-Up)	25	Pretest	35.56	6.41	
		Posttest	41.92	6.26	42.72
Group II (Conventional Hook Sit-Up)	24	Pretest	36.71	8.17	
		Posttest	46.46	8.59	46.30
Group III (Modified Hook Sit-Up)	26	Pretest	36.62	9.01	
		Posttest	43.62	10.83	43.54
Group IV (Generalized Exercises)	24	Pretest	37.25	8.23	
		Posttest	41.79	8.46	41.19

Table IV reveals the comparison among the groups for the timed sit-up tests. By using Tukey's Test Table, it is determined that a value of 2.92 must be reached in order for a significant difference between the groups to occur.

Therefore, the data suggests that the value given Group II is significantly superior to both Group I and Group IV, the control group. This would tend to show that the conventional hook sit-up as prescribed by Gutin (4) is superior to the curl-up and to the generalized exercises in increasing the number of bent knee sit-ups performed in one minute.

TABLE IV

COMPARISON OF GROUP MEANS USING THE TUKEY (HSD) METHOD FOR THE TIMED SIT-UPS

Group	I	II	III	IV
I	0.0	-3.1591	-0.7200	1.3546
II	3.1591*	0.0	2.4391	4.5137*
III	0.7200	-2.4391	0.0	2.0746
IV	-1.3546	-4.5137	-2.0746	0.0

*Value of 2.92 is necessary for significance at the .05 level of significance

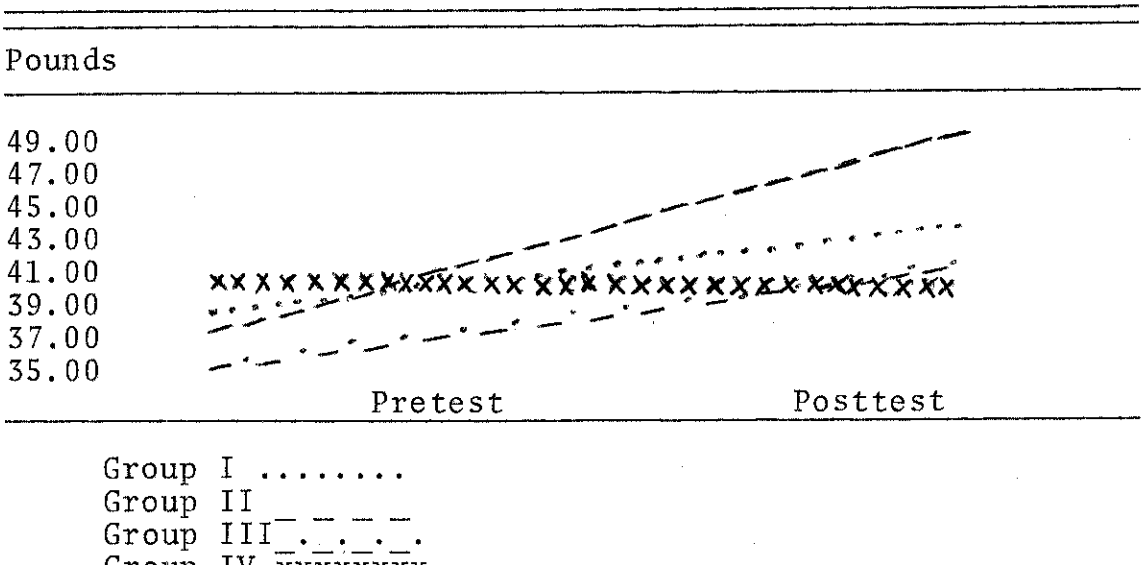
Profiles of the Groups

Table V gives a graphic presentation of the results of the cable tensiometer pretests and posttests. A gain was shown in each of the three abdominal exercise groups. Group I, which exercised with the curl-up, showed an increase from 38.96 pounds of pull to a group mean of 43.68 pounds which is the least gain of the three abdominal exercise groups. Group II, which did the conventional hook sit-up increased from 37.56 to 48.38. This is the only statistically

significant gain recorded. Group III had the second best gain, from 35.31 pounds to 41.46, as the result of doing the modified hook sit-up. Group IV, the control group

TABLE V

GROUP PROFILES IN THE CABLE TENSIOMETER TESTS



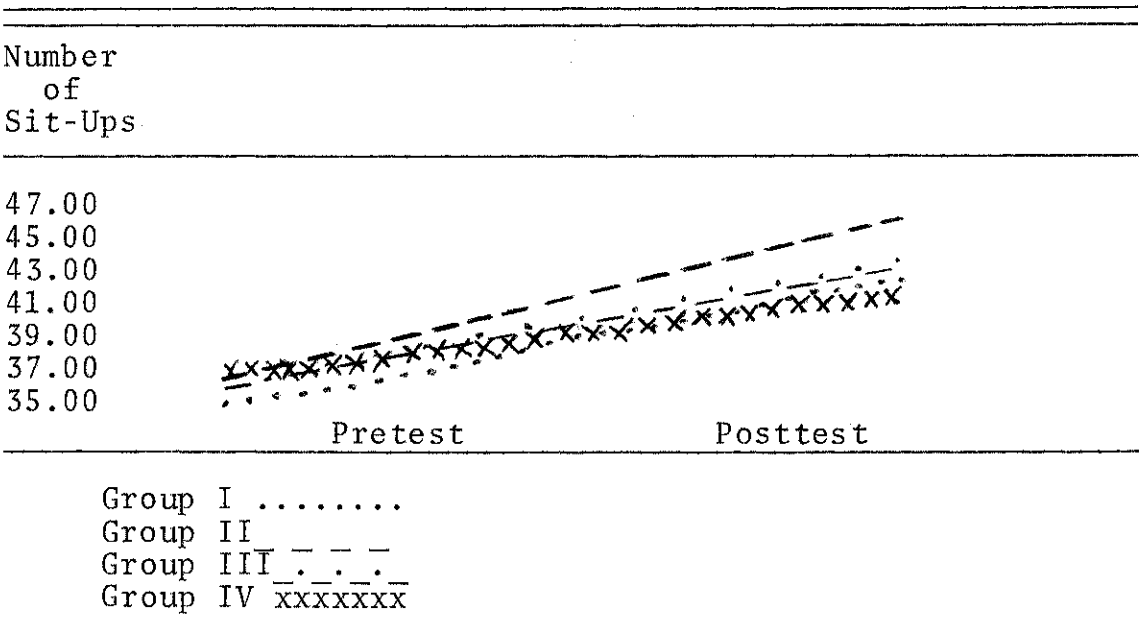
which did generalized exercises, showed a slight decrease in the group means from 40.08 to 39.96.

Table VI presents the profiles of the groups in the timed sit-up tests. Gains were shown in the three abdominal exercise groups. A lesser, but marked gain was also exhibited by Group IV, the control group. Group I, the group who executed the curl-up, displayed an average increase of six sit-ups. Group II who performed the conventional hook sit-up revealed a greater increase than any of the other groups and showed a significant gain over Group I and Group IV,

control group. The net gain for this group was an average of nine additional sit-ups per person. Group III revealed

TABLE VI

GROUP PROFILES IN THE TIMED SIT-UP TESTS



an increase of seven sit-ups. Group IV, the control group, also raised their group mean by four and a half sit-ups.

Discussion of Results

In Gutin's study, there was a significant difference between the intensity of MAP elicited by the three exercises used in this present study. The modified hook sit-up showed the greatest degree of muscle participation followed by the conventional hook sit-up. The curl-up required the least intensity in muscle contraction. This

order of intensity in muscle activity did not appear to show a direct relationship with the results of the chronic exercise program conducted with upper elementary school girls.

In comparing the group means for determining abdominal strength gains as registered by the cable tensiometer reading, only Group II which performed the conventional hook sit-up was significant from group IV, the control group. No other groups were significantly different from the other three. This would suggest that the performance of three selected isotonic abdominal exercises selectively produced static strength incresses. More specifically, of the treatment administered, only the conventional hook sit-up produced significant static strength gains during the eight week training period.

The results of the data obtained from the timed sit-ups, which served as a measure of isotonic muscular endurance, showed the conventional hook sit-up done by Group II to be superior to the generalized exercises of the control Group IV and also to be significantly superior to the curl-up, which was Group I's assigned exercise.

Therefore, according to the data obtained from this study, the conventional hook sit-up, not the modified hook sit-up with its higher intensity rating, would appear to be the favored exercise in developing abdominal strength and endurance in upper elementary school girls.

Although similar results in the comparison of exercises were expected by the examiner, a true similarity between Gutin's study and this study would be difficult to establish. Gutin was interested in acute data obtained by measuring the intensity of a maximum isometric effort employed in the execution of each of the abdominal exercises. This present study was more concerned with the chronic effect of an eight week exercise program upon the abdominal muscles.

A second major difference in the two studies was the population used as subjects. Gutin used eight male high school varsity athletes with well defined abdominal musculature. The population for the study on the comparison of three selected exercises was nine, ten and eleven year old girls in the fourth and fifth grade whose muscular growth and development may be a determining factor in their exercise performance. The present findings do not provide enough information on the relationship between maturity and development to establish a projection for strength gains.

The results of the present study may also have been influenced by other conditions which occurred during the eight week exercise program.

All children are not receptive to a training program. Less cooperation in performing the exercises was received from Group I than any of the other three subject groups. The use of the elbows and gripping of the pant-legs in the

raising motion was common even though the group was closely watched and repeatedly encouraged to do the exercise properly by the instructor. Perhaps a different group would show a different result in strength gains using the curl-up exercise.

The modified sit-up was extremely difficult for the fourth and fifth grade girls in Group III. Few of the girls were able to perform it correctly. When instructed to do it to the best of their ability, the exercise, for most of the girls, resulted in many contractions but little raising of the upper torso against the pull of gravity. A different age group may show a different degree of strength gain.

The control group (Group IV) did generalized exercises selected to use the abdominal muscles as little as possible. These exercises were mild in nature, but as the time period increased from one minute to two minutes, the exercises became more aerobic. Therefore, a training effect that was not intended may have resulted--especially in the ability to increase the number of sit-ups performed in one minute. If possible, the control group should do nothing during the exercise time. However, this was not practical in the situation in which this exercise program was done.

Another factor that may have influenced the results of the exercise program was the lack of uniform tautness in the cable while administering the pretest and the posttest.

A very conscious effort was made to achieve a uniform tautness on each girl, but some girls tolerated the tightness of the belt around the chest better than others. There was also a problem in that some of the girls were between chain links in hooking the chain to the wall although the smallest chain possible was used. When this occurred, the cable was either slightly tighter or slightly looser than it should have been.

An additional observation was made by the examiner. Although all of the girls appeared to contract the rectus abdominis maximally when performing the pull against the cable, competition and aroused motivation might have played a part in some of the pulls.

The timed sit-up tests seemed to provide a more stable determination for the success of the exercise program.

Summary of the Results

The primary finding of this study was that an eight week exercise program can be significant in increasing the abdominal strength and endurance of upper elementary school girls.

The conventional hook sit-up appears to be the favored exercise for developing abdominal strength with the modified hook sit-up moderately successful and the curl-up mildly effective. The generalized exercises accomplished very little in the way of strength development of the abdominal muscles and appears to be of little value if abdominal strength gain is the goal.

The conventional hook sit-up performed for eight weeks also revealed a signifcant gain in the number of sit-ups performed in a one minute time period. The modified hook sit-up and the curl-up were almost equally effective in producing a net gain of seven sit-ups a piece. The generalized sit-ups were also successful in showing an average increase of four sit-ups.

From the experimental evidence obtained in this study, the conventional sit-up would appear to be the best exercise to use with upper elementary school girls for building both strength and endurance of the abdominal muscles.

CHAPTER BIBLIOGRAPHY

1. American Alliance for Health, Physical Education, and Recreation, Youth Fitness Test Manual, Revised 1976 edition, Washington, D. C., AAHPER Publication, 1976.

2. Clarke, H. Harrison and Richard A. Munroe, Oregon Cable Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College, Eugene, Oregon, Microform Publications, University of Oregon, 1970.

3. Flint, M. Marilyn and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, 36 (March, 1965), 29-37.

4. Gutin, Bernard and Stanley Lipetz, "An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises," Research Quarterly, 42 (October, 1971), 256-263.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study of the abdominal muscles has been the concern of many physiologists, notably Gutin and Lipetz who tested ten abdominal exercises and then ranked them in order of muscle action potential intensity.

The purpose of this study was to find out if an eight weeks exercise program could increase the abdominal strength and endurance of fourth and fifth grade girls and whether an exercise with greater intensity would show a greater gain in static strnegth and the ability to increase the number of sit-ups done in a one minute sit-up test.

The fourth and fifth grade girls from Armstrong Elementary School in Highland Park, Texas were randomly divided into four groups. Three of Gutin's exercises were selected to be tested. The exercises selected in ascending order of intensity were the curl-up, the conventional hook sit-up and the modified hook sit-up. One of the selected exercises was assigned to each of the exercise groups. The fourth group did a series of mild generalized exercises and served as the control group. The exercise program lasted for eight weeks.

Data were obtained from pre and posttests on a cable tensiometer and timed sit-ups and treated with an analysis of covariance. The conventional hook sit-up was the only exercise to show a significant difference over any of the other exercises and therefore would appear to be the superior exercise in developing abdominal strength and endurance in upper elementary school girls.

Determination of the Hypotheses

The hypothesis that there will be no significant difference in the abdominal strength and endurance of upper elementary school girls following an eight weeks exercise program must be rejected on the basis of the strong improvement shown by the group working with the coventional hook sit-ups.

The hypothesis that there will be no significant difference between the results of the three exercises is accepted with regard to strength development, but is rejected in endurance development because of a significant gain of the conventional hook sit-up over the curl-up.

The hypothesis that a selected abdominal exercise with greater muscle action potential will not show a greater improvement following an eight weeks exercise program is accepted when pertaining to fourth and fifth grade girls.

Conclusions

This study shows that the conventional hook sit-up was the only exercise to be effective in promoting a significant

gain in both abdominal strength and endurance in upper elementary school girls, although all three exercises tested shows a gain.

The modified hook sit-up, which received the highest intensity rating by Guitn, was not significantly effectiv in training fourth and fifth grade girls, perhaps because of the difficulty in executing the exercise properly.

The conventional hook sit-up was also superior to the curl-up in developing endurance in upper elementary school girls.

Recommendations

It is recommended that further study is needed on the relationship between the development and the maturation of abdominal muscles in young children. Furthermore, it is recommended that similar studies be conducted using different muscle groups and with different populations.

It is also recommended that in any formal exercise study the control group should not participate in any assigned exercises during the prescribed exercise time since even mild exercises when extended over a period of time may produce a training effect.

APPENDIX

APPENDIX A

EXAMPLE OF INDIVIDUAL CHART

NAME_____

GRADE_____

Age____years ____months

Height _____

Weight _____

Abdominal Strength

T_1_____ Date _____

T_2_____ Date _____

Number of Bent-Knee Sit-Ups in one minute

T_1_____ Date _____

T_2_____ Date _____

Assigned Exercise _____

Number of Absenses _____

Comments:

Number of Exercise Repetitions

First Week___ Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Second Week___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Third Week ___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Fourth Week___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Fifth Week ___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Sixth Week ___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Seventh Week__Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

Eighth Week___Time Limit _____
Monday _____
Tuesday _____
Wednesday_____

APPENDIX B

RAW DATA FOR GROUP I

Exercise - Curl-Up

Subject	Tensiometer - Lbs.		Timed Sit-Ups - No.	
	T_1	T_2	T_1	T_2
1	25	18	28	30
2	32	35	41	48
3	13	20	31	45
4	18	20	22	36
5	19	25	26	40
6	33	32	36	40
7	32	60	36	48
8	54	60	40	51
9	36	40	22	30
10	54	60	36	39
11	28	35	36	40
12	49	44	36	36
13	38	38	45	46
14	46	49	43	46
15	27	47	36	58
16	50	47	30	41
17	39	42	38	44
18	30	32	38	50
19	37	44	47	41
20	50	65	41	38
21	58	45	30	40
22	69	65	38	41
23	46	82	38	38
24	55	42	37	42
25	36	45	38	40

APPENDIX B (Continued)

RAW DATA FOR GROUP II

Exercise - Conventional Hook Sit-Up

Subject	Tensiometer - Lbs.		Timed Sit-Ups - No.	
	T_1	T_2	T_1	T_2
1	21	37	39	42
2	32	33	26	44
3	37	40	32	37
4	37	37	47	59
5	23	34	22	39
6	44	39	27	33
7	37	42	30	53
8	47	35	32	35
9	42	42	34	55
10	36	45	30	38
11	32	37	40	43
12	30	40	31	36
13	30	52	44	41
14	49	47	50	59
15	46	84	30	40
16	42	94	31	49
17	49	55	41	45
18	19	57	32	44
19	33	47	40	52
20	28	59	45	56
21	37	52	54	64
22	58	52	45	52
23	41	59	41	53
24	49	42	38	46

APPENDIX B (Continued)

RAW RATA FOR GROUP III

Exercise - Modified Hook Sit-Up

Subject	Tensiometer - Lbs.		Timed Sit-Ups - No.	
	T_1	T_2	T_1	T_2
1	12	54	36	46
2	22	33	32	42
3	18	26	41	42
4	33	45	27	29
5	23	33	27	36
6	18	22	40	46
7	41	52	35	47
8	30	32	15	20
9	27	40	27	27
10	23	45	32	38
11	50	42	47	58
12	47	40	36	39
13	38	44	40	58
14	58	52	42	48
15	44	42	33	47
16	36	44	35	46
17	16	32	40	51
18	50	50	48	56
19	21	30	21	21
20	30	44	30	36
21	38	35	33	42
22	38	42	49	53
23	32	37	40	42
24	69	57	50	60
25	50	55	48	49
26	54	50	48	55

APPENDIX B (Continued)

RAW DATA FOR GROUP IV

Exercise - Generalized Exercises

Subject	Tensiometer - Lbs.		Timed Sit-Ups - No.	
	T_1	T_2	T_1	T_2
1	27	20	32	33
2	21	21	19	33
3	30	44	39	37
4	21	21	32	41
5	33	30	32	43
6	30	37	42	56
7	44	37	35	41
8	27	22	34	39
9	44	42	48	48
10	44	55	31	38
11	62	52	45	51
12	42	50	37	40
13	53	49	33	32
14	46	44	34	46
15	34	42	53	50
16	30	20	40	36
17	35	44	48	48
18	56	50	44	39
19	57	55	38	42
20	57	50	42	53
21	44	55	43	43
22	44	44	40	39
23	19	21	24	19
24	62	55	50	56

BIBLIOGRAPHY

Books

Astrand, Per-Olof and Kaare Rodahl, Textbook of Work Physiology, New York, McGraw-Hill Book Co., 1970.

Clarke, H. Harrison, Muscular Strength and Endurance in Man, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

Clarke, H. H. and D. H. Clarke, Developmental and Adapted Physical Education, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1963.

Clarke, H. H. and Richard A. Munroe, Oregon Cable-Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College, Eugene, Oregon, Microform Publications, University of Oregon, 1970.

DeLorme, T. L. and A. L. Watkins, Progressive Resistance Exercise; Technique and Application, New York, Appleton-Century-Crofts, Inc., 1951.

deVries, Herbert A., Physiology of Exercise for Physical Education and Athletics, 2nd edition, Dubuque, Iowa, W. C. Brown, Co., 1974.

Falls, H. B., E. J. Wallis and G. A. Logan, Foundations of Conditioning, New York, Academic Press, Inc., 1970.

Fleishman, E. A., The Structure and Measurement of Physical Fitness, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1964.

Gawer, Herman and Herbert Michelman, Body Control and Physical Fitness, New York, Gramercy Publishing Co., 1970.

Hettinger, Theodore, Physiology of Strength, Springfield, Illinois, Charles C. Thomas, 1961.

Logan, Gene A. and Wayne C. McKinney, Kinesiology, USA, W. C. Brown, Co., Inc., 1970.

Mathews, Donald K., Measurement in Physical Education, 4th edition, Philadelphia, Pennsylvania, W. B. Saunders Co., 1973.

Morehouse, Laurence E. and Augustus T. Miller, Jr., Physiology of Exercise, 7th edition, Saint Louis, C. V. Mosby Co., 1976.

Wallis, Earl L. and Gene A. Logan, Exercise for Children, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

Wells, Katharine F., Kinesiology, 3rd edition, Philadelphia, Pennsylvania, W. B. Saunders Co., 1960.

Wilmore, Jack H. and Jack F. Keogh, editors, Exercise and Sport Sciences Reviews, Vol. III, New York, Academic Press, 1975.

Articles

Allsop, Kent, "Potential Hazards of Abdominal Exercises," Journal of Health, Physical Education and Recreation, XLII (January, 1971), 89.

Asmussen, Erling, "Growth in Muscular Strength and Power," Physical Activity, edited by G. Lawrence Rarick, New York, Academic Press, 1968.

_____, "Neuromuscular System and Exercise," Exercise Physiology, edited by Harold B. Falls, New York, Academic Press, 1968.

Beyer, Richard A., "Evaluation of the 2-Minute Sit-Up Test as a Measure of Muscular Endurance and Strength," Journal of Association for Physical and Mental Rehabilitation, XX (July-August, 1966), 140.

Clarke, H. H., "Development of Volitional Muscle Strength as Related to Fitness," Exercise and Fitness, Chicago, Illinois, The Athletic Institute (1960), pp. 200-213.

Coleman, Alfred E., "Comparison of Weekly Strength Changes Following Isometric and Isotonic Training," Journal of Sports Medicine and Physical Fitness, XII (1972), 26-29.

DeWitt, R. J., "A Study of the Sit-Up Type of Test, as a Means of Measuring Strength and Endurance of the Abdominal Muscles," Research Quarterly, XV (March, 1944), 60.

Flint, M. Marilyn, "Abdominal Muscle Involvement During the Performance of Various Forms of Sit-Up Exercise," American Journal of Physical Medicine, XLIV (October, 1965), 224.

_____, "Selecting Exercises," Journal of Health, Physical Education and Recreation, XXXV (February, 1964), 19.

Flint, M. Marilyn and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, XXXVI (March, 1965), 29-37.

Gutin, Bernard and Stanley Lipetz, "An Electromyographic Investigation of the Rectus Abdominis in Abdominal Exercises," Research Quarterly, XLII (October, 1971), 256-263.

Hellebrandt, F. A. and Sara Jane Houtz, "Mechanisms of Muscle Training in Man: Experimental Demonstration of the Overload Principle," Physical Therapy Review, XXXVI (June, 1956), 371.

Hunsicker, Paul A. And Richard L. Donnelly, "Instruments to Measure Strength," Research Quarterly, XXVI (December, 1955), 408-420.

Kraus, Hans and Ruth P. Hirschland, "Minimum Muscular Fitness Tests in School Children," Research Quarterly, XXV (May, 1954), 178.

Lipetz, Stanley and Bernard Gutin, "An Electromyographic Study of Four Abdominal Exercises," Medicine and Science in Sports, II (Spring, 1970), 35.

Lippold, O. C. J., "The Relation Between Integrated Action Potentials in a Human Muscle and Its Isometric Tension," Journal of Physiology, CXVII (1952), 492.

Soderberg, Gary L., "Exercise for the Abdominal Muscles," Journal of Health, Physical Education and Recreation, XXXVII (September, 1966), 67.

Walters, C. Etta and Mariam J. Partridge, "Electromyographic Study of the Differential Action of the Abdominal Muscles During Exercise," American Journal of Physical Medicine, XXXVI (October, 1957), 259.

Wedemeyer, Ross, "A Differential Analysis of Sit-Ups for Strength and Muscular Endurance," Research Quarterly, XVII (March, 1946), 40.

Publications of Learned Organizations

American Association for Health, Physical Education and Recreation Youth Fitness Project, Your Child Can't Sit and Keep Fit, Washington, D. C., AAHPER Publication.

American Alliance for Health, Physical Education and Recreation, Youth Fitness Test Manual, Revised 1976 edition, Washington, D. C., AAHPER Publication, 1976.

Cureton, T. K., Improving the Physical Fitness of Youth, Monogr. soc. Res. in Child Development, No. 4 (Serial No. 95), 1964.

Physical Fitness Research Digest, President's Council on Physical Fitness and Sports, Washington, D. C., edited by H. Harrison Clarke, Series 6, No. 3, July, 1976.

Unpublished Materials

Craven, Charles W., "An Evaluation of Methods of Administering the Sit-Up Test," unpublished master's thesis, Department of Education, University of Texas at Austin, Austin, Texas, 1968.