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Isometric Exercise Versus Isotonic Exercise as a Means of Building and Retaining Strength

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ISOMETRIC EXERCISE VERSUS ISOTONIC EXERCISE AS A MEANS OF BUILDING AND RETAINING STRENGTH

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by

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CHAPTER I

I. THE PROBLEM

The low fitness level of American youth is becoming more and more apparent. At present, doctors, educators, and people in general are becoming increasingly aware that our fitness level must be raised so that we may survive as a leading nation.

In view of today's emphasis on physical fitness for our nation, the author believes that more research should be conducted which might indicate ways of improving the components of physical fitness. One of the more important components of physical fitness is strength. Today, there are two major theories, as to what types of exercise develop the greatest amount of strength. One theory is that greater gains in strength occur through isometric exercising, and the other is that greater gains in strength occur through isotonic exercising.

Statement of the problem. It was the purpose of this study to compare results from the selected isotonic exercises as recommended by Steinhaus, the selected isometric exercises as recommended by Karpovich, and a non-directed exercise program on the seventh and eighth grade male students of Monroe Junior High School as a means of building and retaining strength which was measured by the Roger's Strength Test.

Basic assumptions. It was assumed that all of the subjects participating in the experiment had participated in approximately the same amount of physical activity outside of school hours during the twenty-seven week period of this study, and differences in the average changes in strength of the two groups (isometric, isotonic) were due to the exercise program assigned to each group.

This study proceeded on the assumption that strength can be developed by selected isotonic and by selected isometric exercises.

It was assumed that resulting differences in strength can be effectively measured by Roger's Strength Index (10:200).

It was further assumed that a twenty-seven week training period would allow sufficient time to evaluate the effectiveness of the two types of exercise programs.

Delimitations of the study. This study was limited to only those students who stayed in the seventh and eighth grades for one full year without an extended illness or without moving.

This study was limited to twenty-seven weeks, with the isotonic group doing selected isotonic exercises three days a week and the isometric group doing selected isometric exercises five days per week.

The Roger's Strength Test was administered four times and no practice tests or second chances were given.

The study was limited to comparisons of the changes in muscular strength to determine whether or not there was statistically significant differences in changes among the isotonic, isometric, and the control group.

II. DEFINITIONS OF TERMS USED

Isometric contraction. A type of exercise which allows no shortening or lengthening of the muscle fibers during the contraction period.

Isotonic contraction. A type of exercise which allows shortening or lengthening of the muscle fibers during the contraction period.

Strength index. The strength index, or SI, is the total score determined by adding together the scores made on each test item: lung capacity, right grip, left grip, back strength, leg strength, and arm strength.

Physical fitness index. The physical fitness index is computed from the following formula:

$$PFI = \frac{\text{Achieved SI}}{\text{Normal SI}} \times 100$$

A standard card should be used for recording the scores made on the physical fitness index test. Spaces for

several tests should be provided on this card to allow for retest, together with annual tests over a period of years.

Dynamometer. An instrument used to measure the strength of both back and leg muscles.

Wet spirometer. An instrument for measuring the lung capacity within the human body. It is calculated in cubic inches.

Manuometer. An instrument used to measure grip strength of both the right and left hands.

Isometric group. A group of twenty-five male members of Monroe Junior High School seventh and eighth grades who performed prescribed isometric exercises for an eighteen week period, five times per week.

Isotonic group. A group of twenty-five male members of Monroe Junior High School seventh and eighth grades who performed prescribed isotonic exercises for an eighteen week period, three times per week.

Non-directed group. A group of twenty-five male members of Monroe Junior High School seventh and eighth grades who performed no formal exercise during the twenty-seven week period.

III. NEED FOR THE STUDY

For many years man has engaged in running, jumping and throwing objects and in a combination of these activities. These inherent and very natural activities have been incorporated into the modern day athletic games. Since the revival of interest in amateur athletics, dating from the middle of the nineteenth century, athletes and coaches have striven to improve techniques of sport. The coaches and athletes who have developed more efficient techniques have shared their findings with fellow coaches and athletes and also the interested public. Many books, magazine articles, monographs and theses have been written on the various aspects of athletics to increase our knowledge of all phases of athletics (28:8).

However, we have only scratched the surface of new techniques and procedures; much investigating, experimenting, and reporting still needs to be done.

Several studies have been made showing the effect isometric and isotonic exercising have upon muscular strength, however, as the author reviewed the literature he did not find any studies that compared the two methods as a means of gaining and retaining strength.

The author felt there was a need for research to determine the relative effect the two methods of exercise have for gaining and retaining strength in seventh and

eighth grade male students. As strength is a component of physical fitness, and both isotonic and isometric strength building programs have proven their value in previous studies, an effort has been made in this study to ascertain which method would produce the greater gain and retain the greater strength in a limited period of time.

CHAPTER II

REVIEW OF THE LITERATURE

There seems to be general agreement among researchers in physical education concerned with the scientific aspects of tests, that strength is the most important factor in all forms of motor ability. The pupil with a high strength index is likely to play better in any game, make a better showing in athletic events, and perform better in any activity, including his daily work, than one less developed in strength (40:170).

Muscular strength underlies all of our daily activities. Therefore, strength building programs, as well as strength testing, become important to the teacher concerned with the development of this strength if he is to effectively accomplish his work. Strength testing is not a modern technique, nor are strength building programs new. Cureton sites evidence of strength testing as early as 1702 by De la Hire and Aontons (4:19).

The names of three experimenters, Morpurgo, Siebert and Muller, mark the road that has brought us to our present knowledge of the anatomy and physiology of strength. Their work has yielded findings and conclusions that are essential to an understanding of strength and its development (36:147).

In 1897, Professor B. Morpurgo, of the Pathological Institute of the University of Srena, wrote as follows:

> As certain as is the fact that the mass of voluntary muscles increases in response to greater work, so uncertain is our knowledge concerning the mechanism that underlies this enlargement. There is no lack of assertions in the literature that deals with this subject in more or less decisive fashion and interpret the activity-hypertrophy as either a true hypertrophy in the sense of Virchow or as combination of hyperplasia and hypertrophy: but exhaustive proof is everywhere lacking (36:149).

Murray and Karpovich describe muscles as follows:

> Our muscles are made up of small, thread-like muscle fibers. The fibers vary from 1/25 to 1-1/2 inches in length and from 1/250 to 1/2500 inch in thickness. To form a big muscle, these fibers are arranged in bundles that extend in a chain-like fashion from one end of the muscle to the other. Each fiber and each bundle is wrapped in connective tissue, which is thin in flabby muscles and thick and tough in strong muscles. These wrappings are connected to each other, and at the end of muscles they are fused with tendons, which in turn are attached to the bones. It has been estimated that there are about 250 million fibers in the body (30:334).

In training for strength, muscles increase in size much more than in training for endurance, because strength depends on the cross section of muscle fibers, and endurance on the addition of capillaries around the fibers. Although the size of muscles increases with exercise, the number of fibers remains the same. Obviously, then, each fiber has to become larger and that is what actually happens.

The rate at which muscles enlarge depends on the individual differences and on the type and intensity of training. Although nothing can be done about individual differences with which man is endowed when he is born, the type and intensity of training can be controlled and adjusted to the individual. Although there is no unanimous

agreement regarding the details of training, there is one agreement in principle: If you want to develop strength, use the overload method (28:34-38).

Dr. Arthur H. Steinhaus, said that in a German laboratory where he worked, it was discovered that a muscle could grow at only a certain rate--and a very small amount of the right exercise will start it growing at that rate. If you contract anyone of your muscles to about two-thirds of its maximum power and hold it for six seconds once a day, the muscle will grow as fast as it can grow (25:51-54).

I. ISOTONIC EXERCISES

The word isotonic means having, or indicating, equal tones, or tension, as defined by Webster's New Collegiate Dictionary (38:649).

Isotonic weight training programs involving the use of barbells and similar equipment have been followed by athletes and those who wished to increase their strength through the ages. Many professional football players, wrestlers, competitive swimmers, and most of the nationally and internationally famous throwers of the discus, the javelin, the hammer, and the shot have improved their competitive performances by the inclusion of regular and specific programs of weight training in their preparation for competition. Many of these athletes have become regional, national, or world champions, and a considerable number of

them have established world records in their events (16:27).

The rise in popularity of "weight training"--not only in competition but also as a means of body building and an aid in conditioning for various other sports as well--is relatively recent. Weight lifting goes back to the days of the early Greek Olympic games, and weight training in a sense has developed along with it. Milo of Croton, the Greek wrestler, believed to be the first weight lifter of note in recorded history, furnishes one of the first examples of preparing for another competitive sport by "weight lifting". The "weight training" prepared him for his wrestling contests. He is said to have lifted a young bull and walked with it on his shoulders daily as it grew to full size. Milo's principle of gradual progression from a relatively light weight to a heavy poundage is the same one followed today to develop strength and improve physical condition by exercising with adjustable barbells and dumbbells (28:3).

Gene Hooks, baseball coach at Wake Forest University, conducted several experiments involving strength with his baseball players. They found a very high correlation between strength and success in hitting and throwing a baseball. They also found a definite improvement in the ability of the individual when strength, developed through isotonics, is noticeably increased (18:46).

Pole-vaulter Bob Richards, half-miler Mal Whitfield, hurdler and decathlon champion Milt Campbell, sprinter,

broad jump and hurdler Mike Herman are just a few track and field stars who use weight training.

In baseball, Ralph Kiner and Jackie Jensen of the Boston Red Sox were among the many power-hitters who have strengthened themselves by training with weights. And pitcher Bob Feller, the finest fastballer of our time, worked out regularly with dumbbells, barbells and pulley-weights.

Line and backfield stars such as Stan Jones, Alan Ameche and Steve Van Buren are representative of the many gridiron stars who built themselves up with weight training (16:18-21).

Wilt Chamberlain, who has to be among anybody's top ten modern basketball stars, has worked out with weights for years, which may have a lot to do not only with his muscular build and strength, but with his jumping power, co-ordination, and stamina (16:18).

Gary Gubner, an outstanding shot-putter, is six feet two inches tall and weighs two hundred and eighty pounds and almost all of it is useful muscle. He has not attained such remarkable physical development by accident. He has a very rigorous weight training program that he follows in order to maintain and increase his strength (24:31).

Capen states that weight training is the most effective form of physical training for both visceral, skeltal, and good muscular development. He believes that

exercise with weights produces an optimum physical condition in a minimum of time (9:83).

The average physical education teacher or athletic coach will have little, if any, interest in turning out the rippling-muscled specimens who compete in best-developed-man events. He will, however, often have students who need special attention to gain strength, or team prospects who would perform more efficiently by the simple addition of strength. The basic exercises described by Murray and Karpovich, and used for this study, are not new or different from movements weight-trained men have been practicing for decades, but they do solve the problem of adding strength and increasing the size of all the body's muscles, and therefore have their part in a physical conditioning program.

The system of progression is simple. It is one in which the muscles are trained to do more and more work gradually. Gains in both strength and muscle size are relatively rapid at the start and slower after progress has been made (28:71-73).

II. ISOMETRIC EXERCISES

The word isometric, as defined by Webster, means of pertaining to, or indicating equality of measure (38:640). A muscle contracts isometrically when it exerts force against an immovable resistance. Under such conditions, the muscle remains at the same length, i.e., no shortening of

the muscle fibers occur. In the performance of regular exercises, as in calisthenics and weight training, shortening and lengthening of the muscle occurs.

It was not until 1953 that two German doctors worked out the implications of isometric exercising with a frog and applied them to the human body. Traditional exercise, known as "isotonic", beefs up a muscle by moving it. Isometric exercise on the other hand, does not move the muscle at all; the exercises are all performed against an immoveable object. By this immobile contraction its adherents claim, nearly one hundred per cent of the muscle's thousands of hair like fibers are stimulated--as compared with the mere fifty to sixty per cent involved in isotonic exercise (39:38).

Research has been carried out in the past few years on the effects of static or isometric training for developing strength and muscular endurance. The results of some of these experiments are summarized here:

1. A single static contraction a day at two-thirds maximal strength will result in as maximum increase in strength as other known methods of training involving greater resistance and more frequent contractions (30:336).
2. A series of six-second contractions of the Commander Set variety performed three times a week resulted in gains in muscular endurance

that were equal to results obtained by weight training three times a week (1:176).

3. Strength gained rapidly by concentrated training over a short period of time is lost equally quickly upon cessation of training (26:41). Evidence is available to show that there is greater strength retention when training is spaced over a longer period of time, or when the frequency of contractions per training period is increased (27:217).

4. One practice period per day in which the muscles were held in static contraction for a period of six seconds resulted in as much increase as longer periods of muscle contraction, and more frequent practices. This increase in strength is explained by the principle of overload. A muscle develops in size and strength only as it is overloaded, that is, as it is required to exert force against greater resistance than it normally does. This development comes about by the increase in the cross-section of individual muscle fibers (40:449).

Sports Illustrated devoted four pages to isometric contractions as a method of building strength in the October 30, 1961 issue. Gilbert Rogin described the enthusiasm shown by some of our outstanding athletes toward

isometric training:

> The Notre Dame football team does it enthusiastically. The San Francisco 49er's do it shyly. The Pittsburg Pirates do it. Overweight girls in Baton Rouge do it. Star athletes like Bob Avant and basketball player Bob Petit do it and weight lifters like Louis Reicke and Bill March swear by it (16:27).

Bob Petit, star forward for the St. Louis Hawks, worked with isometric contractions for six weeks last summer and became measureably stronger, as indicated by weight lifting feats. Petit and Avant did isometric training in Baton Rouge, which is no coincidence! The Louisiana capitol is a hotbed of the system. Francis Drury, a Louisiana State physical education professor, was one of its earliest advocates, as was trainer Marty Broussard, who has developed special isometric contraction equipment for Louisiana State University sprinters and football players. Broussard says he has even used isometric contractions to improve his golf game. Holding a club in various positions against immovable objects and straining the muscles employed at those points, he has lenthened his drives fifteen yards. Doctor Drury and Alvain Roy, and the proprietor of a Baton Rouge health studio, predicted that through isometric contractions all world records in weight lifting will be broken this year, and every world track and field record within the next year (16:28).

The strength of muscles is adapted to needs by muscular growth. The stimulus for increasing muscle strength

is not fatigue, but the force exerted during the job. When this force exceeds one-third of maximum strength, the maximum speed of increase in strength is reached with one single, short duration, static contraction per day. With one single, short duration contraction per week the rate is one-third of this maximum loss of strength after training by daily contraction is at the rate at which it was gained. The slower increase by weekly training leads to a more permanent acquisition of strength (27:217).

Some of the advantages of isometric training are (37:37):

1. Exercising can be done at home, office, or at play. It takes but a few minutes to do several exercises.
2. There is no equipment involved in isometric training.
3. Fatigue will be avoided because a single contraction does not lead to fatigue.
4. The heart and circulation are not stressed by static training.

A set of thirteen isometric exercises, aimed at general strength building, was prepared by Doctor Arthur H. Steinhaus in collaboration with the late Commander Charles D. Grauque, United States Naval Reserve (37:40-44). These exercises were used by the author in the experimental exercise program for this study.

III. METHODS OF PERFORMING ISOTONIC EXERCISES

It has been found that better results are gained from weight training if the exercise is not practiced daily. Time is needed for the building of muscles and if the exercise periods follow too closely, one after another, the time may not be sufficient. For the person who is underweight or weak, it is very important that no physical activity, of any consequence be undertaken on the "off" days. For a person of normal health and strength, however, other activities on non-weight training days should have no adverse effect (28:75).

A set of twelve basic resistance exercises described by Murray and Karpovich were used for this study. These exercises are described in Appendix A, page 58.

IV. METHODS OF PERFORMING ISOMETRIC EXERCISES

The fact that persistent use of muscles causes their enlargement and a correlated increase in their strength has been known ever since there were boys, and finally found its way into Greek Mythology. But only the most careful researchers of the past fifty-seven years have revealed the nature and limitations of this increase, the kind of exercise that brings it about, and the laws that govern its development (37:147-150).

Isometric contraction is, in fact, neither new nor revolutionary, but only recently has it been widely applied to a variety of sports. Arthur Steinhaus said that scientists in the early nineteen hundred and twenty's conducted experiments in which one leg of a frog was tied down while the other was left free. The muscle in the tied down leg grew significiently (37:21).

Steinhaus contends that you don't have to do repetitive exercises to build muscle, but he says athletes have been taught to suffer, and any system that makes it easy seems wrong to them (37:12).

Karpovich recognizes isometric contractions as a valuable system for rehabilitating the handicapped. Indeed, it has been used to maintain and rebuild the strength of hospitalized and convalescent patients. Doctor W. T. Liberson, in a controlled study at a veterans' hospital in Rocky Hill, Connecticut, reported strength increases up to three hundred per cent through the program of isometric contractions (37:13).

Steinhaus prescribes thirteen isometric exercises for use in general strength building. The author decided to use this group for the study, and a description of these exercises can be seen in Appendix B (37:40), page 63.

V. SELECTION OF TEST EXERCISES

The place and importance of measurement in health and physical education are well established in today's modern programs. There are available several excellent texts in this area which provide such information as historical background, purposes and scope, general administration procedures, critical evaluations of available tests, test construction principles, and statistical techniques for the organization and interpretation of test results.

Good testing programs consume time, usually time taken from already crowded programs of activity. The use of this valuable time is justified only when the testing is carried out in order to achieve some worthy purpose in line with sound education principles.

Plans for testing should stem from the needs of the program and of the participants in the program. These two should be interwoven. The individual's needs become the basis for the program. These needs are pinpointed and expressed through stated program objectives. It is in the attainment of these objectives that plans for testing should be rooted. As an example, the organic needs of persons are expressed through the physical fitness objective in physical education. It is a worthy purpose to test a group of persons at the start of a program in order to ascertain their physical fitness needs (10:180).

The purpose of the Roger's Strength Test is to determine the Strength Index (SI) which indicates the strength of the large voluntary muscles of the body and is used as a measure of general athletic ability. It may be used to classify individuals into homogenous groups (10:183).

Instructions for administering the Roger's Strength Test are prescribed in Appendix C (10:184-195), page 65.

VI. SUMMARY

In Chapter II, the author has cited representatives of various sports who have employed either, or both, isotonic and isometric exercises in their training programs. Also, related literature concerning research in the two methods has been cited.

A brief outline has been sketched of the methods of selecting the exercises used in this experiment conducted in conjunction with this study, and of the selection of the methods of performance of the same.

Chapter III will be devoted for the main part, to a description of the experiment itself--the methods employed in selection of subjects, the equipment involved, and the training tactics.

CHAPTER III

PROCEDURES OF THE STUDY

When preparing to do an experimental study there are several things one should take into consideration before he actually involves himself in the experiment. The following is a list of procedures one should follow when doing a study of this type.

I. PREPARATION

In preparing for a study like this, one must first get the approval of the school administration. Late in the summer of 1964, a proposal was presented to the Superintendent, Principal and School Board of a desire to work a program of isometric and isotonic exercises in the seventh and eighth grade physical education classes. The plans were received with enthusiasm and interest.

In planning any program that is new or different, the parents should be notified. A letter which explained the exercise program was sent to all the parents of male students in the seventh and eighth grade. A copy of this letter is described further in detail in Appendix E, page 69.

After the program was explained to the students an information sheet was handed out to each student explaining both the isotonic and isometric program. Also attached to this information sheet was a chart to record changes in the

size of large muscle groups to see if there was an increase in girth of the muscle (Appendix D, page 68).

Selection of equipment. The training program for the isometric exercises involved no special equipment. The equipment necessary for the isotonic exercises consisted of six--one hundred and ten pound sets of barbells and six tumbling mats, four feet wide and eight feet long. The barbells were adjustable in weight to accommodate the varied strength capacity of each individual. The equipment used to test the various degrees of strength of the subjects as measured by the Roger's Strength Test, was as follows: (1) for leg and back strength, leg and back dynamometer; (2) for lung capacity, a wet spirometer; (3) for grip strength, hand manuometer; (4) for chinning, a chinning bar; (5) for dipping, the parallel bars. This equipment for testing was borrowed from the Physical Education Department at Central Washington State College.

Method of division into sub-groups. All the seventh and eighth grade students were administered the Roger's Strength Test at the beginning of the year.

After all the scores were computed, the boys with the highest score and the boys with the fourth highest, seventh highest, and those with each third ranks below, were selected for the isometric group.

The boys who made up the isotonic group ranked second, fifth and each subsequent third ranks below.

The control group was made up of those boys whose scores placed them in order of ranks which were evenly divisible by three.

Separate data cards were made listing the name of the boy and the score made in the Roger's Strength Test for the isometric group, isotonic group, and the control group. This procedure was done each time the tests were given.

II. SELECTED EXERCISES

Isotonic exercise. The system of progression in isotonic training is very simple. It is one in which the muscles are trained to do more and more work gradually.

It has been found that better results are gained from isotonics if the exercise is not practiced daily. Time is needed for the building of muscles and if the exercise periods follow too closely, this time may not be sufficient. It is suggested by Murray and Karpovich that exercising should be practiced only every other day, or three alternating days per week (28:72). This suggestion was followed by the author.

Each subject experimented to determine how much weight he could use to perform a given exercise of eight repetitions without stopping, at the first weight training session. In subsequent sessions, when twelve repetitions

were reached five to ten pounds were added to the barbell and the number of repetitions were dropped back to eight (28:72). Each training session lasted approximately thirty minutes when the study begin and decreased to twenty minutes by the end of the study. This was a program of gradually increasing severity, so as to make injury or overwork almost impossible.

The twelve basic exercises, including a suggested warm-up, as prescribed by Karpovich and Murray, are: (1) warm-up, (2) curl, (3) press, (4) rowing, (5) squat, (6) pull-over, (7) rise-on-toes, (8) dead lift, (9) upright rowing, (10) press on bench, (11) bent-arm lateral raise, lying, (12) lateral raise, standing.

The exercises as recommended by Karpovich and Murray are described in detail in Appendix A, page 58.

Isometric exercises. The training program for the isometric group consists of thirteen exercises recommended by Steinhaus for building general strength. Steinhaus indicates that since fatigue is not a factor in isometric training these exercises can be performed daily without undue strain (37:40). The isometric group performed their exercises five times per week during their physical education class period. They did these exercises at maximum tension of six seconds each.

The exercises as recommended by Steinhaus are: (1) the elbow push, (2) the hand push, (3) the reach, (4) the muscle-maker, (5) the twist, (6) the grip, (7) the finger stretch, (8) the front flatterner, (9) the curver, (10) the spread, (11) the squat, (12) the heel stand, (13) the arch raiser.

The exercises as recommended by Steinhaus are described in Appendix B, page 63.

Retainment of strength. At the end of the eighteen weeks of the experimental testing, the students in the control, isotonic, and isometric groups participated in no directed physical exercise. They participated only in their regular physical education activities. These students were tested at the end of nine weeks to determine which group, isotonic, isometric, or control, had the greatest retainment of strength.

Psychological considerations. The students involved in the experiment were oriented to the purpose of the program and the tests that were to be given. A great amount of interest was displayed by the boys who were involved in the isotonic program and the isometric program. The attitude of the group would continue to improve immediately after being tested on the Roger's Strength Test or following the measuring of the large muscle groups. The author encouraged this attitude whenever possible in order to

obtain maximum effort from each student.

III. ADMINISTRATION OF TESTS

In the selection of the tests to be given, one was needed that would test the fitness of the body as a whole, as well as the strength in the large muscle groups of the body. To accomplish this the Roger's Physical Fitness Index was utilized because of its high reliability and objectivity (10:203).

In selecting the individual elements composing the Physical Fitness Index Battery, Rogers included tests that would measure most of the large muscle groups of the body. As a result the complete test involved the following muscle groups; forearms, upper arms, shoulder girdle, back and leg. Most of the large muscles not tested were antagonistic of those tested.

To begin the study all boys in the seventh and eighth grades were given the Roger's Strength Test. The Strength Index for each student participating in the experiment was determined by using the six test items within the Roger's Strength Test.

In all tests the individual should be encouraged to do his best, but should not be driven. The test was administered by the author and assisted by students in the seventh and eighth grades. Information sheets and directions for their completion, and administration of the test were

issued to all male students of the seventh and eighth grades. The following method of testing was used in the study.

Station 1: Age, height, weight, scales, record cards

Station 2: Lung capacity

Station 3: Grip strength

Station 4: Back and leg strength

Station 5: Chins

Station 6: Dips

The items listed above are described in further detail with instructions for administration in Appendix C, page

IV. SCORING

Scoring of the Roger's Physical Fitness Index tests is accomplished in the following manner.

Arm strength. Arm strength is scored according to the following formula: (pull-ups + push-ups) $x\left(\frac{W}{10} + H-60\right)$, in which W represents the weight in pounds, and H the height in inches. Fractions are corrected to whole numbers.

Strength index. The Strength Index, or SI, is the total score determined by adding together the scores made on each test item: lung capacity, right grip, left grip, back strength, leg strength, and arm strength.

The norm. The norm charts are based upon sex, weight, and age, the normal score being changed for each

two-pound increase in weight and for each half-year increase in age. Instead of interpolating to determine the norm for those individuals between points on the norm charts, the weight above and the age below should be taken.

As norm charts have been prepared for Physical Fitness Index tests both with the belt in the leg lift and without, care should be taken to use the proper chart in scoring the tests.

Physical fitness index. The Physical Fitness Index is computed from the following formula:

$$PFI = \frac{\text{Achieved SI}}{\text{Normal SI}} \times 100.$$

A standard card should be used for recording the scores made on the Physical Fitness Index Test. Spaces for several tests should be provided on this card to allow for retest, together with annual tests over a period of years.

CHAPTER IV

RESULTS OF THE STUDY

Statistical Procedures

The subjects of the isotonic, isometric, and the control group were compared by gains or losses in mean scores.

The raw score obtained from the Roger's Physical Fitness Test first had to be calculated to find the strength index. The Strength Index (SI) is the total score determined by adding together the scores made on each test item. Arm strength is scored according to the following formula: (pull-ups + push-ups) $x\left(\frac{W}{10} + H\text{-}60\right)$, in which W represents the weight in pounds, and H the heighth in inches. Lung capacity scores are multiplied by 61 to change liters to cubic inches. All test items are added to give an achieved strength index (10:195).

The mean of the scores of the Roger's Strength Index made by each group before the training period began, and the mean of the scores in the same test administered at nine weeks, eighteen weeks, and twenty-seven weeks by each group were found. The mean score was also found for each test item within the Roger's Physical Fitness Test at each period.

The critical ratio of the scores made at the pre-test and at the end of eighteen weeks was computed and evaluated

in terms of the .01 level of confidence in order to determine whether the existing difference between the groups was real or perhaps due to chance. Also the critical ratio of the scores made at the eighteenth week and at the twenty-seventh week were computed to compare the retainment of strength. The standard error of the mean and the standard error of the difference made at each testing period by each group was computed. Using this data, the difference between the means was tested for significance at the .01 level of confidence. In this study, since samples were small, N-1, rather than N, was used to compute all standard deviations.

Control Group

The mean score for push-ups, pull-ups, arm strength, leg lift, back lift, right grip, left grip, and lung capacity were computed for the seventh and eighth grade control groups at each testing period, every nine weeks. The results for the eighth grade are shown in Table I, page 32 and the results of the seventh grade in Table II, page 33.

Additional information concerning the mean, mean gain, critical ratio, and level of confidence for the pre-test, ninth week, eighteenth week, and twenty-seventh week for the seventh and eighth grade control group can be found in Table III, page 34.

The mean gain for the eighth grade control group between the initial Roger's Strength Test Index and the end of eighteen weeks was 348.58 points. The standard error of the difference between the two means was 140.81. The critical ratio was 2.47, which is not significant at the .01 level of confidence. (See Table X, page 45.)

The mean loss for the eighth grade control group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 79.67 points. The standard error of the difference between the two means was 153.67. The critical ratio was .52 which is not significant at the .01 level of confidence.

The mean gain for the seventh grade control group between the initial Roger's Strength Test Index and the end of eighteen weeks was 124.72 points. The standard error of the difference between the two means was 140.81. The critical ratio was .89, which is not significant at the .01 level of confidence. (See Table XI, page 46.)

The mean loss for the seventh grade control group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 60.45 points. The standard error of the difference between the two means was 126.67. The critical ratio was .48 which is not significant at the .01 level of confidence.

TABLE I

MEAN SCORES OF 8TH GRADE CONTROL GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	4.50	4.66	5.00	6.00
Pull-ups	4.67	4.00	5.00	4.92
Arm Strength	102.67	110.75	140.58	126.58
Leg Lift	431.67	585.00	588.88	529.58
Back Lift	197.08	307.50	299.08	328.75
Right Grip	37.00	39.58	38.92	36.08
Left Grip	30.17	32.67	34.25	31.67
Lung Capacity	142.33	190.42	193.25	199.33

TABLE II

MEAN SCORES OF 7TH GRADE CONTROL GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	7.00	7.73	7.36	6.45
Pull-ups	3.64	4.73	4.82	5.18
Arm Strength	123.45	134.91	134.64	135.18
Leg Lift	381.36	385.00	440.00	405.91
Back Lift	231.82	253.36	268.18	247.27
Right Grip	36.81	36.63	38.54	35.82
Left Grip	30.82	31.91	40.91	30.91
Lung Capacity	167.64	167.00	169.36	172.00

TABLE III

CONTROL GROUP

Statistic	Pre-Test	9 Weeks	18 Weeks	27 Weeks
8th Grade				
Mean	940.92	1264.17	1289.50	1209.83
Mean Gain	-	323.25	25.33	-79.67
Critical Ratio	-	2.33	.17	.52
Level of Confidence	-	N.S.*	N.S.*	N.S.*
7th Grade				
Mean	962.82	999.54	1087.54	1027.09
Mean Gain	-	36.72	88.00	-60.45
Critical Ratio	-	.34	.21	.63
Level of Confidence	-	N.S.*	N.S.*	N.S.*

*Not Significant

Isometric Group

The mean score for push-ups, pull-ups, arm strength, leg lift, back lift, right grip, left grip, and lung capacity were computed for the seventh and eighth grade isometric groups at each testing period, every nine weeks. The results for the eighth grade are shown in Table IV, page 37 and the results of the seventh grade are in Table V, page 38.

Additional information concerning the mean, mean gain, critical ratio, and level of confidence for the pre-test, ninth week, eighteenth week, and twenty-seventh week for the seventh and eighth grade control group can be found in Table VI, page 39.

The mean gain for the eighth grade isometric group between the initial Roger's Strength Test Index and the end of eighteen weeks was 873.34 points. The standard error in the difference between the two means was 135.51. The critical ratio was 6.44, which is significant at the .01 level of confidence. (See Table X, page 45.)

The mean loss for the eighth grade isometric group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 306.25 points. The standard error of the difference between the two means was 160.29. The critical ratio was 1.91 which is not significant at the .01 level of confidence.

The mean gain for the seventh grade isometric group between the initial Roger's Strength Test Index and the

end of eighteen weeks was 321.08 points. The standard error of the difference between the two means was 135.80. The critical ratio was 2.36, which is not significant at the .01 level of confidence. (See Table XI, page 46.)

The mean loss for the seventh grade isometric group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 158.33 points. The standard error of the difference between the two means was 141.41. The critical ratio was 1.12 which is not significant at the .01 level of confidence.

TABLE IV

MEAN SCORES OF 8TH GRADE ISOMETRIC GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	7.00	8.50	10.50	8.25
Pull-ups	4.75	8.33	11.33	9.00
Arm Strength	184.08	245.83	318.83	197.00
Leg Lift	428.33	606.67	784.58	673.75
Back Lift	207.50	344.17	472.33	379.50
Right Grip	49.58	58.00	57.75	51.17
Left Grip	44.83	46.00	54.42	51.67
Lung Capacity	168.92	205.56	235.75	229.08

TABLE V

MEAN SCORES OF 7TH GRADE ISOMETRIC GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	7.92	8.42	10.25	8.58
Pull-ups	3.75	5.00	8.25	7.50
Arm Strength	115.83	146.54	189.33	180.00
Leg Lift	449.17	513.33	538.33	450.42
Back Lift	176.67	277.50	290.83	246.25
Right Grip	32.00	34.83	37.67	34.58
Left Grip	28.25	30.83	32.08	29.00
Lung Capacity	157.75	170.33	193.25	181.33

TABLE VI

ISOMETRIC GROUP

Statistic	Pre-Test	9 Weeks	18 Weeks	27 Weeks
8th Grade				
Mean	1088.33	1484.17	1961.67	1655.42
Mean Gain	-	395.84	477.50	-306.25
Critical Ratio	-	2.31	3.14	1.91
Level of Confidence	-	N.S.*	.01	N.S.*
7th Grade				
Mean	959.67	1148.42	1280.75	1122.42
Mean Gain	-	188.75	132.33	-158.33
Critical Ratio	-	1.52	1.08	1.25
Level of Confidence	-	N.S.*	N.S.*	N.S.*

*Not Significant

Isotonic Group

The mean score for push-ups, pull-ups, arm strength, leg lift, back lift, right grip, left grip, and lung capacity were computed for the seventh and eighth grade isotonic groups at each testing period, every nine weeks. The results for the eighth grade are shown in Table VII, page 42 and the results of the seventh grade in Table VIII, page 43.

Additional information concerning the mean, mean gain, critical ratio, and level of confidence for the pre-test, ninth week, eighteenth week, and twenty-seventh week for the seventh and eighth grade control group can be found in Table IX, page 44.

The mean gain for the eighth grade isotonic group between the initial Roger's Strength Test Index and the end of eighteen weeks was 581.10 points. The standard error of the difference between the two means was 119.80. The critical ratio was 4.85, which is significant at the .01 level of confidence. (See Table X, page 45.)

The mean loss for the eighth grade isotonic group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 206.50 points. The standard error of the difference between the two means was 135.31. The critical ratio was 1.53 which is not significant at the .01 level of confidence.

The mean gain for the seventh grade isotonic group between the initial Roger's Strength Test Index and the

end of eighteen weeks was 290.91 points. The standard error of the difference between the two means was 147.45. The critical ratio was 1.97, which is not significant at the .01 level of confidence. (See Table XI, page 46.)

The mean loss for the seventh grade isotonic group between the eighteenth and twenty-seventh week (a period of no directed exercise) was 123.41 points. The standard error of the difference between the two means was 162.43. The critical ratio was .76 which is not significant at the .01 level of confidence.

TABLE VII

MEAN SCORES OF 8TH GRADE ISOTONIC GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	4.70	5.00	5.60	4.90
Pull-ups	3.70	4.90	6.70	6.20
Arm Strength	139.90	161.00	206.00	188.33
Leg Lift	384.00	597.00	685.00	530.50
Back Lift	199.00	313.50	332.00	299.50
Right Grip	48.30	51.10	58.20	53.00
Left Grip	39.60	42.00	47.60	47.60
Lung Capacity	169.70	215.30	233.80	223.20

TABLE VIII

MEAN SCORES OF 7TH GRADE ISOTONIC GROUP

Test Items	Pre-Test	9 Weeks	18 Weeks	27 Weeks
Push-ups	6.58	7.17	7.08	6.75
Pull-ups	3.50	7.33	5.92	5.83
Arm Strength	116.67	154.58	150.00	181.58
Leg Lift	402.08	526.67	557.92	468.33
Back Lift	196.25	166.67	296.25	231.25
Right Grip	38.33	42.33	40.58	37.08
Left Grip	32.17	35.25	34.83	31.67
Lung Capacity	177.83	190.33	184.08	189.25

TABLE IX

ISOTONIC GROUP

Statistic	Pre-Test	9 Weeks	18 Weeks	27 Weeks
8th Grade				
Mean	980.50	1380.90	1561.60	1355.10
Mean Gain	-	400.40	280.70	-206.50
Critical Ratio	-	1.50	2.08	1.53
Level of Confidence	-	N.S.*	N.S.*	N.S.*
7th Grade				
Mean	974.17	1214.17	1265.08	1141.67
Mean Gain	-	240.00	50.91	-123.41
Critical Ratio	-	1.73	.31	.76
Level of Confidence	-	N.S.*	N.S.*	N.S.*

*Not Significant

TABLE X

GROWTH CHART FOR 8TH GRADE GROUP
(0 to 18 Weeks)

	Isotonic	Isometric	Control
Mean Gain	581.10	873.34	348.58
Standard error of the Difference	119.41	135.57	140.91
Critical Ratio	4.85	6.41	2.47
Level of Confidence	.01	.01	Not Significant

TABLE XI

GROWTH CHART FOR 7TH GRADE GROUP
(0 to 18 Weeks)

	Isotonic	Isometric	Control
Mean Gain of the Two Means	290.91	321.08	124.72
Standard Error of the Difference of the Two Means	147.45	135.80	126.67
Critical Ratio	1.97	2.36	.48
Level of Confidence	Not Significant	Not Significant	Not Significant

Comparison of Isotonic Group with Control Group

The standard error of the difference of the mean gain in scores made by the isotonic group and by the control group from the pre-test to the end of eighteen weeks was computed and the actual difference in the mean gains in scores by the two groups tested for significance. The critical ratio for the eighth grade group was 2.91 which is significant at the .01 level of confidence. The critical ratio for the seventh grade group was 1.14 which is not significant at the .01 level of confidence.

Comparison of Isometric with Control Group

The standard error of the difference of the mean gain in scores made by the isotonic group and by the control group from the pre-test to the end of eighteen weeks was computed and the actual difference in the mean gains in scores by the two groups tested for significance. The critical ratio for the eighth grade group was 5.09 which is significant at the .01 level of confidence. The critical ratio for the seventh grade group was 1.93 which is not significant at the .01 level of confidence.

Comparison of Isometric with Isotonic

The standard error of the difference of the mean gain in scores made by the isometric group and by the isotonic group from the pre-test to the end of eighteen weeks was computed and the actual difference in the mean

gains in scores by the two groups tested for significance. The critical ratio for the eighth grade group was 3.29 which is significant at the .01 level of confidence. The critical ratio for the seventh grade group was .10 which is not significant at the .01 level of confidence (see Table XII below).

TABLE XII

COMPARISON CHART

	Comparison of Isometric with Isotonic	Comparison of Isotonic with Control	Comparison of Isometric with Control
8th Grade			
Critical Ratio	3.29	2.91	5.09
Level of Confidence	.01	.01	.01
7th Grade			
Critical Ratio	.10	1.14	1.93
Level of Confidence	Not Significant	Not Significant	Not Significant

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The lack of time and the need for tremendous facilities in developing physical fitness has lead to some concern for the physical fitness of our nation. As strength is one of the basic components for physical fitness, the author felt that more research was needed to determine the feasibility of using isometric training, a short cut to strength in regards to time and equipment and compare this with isotonic training, a method that takes considerably longer and more equipment. Also the author wanted to find out which training method would retain this increase in strength the longest.

The purpose of this study was to compare isometric exercise with isotonic exercise as a means of building and retaining strength.

By review of literature and by experimentation, the author sought to gain evidence that would support the hypothesis that strength can be gained through isometric and isotonic training programs.

Conclusion

In analyzing the improvements in the Roger's Strength Test Index made in the twenty-seven weeks by the groups

engaged in the isotonic training and the isometric training, it was apparent that there was statistically significant difference shown by the Monroe eighth grade students comprising the isotonic and isometric group.

In analyzing the improvements in the Roger's Strength Test Index made in the eighteen weeks, it was found that the eighth grade isometric and isotonic groups showed significant gains in strength as compared to the control group. The seventh grade isometric and isotonic groups showed no significant gains in strength as compared to the control group, however, they did show a gain in strength but not significant. The growth in strength shown by the eighth grade training groups indicates there is a definite advantage in following either of the exercise programs outlined in this study, at the eighth grade level.

The author believes the reason there wasn't any significant gain in strength for either the isometric or isotonic group at the seventh grade level is that seventh grade boys participate in more outside physical activity than eighth graders, also, that seventh grade boys are not ready anatomically for strength building exercises.

The isometric group showed significant gains in strength as compared to the isotonic group. Part of this gain in strength is probably due to the interest and excitement shown to isometric exercising. The loss in strength shown by the isometric and isotonic group decreased

at about the same rate that it increased. The isometric group showed the greatest gain in strength but also showed the greatest loss in strength for the last nine weeks of the study, in which there was no directed exercise.

On the basis of the evidence shown in this writing, the author has found that isometric exercising will show greater gains in strength than isotonic exercising.

Recommendations

The author recommends that more study is needed, and suggests that further research be conducted, using only isotonic and isometric groups, since the control group cannot be controlled adequately in their outside activities, as shown by their slight gain in strength.

It is also recommended that a research program of this type be continued over a number of years with several different age groups.

The author recommends that a research program like this one be done with students who do not participate in physical education or any physical, extra-curricular activity.

The author would recommend that physical education instructors use isometric exercising for building of strength, in their physical education programs. It takes less time and facilities than isotonic training.

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APPENDIXES

APPENDIX A

The basic isotonic exercises prescribed by Murray and Karpovich and used in this study are as follows:

1. Warm-up. In any vigorous activity, it is customary to warm-up the muscles before the actual exercise. Resistance exercise with barbells is no exception, and there are several good methods of warming up with a single exercise. One is to work the muscles in stages, as follows: Stand close to a barbell that is well within your strength ability to handle in any exercise. By lowering the hips, grasp the barbell with palms toward the legs at shoulder width. Maintain a straight back while pulling the weight up, and straighten fully and lean back slightly with the weight hanging across the thighs; lower the barbell to the floor and repeat three to five counts. Without setting the weight down, increase the action to the extent of pulling the barbell fully to the chest, but do not lift it overhead. Lower it again to a point below the knees and repeat the pull to the chest three to five times. Then, with the weight at the chest, push it overhead three to five times. This three-stage warm-up with a total of nine to fifteen actual movements will serve to activate all the muscles of the body.

   Remember to maintain a straight back at all times when pulling weights up from the floor.

2. Curl. An exercise which develops the biceps and allied arm and forearm muscles is the curl, which is performed as follows: The barbell is grasped with palms away from the legs and raised to a position across the thighs as the exerciser stands erect. Then it is raised to the chest (sternum) by flexing the arms (folding the forearms against the upper arms), the barbell moving in an arc as the elbows remain at the sides. The exerciser should stand straight as possible throughout and endeavor to limit the action to the arms. (Eight to twelve repetitions.)

   This exercise can also be practiced starting with palms toward the legs. This variation, called the reverse curl, affects the forearms more strongly and less weight can be used.

3. Press. For general development of the shoulders and triceps of the arms, the following exercise is unexcelled: Grasp the barbell with palms toward the legs and pull it to the upper chest (remembering to go for the weight with back straight, by lowering the hips). Then push it to fully locked arms overhead, lower the chest, and repeat the overhead lift. The exerciser should stand straight throughout the performance of this exercise, leaning back only slightly to get the barbell past the face.

   For the regular press, as described, the barbell should be held with a shoulder-width hand spacing. A valuable variation of this exercise, affecting the same muscles, but slightly differently, is to use a somewhat wider hand spacing and perform the presses from behind the neck. In pressing behind the neck, the barbell should be lowered all the way until it touches the shoulders. (Eight to twelve repetitions.)

4. Rowing. For development of the upper back muscles (and the arms), the following exercise is performed: With legs straight or very slightly bent, the exerciser leans forward and allows the barbell to hang just off the floor (palms of the hands toward the legs). The position is one with the body parallel to the horizon, bending forward from the hips. Without any motion of the legs or body, the barbell is pulled up to touch the chest at the bottom of the pectoral muscles. Then it is lowered and the movement repeated for the desired number of counts. (See movement repeated for the desired number.) To eliminate body motion and be sure that the upper back and arms are doing the work, it is a good idea to place the forehead against the top of the back of a chair, or something of similar height. (Eight to twelve repetitions.)

5. Squat. No exercise can match full knee bends with a barbell on the shoulders for powerful thighs and hips. The barbell is placed on the shoulders at the back of the neck. The exerciser can lift it there himself as though pressing, or it can be placed across the shoulders by training partners, or it can be lifted from shoulder-high stands. The heels can be raised slightly on a board one or two inches thick for comfort. Keeping the back straight and chest high, the exerciser lowers into a full squat and rises, repeating for the desired number of counts.

A variation of this exercise is to practice squats with a barbell while maintaining an on-toes position, as in doing free-hand calisthenic knee bends. Squatting on toes helps develop balance as well as strength, and is valuable when only cooperatively light weights are available, being more difficult than the flat-footed variety with a given weight.

When squatting on toes, the feet should be kept close together, with toes turned out somewhat. When squatting flat-footed (with or without the heels elevated), any comfortable stance is advised. Usually the most comfortable position will be to place the heels at approximately shoulder width, with the toes pointing slightly outward. (Ten to fifteen repetitions.)

6. Pullover. The straight-arm pullover is one which should be practiced with a light weight in order that proper emphasis can be placed on correct breathing for chest expansion. It is a good idea to practice pullovers immediately after a vigorous movement like the squat, which will have created a natural need for deep breathing.

Lying supine, the barbell is grasped at shoulder width with arms stretched fully over (behind) the head. After inhaling fully it is pulled over to a position directly above the chest, exhaling as the weight rises in an arc. It is then lowered to the starting position with accompanying full inhalation as it is lowered. The raising and lowering of the barbell, accompanied by exhalation and inhalation, is continued for the desired number of counts. No attempt should be made to handle heavy weights in this exercise and the arms should remain rigid. In almost every case, the weight of the bar alone will be sufficient at the start. Ten to fifteen repetitions should be performed, with a weight that is comfortable to use throughout the exercise.

7. Rise-on-toes. The calf muscles are dense and hard-to-develop because of the action they receive in walking, even in the case of the most sedentary person. To develop greater strength and size, it is necessary to work this muscle from full extension to full contraction against heavy resistance. The barbell is placed across the shoulders at the back of the neck, and the toes and balls of the feet are elevated on a 2-inch board, or higher, to allow the heels to extend

below the level of support and stretch the muscles. The exerciser then rises fully on the toes, lowers, and repeats for the desired number of counts.

It is a good system to work the calves by placing the feet in three positions; toes pointing in, out, and straight ahead. Ten to fifteen repetions should be performed in each position, since the calves need more work than other portions of the body.

8. Dead lift. The dead lift, while it sounds ominous, is simple to perform and one of the best exercises to develop the strength of the lower back. It also strengthens the grip, upper back, legs, and hips, and is excellent test of strength.

With feet spaced comfortably apart, bend the knees, lower the hips, and lean forward to grasp the barbell. Then simply straighten fully until the barbell is resting across the thighs with the body erect and shoulders back. Lower and repeat. To make it easier to hold the barbell until the repetitions are completed, the hands may be reversed, one palm toward the legs and the other away. (Eight to twelve repetitions.)

9. Upright rowing. An exercise to develop the trapezius, deltoids, and allied upper back muscles, as well as the arms, is performed as follows: Hold a barbell (palms toward the body), with a narrow hand spacing, at the hang position across the thighs. Then, keeping elbows higher than the barbell throughout the movement, pull it up along the abdomen and chest to the throat or chin. The legs and body should remain straight throughout the exercise. The entire action is the pull from hang position to the throat, working from eight to twelve repetitions.

10. Press on bench. To develop the muscles of the chest, as well as the triceps of the arms and the deltoids, one of the best exercises is to press a barbell from a point on the pectorals to locked arms over the chest while lying supine. The hands should be placed slightly wider than the width of the shoulders. Arm strength will be affected more if the elbows are kept close to the sides; the pectorals will be developed more if the elbows are held wide.

To place the barbell in position, it can be lifted to a position at the top of the thighs

while the exerciser seats himself at the end of the bench and lies down. He then tosses the barbell back on the chest by forcibly bridging up and back with a leg thrust, keeping shoulders in place on the bench. If training partners are present, they can hand the barbell to the exerciser (in which case more weight can be handled with grater comfort and safety). The exercise can also be practiced lying supine on the floor (Eight to twelve repetitions.)

11. Bent-arm lateral raise, lying. A combined chest-expanding and pectoral-developing exercise is performed as follows: The exerciser grasps a pair of dumbbells and lies supine on a bench. With arms slightly bent and held rigid, the weights are lowered, in arcs to each side, from a point directly over the chest. The lowering to full stretch of the pectoral muscles is accomplished by forceful inhalation. The dumbbells are then returned to the starting point in the same arc, with exhalation. (Eight to twelve repetitions is recommended, but weight and repetition increases will be gradual in a leverage exercise of this type.)

12. Lateral raise, standing. For direct development of the deltoid muscles of the shoulders, the exerciser should stand in a position of attention with dumbbells held at the sides, arms straight. Keeping the arms straight and knuckles up, the dumbbells are raised directly to the sides in a full semicircular or until they are fully overhead. The arms should be kept rigid throughout. It will be found necessary to rotate the hands to bring the dumbbells fully overhead, but this rotation should be avoided as much as possible, which means that the knuckles should be pointing up as far along in the arc as possible. The knuckles should remain up until the hands have passed the height of the ears in every case. (Eight to twelve repetitions.)

APPENDIX B

The basic isometric exercises prescribed by Steinhaus and used in this study are as follows:

1. The elbow push. Stand with back to wall--elbows at shoulder height and touching wall--hands at collarbone level with palms down. Press elbows hard against the wall.

2. The hand push. Stand with palms touching and the elbows at shoulder height. Press palms together hard.

3. The reach. Stand with left arm extended high over the head. Reach up as high as possible while keeping the heel on the floor. Repeat with right arm.

4. The muscle-maker. Stand with both elbows bent and the hands relaxed, contract the biceps as hard as you can.

5. The twist. Stand with the arms extended forward--fingers interlocked. Try to twist the arms inward. Repeat outward.

6. The grip. While standing, grip both hands as hard as possible.

7. The finger stretch. Stand with the arms stretched out in front and extend the fingers as hard as possible.

8. The front flattener. Lie on your back on the floor with hands on hips (elbows off the floor). Raise head and shoulders and feet from the floor.

9. The curver. Lie face down on the floor with hands on hips. Raise the head and shoulders and the feet from the floor. (Keep knees straight.)

10. The spread. Stand with the left side toward the wall. Press the left foot against the wall--keeping the leg straight. Repeat with right leg--right side toward wall.

11. The squat. Stand with hands on hips, knees bent, heels off floor.

12. The heel stand. Standing on heels, touching wall lightly for balance.

13. The arch raiser. Sit with the soles of the feet turned in toward each other and the toes curled under.

APPENDIX C

INSTRUCTIONS FOR THE ROGER'S STRENGTH TEST

The subjects start at Station 1 and move from one test to the next. The testing is from the least to most strenuous. In general this order should not be reversed or the results will be unsatisfactory.

Age, height, and weight. Age should be taken in years and months. Height and weight should be taken with the subjects in gymnasium uniforms, and recorded at the nearest half inch and pound, respectively.

Lung capacity. Before each test, change the mouthpiece and lower the spirometer bell to the zero mark. The rubber plug at the base of the spirometer should be removed when lowering the bell, and then replaced again.

Fire the signal for the subject to start, and then watch the indicator closely to note when it reaches the highest point. Record to the nearest cubic inch. Watch to see that the subject performs properly and that a second breath is not taken during the test. Test the subject at least twice. If any great discrepancy appears, retest again.

Grip strength. Take the right-hand corner of the manuometer between the thumb and forefinger of the right hand and place it dial down in the palm of the subject's hand while holding the hand to be tested with the left hand. Check the position of the manuometer to be sure it is correct. Watch carefully during the test to be certain the subject does not touch the body or any object with the hands. Test the subject twice for each grip and repeat if any great discrepancy appears. Record the best score to the nearest pound for each hand. Return the indicator to zero after each test.

Back lift. Have the subject stand on the base of the dynamometer with feet close to the attachment and toes even with front edge of the base. Adjust the handle of the dynamometer so that when the subject is standing erect, his finger tips are just above the handle. When the subject is in the position to lift, the back should be slightly bent at the hips just

enough so that he will not completely bend at the knees. It is important not to bend the back too much, as the resultant poor leverage is conductive to a poor lift as well as to the possibility of strain. With the back properly bent, however, there is little likelihood of injury from lifting.

Grasp the subjects hands firmly and give the signal to lift. During the lift, look to see that the subject is in the most advantageous position. An attempt to lift by standing on the toes indicates that the chain is too long. At the end of the lifting effort, the back should be almost straight. Any initial lateral sway should be checked immediately. Test the subject at least twice and repeat if any great discrepancy appears. Record the best lift to the nearest five pounds.

Leg lift. First adjust the belt and handle to the subject. Slip the loop of the belt over one end of the handle. With the handle in position at the junction of thighs and trunk, sling the belt around the back of the subject, placing it as low as possible over the hips and gluteal muscles. Then loop the free end of the belt around the other end of the bar, folding it back upon itself and tucking it in so that it rests next to the body. In this position the belt will bind firm, and will not slip.

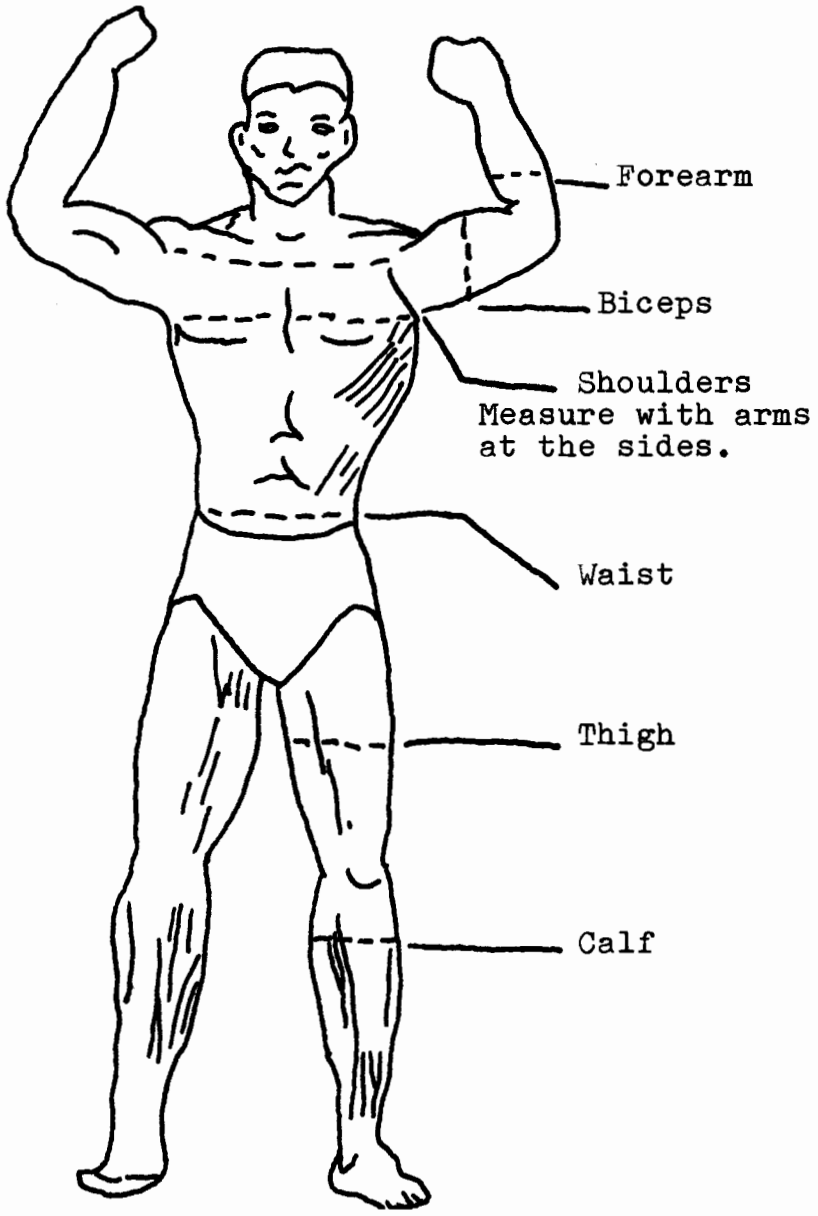
Then, have the subject take his position on the dynamometer base, have him bend his knees enough so that when the chain is hooked to the handle the angle of the knees will be between 115 and 124 degrees. If a change of one link is too much, adjust by twisting the chain. Before instructing the subject to lift, be sure that the arms and back are straight, the head erect, and chest up. Give the signal to lift. If the subject begins to sway, steady him by grasping the knees firmly. Test the subject at least twice and repeat if any great discrepancy appears. Record the best lift to the nearest five pounds.

Pull-ups. This item measures the muscular strength and endurance of the arms and shoulders. Hang from the rings using any grip. Use the reverse grip when hanging from a bar. Chin as many times as possible. In executing the movement, pull up until the chin is even with the hands, then lower the body until the arms are straight. Do not kick, jerk, or use a hip motion. You will be penalized for each improperly executed pull-up.

Dips. This item measures the muscular strength and endurance of the arms and shoulders. Stand at the end of the parallel bars, grasp one bar in each hand, and jump to the front support position with arms straight. Execute the dip as many times as possible. In performing this movement, lower the body until the angle of the upper arm and forearm is less than a right angle. Then push up to the straight-arm position. Do not jerk or kick. You will be penalized for each push-up improperly executed.

Name _____

Birth Date _____



Date				
Neck				
Shoulders				
Forearm Left				
Forearm Right				
Biceps Left				
Biceps Right				
Chest Expanded				
Chest Deflated				
Thigh Left				
Thigh Right				
Calf Left				
Calf Right				
Body Weight				
Height				

APPENDIX E

LETTER TO PARENTS

Dear Parent,

This year at Monroe Junior High School we are going to run an experimental program in physical education. Through this experimental program we are going to try and find out which method of exercise, isotonic or isometric has the greater effect on building and retaining of strength. As you know, physical fitness is a very important part of our everyday life and strength is a very important component of physical fitness.

Isometric exercising is an exercise which allows no shortening or lengthening of the muscle fibers during the contraction period. Isotonic exercising, often referred to as weight training, is an exercise which allows shortening or lengthening of the muscle fibers.

The first week of school each boy in the seventh and eighth grade physical education class will be tested with equipment designed to measure strength of the large muscle groups. From these test results, each physical education class will be divided into thirds; one-third in the control group, one-third in the isometric group, and one-third in the isotonic group. This experiment will last the entire school year. During the physical education period, however, your son will continue to participate in our regular physical education activities.

If you feel that you do not want your son to participate in this experiment or in one of the groups, please drop us a note letting us know.

Sometime around the second week of school, your child will be bringing home more information explaining in more detail our program. If you have any questions concerning this program please contact us.

Sincerely,

Rodney Waddell