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A Comparison of the Effectiveness of Isometric and Isotonic Exercises When Performed at Different Frequencies Per Week.

Jerry Nolley Barham

Louisiana State University and Agricultural & Mechanical College

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A COMPARISON OF THE EFFECTIVENESS OF ISOMETRIC AND ISOTONIC
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A Dissertation

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Louisiana State University and
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The Department of Health and Physical Education

by

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B.S., Arkansas Agricultural and Mechanical College, 1953
M.S., Louisiana State University, 1958
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The purpose of this study was to compare the effectiveness of isometric and isotonic methods of exercise, when performed at different frequencies per week, in the improvement of muscle strength performance.

Six experimental groups consisting of fifteen subjects each were used in this study. Three experimental groups used isometric exercises and three experimental groups used isotonic exercises. One experimental group from each method group exercised five days a week; another two groups exercised three days a week; and a third set of two groups exercised two days a week.

Ninety male students enrolled in physical education activity classes at Louisiana State University were used as subjects.

The isometric training program of the three isometric groups consisted of one maximum static contraction, held for six seconds on the testing apparatus. In addition to the isometric training program, the isometric groups participated in their regular physical education activity classes.

The experimental exercise selected for the three isotonic groups was full-knee bends with a plate-loaded barbell resting across the shoulders. A resistance was selected for this exercise that would permit a maximum of five executions. Three sets of exercise bouts were used, with a three-minute rest period between
sets. In addition to the weight training exercises, the isotonic
groups performed the same isometric exercises as did the isometric
groups. The subjects were tested for maximum strength at each
training session.

The difference between the initial and final strength tests
was used to determine the effects of the six training programs.

Within the limitations of this study, the following findings
were reported:

1. Significant improvements in muscle strength performance
   may be achieved through the use of isometric methods of
   exercise.

2. The addition of isotonic exercises to a "one maximum
   isometric contraction" exercise program does not
   significantly affect the amount of strength improvement
   obtained through the use of isometric exercises alone.

3. There is no significant difference in the amount of
   strength acquired through exercises performed five days
   a week and the amount of strength acquired through
   exercises performed three days a week.

4. The amount of strength acquired through exercises performed
   five days a week and three days a week is significantly
   greater than the amount of strength acquired through
   exercises performed two days a week.
CHAPTER I

STATEMENT OF THE PROBLEM

I. INTRODUCTION

In 1953, Hettinger and Muller published a pioneer study of the effects of isometric contractions on strength performance. They reported that one daily exercise bout in which the subject maintained for six seconds, two-thirds maximal tension was as effective in building strength as longer and more frequent periods of static exercise.\footnote{Th. Hettinger and E. A. Muller, "Muskelleistung und Muskel-training," \textit{Arbeitsphysiologie}, 15:111-26, 1953. As found in Arthur H. Steinhaus, "Strength from Morpurgo to Muller--A Half Century of Research," \textit{The Journal of the Association for Physical and Mental Rehabilitation}, 9:147-50, September-October, 1955.}

Hettinger and Muller did all of their work with isometric contractions. After the publication of their work, several investigators have attempted to compare the effectiveness of isometric methods with isotonic methods in the improvement of muscle strength performance. As reported in Chapter II of this report, these investigations showed contradictory evidence as to the effectiveness of these two methods. In light of these contradictory findings, there seems to be a great need for further study in this area.
As shown in Chapter 11, only one study has been published in the research literature which has attempted to compare the effectiveness of isometric and isotonic exercise when performed at different frequencies per week. The results of this study, as reported by the authors, were inconclusive.

II. PURPOSE OF THE STUDY

The purpose of this study was to compare the effectiveness of isometric and isotonic methods of exercise, when performed at frequencies of five, three, and two days per week, in the improvement of muscle strength performance.

III. DEFINITION OF TERMS

The following differentiation of isometric and isotonic type contractions is that given by Morehouse and Miller. If a light weight is suspended from a muscle, the weight will be lifted when the muscle shortens. This type of contraction is called isotonic. If, however, a weight too heavy for the muscle to lift is attached, stimulation of the muscle will result in the development of tension without shortening. This is an isometric contraction. Muscular effort which does not result in movement is isometric; that which results in movement is isotonic. Isotonic contractions involve the application of a force through a distance and result in the performance of work (work = force X distance). No work is done in isometric contractions (distance = zero), and all the energy of the contraction is eventually converted into heat.

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CHAPTER II

REVIEW OF LITERATURE

The studies related to the effects of isometric exercises on the development of strength, revealed in the literature, may be arbitrarily divided into three groups which are closely related to the problem. These three groups are: (1) the Hettinger and Muller experiments, (2) other studies concerning the effectiveness of isometric exercises, and (3) studies comparing isometric exercises with isotonic exercises.

I. THE HETTINGER AND MULLER EXPERIMENTS

The Hettinger and Muller experiments were conducted in Germany and were published in German publications. Steinhaus has translated these studies into English and has summarized them as follows:

Hettinger and Muller performed seventy-one separate experiments on 9 male subjects over a period of 18 months. These experiments provided data on how the development of strength in muscle was related to the intensity and frequency of training activities.

All training was in the form of static contraction held for a measured length of time against a spring scale and most of the observations were made on the flexors and extensors of the forearm held horizontal at right angles to the upper arm. On Saturdays maximal strength was recorded. Sunday was a day of rest. Mondays through Fridays were spent in training sessions.

1Th. Hettinger and Muller, loc. cit.
in which the intensity of contraction, the amount of time held, and the number of practices per day were varied.  

According to Mueller, the Hettlinger and Muller study revealed the following findings:

1. Muscle strength increases an average of 5% per week when the training load is as little as 1/3, or even less, of maximal strength.

2. Muscle strength increases more rapidly with increasing intensity of training load up to about 2/3 of maximal strength. Beyond this, increase in training load has no further effect.

3. One practice period per day in which the tension was held for six seconds resulted in as much increase in strength as longer periods (up to 7 per day).

4. The cause of the increase in strength (training stimulus) they believe is neither the intensity of contraction nor the degree of exhaustion of a muscle fiber, but rather a condition in which the oxygen supply to a muscle fiber ceases to be enough for its needs. A further oxygen deficit is not a stronger or more effective stimulus. Thus, they postulate an "all or none" characteristic of the "training stimulus" or stimulus to hypertrophy. The observation that strength grows more rapidly as the training load increases from about 1/3 to 2/3 maximal strength is to them only an apparent contradiction. They believe that due to the internal arrangement of fibers within a muscle not all fibers are equally taxed so that not until the training load is about 2/3 maximum are all fibers suffering some oxygen deficit.

5. From measurements of biceps diameters in maximal contraction they calculate a maximal contraction strength of 6.6 kg/cm² (about 95 pounds per square inch) of muscle cross section. They found that the calculated muscle cross section increased in accord with this factor as strength increased. Thus, they conclude that the effective training stimulus extends from somewhere below 2 Kgs to somewhere under 4 Kgs per square cm. of cross section.

6. They found a correlation of +.77 +0.09 between (a) maximal

---

increase in strength due to training and (b) the speed of this improvement, when 20 different muscle groups were compared. Finger muscles increased maximally 33% and showed an increase of 3.2% per week. For hip flexors the corresponding figures were (a) 177% and (b) 22.1%.

7. When tension per square cm. of cross section is held constant, endurance (holding time) is unchanged with increase in total strength. This is attributed to improvement in capillarization paralleling hypertrophy.

8. The rate of increase in strength sometimes varied considerably in the same person when two comparable training periods, separated by a long rest period, were compared.

9. There is a ceiling on the development of strength in every muscle. This is usually accompanied by pain resulting from some injury within the muscle that stops further increase in effort.

10. They postulate that the maximal strength of any muscle in the body is probably about 3 times the tension demanded of it in everyday activities.3

II. OTHER STUDIES CONCERNING THE EFFECTIVENESS OF ISOMETRIC EXERCISES

The findings of nine studies on the effectiveness of isometric exercises in the development of muscle strength are summarized in this section.

Elbel, Grunberg, Labree and Hughes Studies. According to Lorback4 the effects of isometric contractions were being studied as early as 1928. He reports a series of studies were conducted at

3Ibid.

Springfield College by Elbel (1928), \(^5\) Grunberg (1929), \(^6\) Labree (1930), \(^7\) and Hughes (1930) \(^8\) on the effects of short-static contractions. These investigators endeavored to find out if short-static contraction exercises would improve the strength of certain muscle groups and if muscles so strengthened would have a beneficial effect on some of the common postural defects. The short-static contraction consisted of lifting and holding a weight for a short period of time.

Lorback states that "In general the objectives of these studies were closely related. Each succeeding study in the series was basically a refinement of the methods and techniques used in the previous study. The findings of the studies indicated that it is possible to increase strength by exercise which employs short-static contraction exercises." \(^9\)

Wolbers and Sills Study. This study by Wolbers and Sills \(^10\) was


\(^9\) Lorback, loc. cit.

designed to determine whether static muscle contractions would result in significant changes in strength.

The sample for this study consisted of twenty boys from the eleventh and twelfth grades of the University High School in Iowa City. The subjects were divided at random into two groups: (1) ten in the experimental group, and (2) ten in the control group.

At the beginning of the experiment, the two groups were given a battery of strength tests including the leg lift, back lift, left grip, right grip, and the Sargent Jump.

The experimental group went through an eight-week training period to increase their strength by practicing a series of exercises that required static contractions of the muscles involved. The subjects met daily (at the same time each day, five days a week) for the training sessions.

The authors tried to select exercises that would develop the muscles measured by the strength tests. Nine exercises were selected and pictures showing subjects performing seven of these exercises are included in the text. In performing an exercise, the muscle was held in static contraction for a period of six seconds once a day. The resistance for the exercise was offered by a partner who resisted the movement of the subject. The subjects worked in pairs—B supplying the resistance for A, then they reversed roles.

The experimental group showed greater gains in all the items (except the Sargent Jump) than did the control group. The differences

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11 ibid., pp. 448-49.
between the mean gains of the experimental group and the control group on the back lift and leg lift were statistically significant at the one per cent level; combined hand grips were significant at the five per cent level.

As a result of these findings the authors concluded that:

... for the muscle groups tested in this experiment, static muscle contractions of six seconds' duration will cause significant gains in strength. The increases in leg strengths made by the members of the experiment group were not proportionately great enough to produce a statistically significant gain in the Sargent Jump. 12

Rarick and Larsen Study. The purpose of the Rarick and Larsen study 13 was to compare the relative effectiveness of single daily isometric exercise bouts maintained at two-thirds maximum tension with a program of static exercise in which the frequency of the six-second bouts was progressively increased with tension levels at eighty per cent of maximum static strength.

In this study, thirty post-pubescent eleventh and twelfth grade high school boys were used as subjects. The subjects were divided into two experimental groups and one control group. The control group did not engage in the specialized training program. Experimental Group I followed the procedures used by Hettinger and Muller in which two-thirds maximum tension was held by each subject

12 Ibid., p. 450.

for only six seconds once each day, Mondays through Thursdays. Experimental Group II held eighty per cent of maximum tension for five periods of six seconds each on Mondays increasing the number of exercise bouts once each day with a maximum of eight on Thursday. A ten-second rest period was given following each exercise bout. Fridays were devoted to testing to determine the tension levels which the experimental groups were to employ the following week.

The three groups were equated on the basis of the initial strength scores secured on the Friday prior to initiating the experimental procedures. The best of three trials was taken as each subject's strength score and was used as the basis for matching subjects into three equated groups.

Each experimental group was given a four-week training program restricted to isometric exercise of the wrist, the programs differing only in regard to the frequency of the exercise bouts and the levels of static muscular tension employed.

The program of exercise and all tests were confined to flexion of the right wrist. All subjects in the experimental groups were given tests of wrist flexion strength at the end of the second, fourth, and eighth week.

Within-group and between-group comparisons of strength scores were made at the conclusion of the four-week period of training and again four weeks after the termination of the exercise program.

The following summarizes the findings of the investigation:

1. In terms of raw score and percentage gains both experimental groups elicited gains during the experimental period. However, the strength increase achieved by the group utilizing 80 per cent maximum tension with progressively greater numbers of daily exercise
bouts was slightly greater at the end of the training period and the decline less during the post training period than for the group employing the daily six-second method.

2. The gains achieved by the two experimental groups at the end of the training period were significant beyond the .01 level. Loss in strength during the four weeks post training period was significant for both groups at or beyond the .05 level.

3. In comparing differences among groups, the two experimental groups showed significantly higher strength scores than the control group at the end of the four-week training period (P = .01 and P = .02). The difference between the strength scores of the two experimental groups was not significant.

4. Differences among the groups four weeks after terminating the special exercise programs were less dramatic, although the strength of the group using 80 per cent maximum tension was still significantly superior to the control group (P = .02). However, there was no significant difference between the group employing two-thirds maximum tension and the control group. The difference between the two experimental groups in strength retention, while not significant (P = .30), favored the group employing the higher tension level for longer periods of time.

The findings of this study generally supported the Hettinger-Muller hypothesis of static strength development. While the data indicated that tension levels greater than two-thirds maximum with more frequent exercise bouts were not superior to the single daily six-second bout in building isometric strength, the former method tended to be slightly more effective in terms of developing qualities of strength retention.\(^14\)

**Taylor Study.** In a survey of completed research in the field of isometric exercises, Lorback\(^15\) pointed out a study of the effectiveness of four static contraction training methods for increasing

\(^{14}\)Ibid., pp. 340-41.

the contractile strength of two body movements. In this study by Taylor\textsuperscript{16} the four methods of training used were: (1) maximum pull held for twelve seconds; (2) maximum pull held for six seconds; (3) two-thirds of possible maximum pull for twelve seconds; and (4) two-thirds of possible maximum pull held for six seconds.

Dorsal flexion of the right wrist and outward-rotation of the right thigh were the body movements used in training. He also used a control group which did not participate in the training. He found no significant difference in the four methods for producing strength in the muscles involved in either of the movements except that two-thirds maximum contraction for six seconds was significantly better at the five percent level of confidence than the same method held for twelve seconds for strength production in muscles of the right thigh outward-rotation movement. There was a higher group mean in strength for the experimental group than for the control group at the conclusion of the training period.\textsuperscript{17}

\textbf{Lyne Study.} The purpose of Lyne's study\textsuperscript{18} was to determine the frequency of static contraction exercise necessary for the maintenance of a new strength level achieved by a brief period of training. More specifically, the study compared three frequencies for effectiveness in maintaining a new strength level acquired from eight weeks of weight training. The three frequencies were: (1) exercise once weekly, (2) exercise once every two weeks, and (3) exercise once every three weeks.


\textsuperscript{17}Lorback, loc. cit.

The exercises performed were in the form of static contraction and involved the flexors and extensors of the preferred arm and the extensors of the legs. The static contractions were of maximum effort, held for a period of six seconds per muscle group.

The entire experiment covered a period of sixteen weeks—eight weeks of weight-training, and eight weeks of training with the six-second static-contraction exercises. At the end of the weight-training period, all subjects in the experiment were given a strength test of all muscle groups involved before going on to the next phase of the experiment.

Immediately following the administration of the strength test, the subjects were assigned to four "non-equated" groups: (1) a control group that did not participate in the training program or any vigorous physical exercise for a period of eight weeks, (2) a group that trained once weekly with the static contraction exercises, (3) a group that trained once every two weeks, and (4) a group that trained once every three weeks. There were twelve subjects in the first two groups and eleven subjects in the other two groups.

A cable tensiometer was used to measure the strength of the flexors and extensors of the preferred arm and to train these muscle groups. A leg dynamometer was used to test the strength and train the muscles of the extensors of the legs.

While in the isometric phase of the experiment the subjects participated in courses of physical education that required a minimum of large muscle activity: sports lecture, bait casting, hunter safety, and golf instruction. The subjects were volunteers and reported in
the evening for the isometric training exercises. The group that trained once weekly had a total of eight training sessions. The group that trained once every two weeks had a total of four training sessions, and the group that trained once every three weeks had a total of three training sessions. During the two days following the last training session, the subjects were administered a post-test in which the maximum strength of the flexors and extensors of the preferred arm and the extensors of the legs was measured.

Although there was a range of individual differences, an analysis of the scores made by the control group showed that there was a decline in strength in each of three movements. The decline in strength level ranged from eleven to eight per cent of the pre-test strength. The differences between the pre-test and post-test mean strength scores on all three movements were significant at the one per cent level of confidence.

Of the group that trained once weekly, it was found that there was a significant increase in the strength level of the muscle groups involved in the study. The greatest increase in strength occurred in the extensor muscles of the legs, where there was an increase of thirteen per cent of the pre-test strength level.

In the group training once every two weeks, there was a very slight gain in the strength level. However, the differences between the pre-test and post-test mean strength scores were not significant at the five per cent level of confidence. Once again, there was a wide range of individual differences within the group.
Of the group that trained once every three weeks, there was a slight decline in the strength level of the three muscle groups, however, the differences between the means were not significant at the five per cent level of confidence.

From the findings of his study, the author was able to make these conclusions:

1. The strength level achieved rapidly during an eight-week session of weight-training declines after the cessation of that training.

2. Training once weekly with static-contraction exercises—maximum exertion for six seconds per muscle group—significantly increases a newly acquired strength level, achieved through eight weeks of weight-training.

3. A newly acquired strength level, achieved during eight weeks of weight-training, can be maintained by training with static-contraction exercises once every two weeks for an additional period of eight weeks.

4. Training with static-contraction exercises once every three weeks for nine weeks following the achievement of a new strength level is not sufficient to maintain that strength level.

Day Study. The purpose of Day's study was to determine if the waistline of women can be materially reduced by maximum isometric contraction of the abdominal muscles.

In this study seventy-two women students enrolled in health and physical education classes were divided into two groups—an experimental group of thirty-eight students and a control group of thirty-four students.

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19 Ibid., p. 58.

The exercise program for the experimental group was to force
in the abdominal muscles as much as possible and, at the same time,
to strongly contract the gluteus muscles for a period of six six-
second intervals. The subjects continued these exercises on a
daily basis.

The control group did not participate in the Isometric exercise
program.

The duration of the Isometric training program was six weeks.

As a result of the findings of this study, Day made the following
conclusions:

isometric contraction of the abdominal muscles over a
period of six weeks caused an average reduction of 1.24 inches
in the waistline of the college women subjects.21

III. STUDIES COMPARING ISOMETRIC AND ISOTONIC METHODS
OF STRENGTH DEVELOPMENT

In this section seven studies are reviewed that compared the
effectiveness of isometric and isotonic exercises in the development
of muscle strength.

Mathews and Kruse Study. The purpose of this study by
Mathews and Kruse,22 was to examine the effectiveness of various
frequencies of training programs upon the changes in strength of the

21 Ibid.
22 Donald K. Mathews and Robert Kruse, "Effects of Isometric
   and Isotonic Exercises on Elbow Flexor Muscle Groups," Research
elbow flexor muscle group. A second problem was to study the effectiveness of an isotonic contraction and an isometric contraction in terms of strength changes.

One hundred and twenty Springfield College male students were used, half exercising isometrically and the other half isotonically. The sixty subjects in the isotonic unit exercised to exhaustion on the Kelso-Hellebrandt ergometer with a weight load equal to 3/16 of their maximum strength. In addition to the isotonic exercise on the ergometer, the subjects performed one isometric contraction of maximal effort with each visit to the laboratory, so that the proper load proportion could be placed on the ergometer.

The subjects in the isometric unit exercised by exerting maximum effort in three consecutive six-second pulls on a strap. Clarke's Cable Tension Strength Test for the elbow flexor muscle group was employed, both in taking the strength measurements and as a means for the isometric exercise.

The two exercise units were divided into four groups, each containing fifteen subjects. The respective groups exercised two, three, four, and five times a week over a period of four weeks. Initial strength of the elbow flexor muscle group was used as a basis for equating the eight groups.

In analyzing their data the authors originally planned to test the significance between group regression lines (rate of improvement of a given group) to determine whether one exercise frequently results in a greater strength gain than does another. This common group regression line was not found, thus indicating
that the individuals within an exercise group do not improve at the same rate but at a rate peculiar to themselves. The authors considered their problem as one of an analysis of variance among regression coefficients.

The authors report that "in every instance, the F tests resulted in significance beyond the .01 level of confidence, indicating that no common regression exists within the groups."\(^{23}\)

As a result of these findings, it is not feasible to test for significance in terms of rate of improvement between the groups as originally planned, for there is no common regression peculiar to a given exercise group. In each of the four groups, the deviations of individual regressions from the group regression account for more of the variance than do the deviations from the individual regressions, implying of course, that the rate of change in strength is peculiar to the individual.\(^{24}\)

The authors state that within the limitations of their study the following conclusions, as well as questions, may be suggested.

1. Individuals, regardless of exercise frequency, react in a manner peculiar to themselves. This was borne out by the fact that 1. a common regression line did not occur within either of the two exercise units; and 2. the individual regression equations, when plotted, exhibit lack of uniformity in terms of rate of increase in strength.

2. As the exercise frequency increased, a greater number of subjects significantly gained in strength in both units.

3. A total of 41 of the 60 subjects in the Isotonic Unit and 44 of the 60 subjects in the Isometric Unit significantly increased their strength scores. It must be kept in mind that the former group averaged approximately 120 seconds per exercise on the ergometer, while the latter group trained a total of only 18 seconds in executing the three, six-second maximal contractions on the strap. Apparently, the isometric-type contraction results in greater strength gains than does

\(^{23}\text{Ibid., p. 29.}\)

\(^{24}\text{Ibid., p. 30.}\)
the isotonic-type contraction in terms of the exercises used in this study.

4. One question might be raised relative to the appearance of greater homogeneity among certain groups as they completed the four-week exercise period. Perhaps a common regression might occur among subjects if they were more homogeneous in terms of strength when they started the training. If this is true, it might then be possible to determine if the rate of increase correlates to the number of times per week the subjects exercise.

5. Perhaps greater homogeneity in strength gains might have occurred also if the subjects were selected according to body type as revealed by the findings of Kohlrausch and Herxheimer.

6. Obviously, another factor which might account for lack of common regression is the amount of load the subject should carry on the ergometer. The question may be raised, is the three-sixteenths of the individual's elbow flexor strength a sufficient strength proportion for all subjects?

7. Should the training period be increased to six or eight weeks to determine whether a common regression will result?

8. Finally, it seems pertinent to suggest that care must be taken in drawing conclusions from similar studies in which the results are interpreted on the basis of mean strength changes. For, in this study, the results would be interpreted somewhat differently as compared to the results found by the analysis of variance of regression lines.  

In summary, the following results were obtained: (1) No common regression line was found in the eight groups, indicating the strength changes were peculiar to the individual, regardless of exercise frequency; (2) the isometric type exercise caused a greater number of subjects to significantly gain in strength; and (3) the five-day-a-week exercise program was most beneficial in terms of strength gains.

Darcus and Salter Study. The effect of repeated muscular

25 Ibd., pp. 35-36.
exertion on muscle strength was studied by Darcus and Salter. Their study was designed to test specifically the response of muscles to repeated isometric and isotonic exercises.

This study was an outgrowth of a series of preliminary studies designed to determine the effect of different joint positions on the maximum isometric forces that can be exerted in pronation and supination of the hand. In these studies it was noted that, although twelve exertions were made at $\frac{1}{2}$-minute intervals twice a day for fifteen days, there was no consistent increase in the force that could be developed. When these experiments were repeated with maximum isotonic contractions against a heavy load instead of isometric contractions there was a progressive increase in the distance that the load could be raised, indicating an improvement in the performance of the muscles.

In the present study, experiments are described on the effects of repeated maximum isotonic and isometric contractions on the strength of pronation and supination of the hand and flexion of the elbow. Each daily training session consisted of thirty contractions


29 Darcus and Salter, *loc. cit.*
at intervals of one minute. This was carried out for five or six days each week. Initially training was limited to one week, but at the end of this time static training gave no consistent results, whereas dynamic training produced immediate and progressive improvements. Due to these findings it was decided to continue both methods for a longer period.

Darcus and Salter describe their experimental procedure as follows:

Static and dynamic pronation training was carried out by two groups of six subjects for 5 or 6 days. All were trained on the right side, and one from each group on both sides. Six subjects, two from the 'static' group and four from the 'dynamic' group continued training for 5 days a week until twenty to twenty-eight sessions had been completed...

Before and after the experiment, three measurements were made at 1-minute intervals of the maximum isometric pronation and supination force exerted in six different hand positions (-60, -30, 0, +30, +60 and +90 degrees) on the trained side. In the two subjects who were trained on one side only, isometric and isotonic strength tests were made of pronation and supination on the opposite side. In one subject, who completed thirty-three dynamic training sessions, tests were made subsequently at fortnightly intervals for 1 year.

Supination of the hand was trained statically on the right side in two subjects and flexion of the elbow in two subjects. Three subjects carried out twenty-five training sessions during 5 weeks. Tests were made before and after training of the strength of isometric supination and flexion on both right and left sides in all four subjects.

Darcus and Salter report the following findings on the effects of static training on maximum force.

The shorter periods of training usually resulted in an increase in the maximum isometric force that could be exerted,

30 *ibid.*, p. 131.
but there was no consistent trend in the mean values over the 5 or 6 days. However, the longer periods always caused a significant improvement. The curves compiled for each subject indicated a progressive increase in the training effect, with the highest rate occurring in the second week. In no case was a plateau level reached.

On the effects of dynamic training on the maximum isotonic work the authors report the following:

This method of training produced an immediate and progressive improvement in the maximum isotonic work that could be achieved, with the most rapid improvement during the first week. In the one subject who completed thirty-three training sessions, a plateau level was reached after the twenty-sixth. Following the total amount of training, the tests made at fortnightly intervals showed a decrease in muscle strength. The decrease was greatest in the first 6 weeks, but even after 1 year the readings were still more than double those taken before training.

On the effect of static training on the maximum isotonic work and vice versa, the authors have the following to report:

The shorter periods of static training had a variable effect on the muscle strength measured isotonically. In the three subjects tested, one showed an increase, one no change and the other a decrease. In the latter case, there was also a decrease in the maximum isometric force. Two subjects were tested after the longer period of static training. In one there was an increase in the maximum isotonic work and the other, trained on both sides, there was an increase on the left side and a decrease on the right side. It is considered that the latter result may be spurious, as the percentage improvement measured isometrically was of the same order on both sides.

Both the short and longer periods of dynamic training produced an improvement in the maximum isometric force. In every case the percentage increase was less than for the maximum isotonic work.

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31 Ibid., p. 335.
32 Ibid.
33 Ibid.
**Liberson and Asa Study.** Liberson and Asa\(^{34}\) attempted to analyze some of the factors involved in brief isometric exercises by comparing isometric exercises with the DeLorme method of isotonic exercises. They studied the responses of the hypothenar muscle mass (especially, the abductor digiti quinti) in 26 normal persons. The authors chose these muscles because they are not used with great frequency in daily living and their training is not contaminated by factors difficult to control in an experiment of long duration.

At first the experimenters divided their subjects into two groups of thirteen each.

Members of the first group (A) exercised the hypothenar muscles according to the method of DeLorme. The second group performed isometric exercises of the hypothenar muscles . . .\(^{35}\)

After nine weeks of training, the second group was divided into two sub-groups, B and C.

Group B (control) comprised seven subjects who continued with the same isometric exercises (once daily) as before until the end of the study (three additional weeks). Group C consisted of six subjects who continued the same type of exercise as before, but instead of performing a single daily contraction for six seconds, each subject repeated the exercise 20 times during each session. The subjects assigned to isometric exercises were divided into two groups in such a manner that at the end of the ninth week, the mean increase (per cent) in muscle strength was the same for Groups B and C.\(^{36}\)

Since the age range for Group A was different from that of the other groups, the A Group was divided as follows: \(^{34}\)

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\(^{35}\) Ibid., p. 827

\(^{36}\) Ibid.
with the same age distribution as Groups B and C (20 to 30) and A2—seven persons in the age range of 30 to 45 years."

The exercises for Group A (isotonic) consisted of abducting the little finger of the right hand against a lever which raised a measured weight. This pushing movement was performed through the full range of motion (limited by a movable peg). The exercises were conducted according to the recommendations of DeLorme.

The exercises for Groups B and C (isometric) consisted of maintaining a maximal pull (attempting to abduct the little finger of the right hand) for six seconds on a cord attached to an isometric strain gauge myograph. The subjects of Group B were asked to execute only one contraction a day; those in Group C repeated the contractions twenty times at 20-second intervals.

At the beginning of the experiment each subject in every group was tested for:

- (1) maximal isometric contraction maintained for six seconds (recorded on the myograph),
- (2) the 1 RM value,
- (3) the 10 RM value,
- (4) the circumference of the hand and
- (5) the thickness of the hypothenar eminence (measured with calipers).

At the end of the experiment, these five determinations were made again and, in addition:

... each subject was asked to maintain a pull on the isometric

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37 Ibid.

38 Here, 1 RM refers to the amount of weight that a subject can lift for a maximum of one repetition; 10 RM refers to 10 repetition maximum; these are terms first used by DeLorme.

39 Liberson and Asa, op. cit., p. 829.
myograph cord with his hypothenar muscles until exhaustion. The time elapsed between the beginning of the pull and the moment that the myograph indicated 50 per cent of the initial amplitude was taken as the index of endurance.\(^4\)

As a measure of the contralateral influence of training a determination of the 1 RM and 10 RM on the left (unexercised) hand was made on the thirteen subjects who had exercised according to the method of DeLorme and on five subjects from Group B who had trained with brief isometric exercises. The remaining two subjects could not be tested.

The results of this study could be outlined as follows:

I. Increase of maximal muscle strength.

A. DeLorme exercises. . . . subjects in Group A increased their maximum muscle strength (1 RM) by 107 per cent at the end of the experiment and reached a plateau after nine weeks. The increase of the 10 RM followed a parallel course with a final increase of 103 per cent. Similar results were obtained in members of Groups A\(_1\) and A\(_2\) (respectively, 103 and 111 per cent for the 1 RM; 101 and 104 per cent for the 10 RM).

B. Isometric exercises. The subjects in Group B (single exercises) increased their maximum strength to a higher degree (170 per cent) and reached a plateau somewhat sooner—after seven weeks. Subjects in Group C (repeated isometric exercises) tripled their maximum strength (203 per cent increase).

II. Intergroup Comparison.

A. Time Factors. Maximum strength was recorded once per week during the 12 weeks of the experiment. In increases per unit of time Group B had a more favorable result than did Group A. The results in Group C were even better, but there was not a real difference between Groups C and B, until the repeated were added to Group C. With progression Group C not only reached the level of Group B but exceeded it by about 10 per cent.

\(^{40}\)ibid.
B. Cross Testing. Groups B and C showed an increase of performance with isotonic exercises (for which they were not trained) comparable with or higher than Groups A1 and A2, the latter failed to reach the results achieved by either Group B or C under conditions of isometric exercise (112 per cent instead of 174 and 203 per cent respectively for Groups B and C.)

C. Endurance. In endurance those in Group C did best and those in Group A1 performed most poorly.

D. Hypertrophy. Only minimal changes of the muscle volume were found, and here again the highest values were found in Group B. In spite of the minimal change in volume, almost all persons reported a subjectively increased firmness of the exercised hypothenar eminence after the experiment ended.

E. Contralateral Findings. There was no significant training effects on the contralateral (unexercised) hand with either the isotonic or isometric exercise. Thus the 1 RM on the right hand (exercised) was equal to twice the 1 RM found on the left hand at the end of the training.41

There was not a statistical test of the difference between any of these intergroup comparisons. The only statistical treatment was the computing of percentages.

Rose, Radzyminski and Beatty Study. According to Liberson and Asa, Rose and co-workers42 attempted to apply the method of Hettinger and Muller clinically.

They asked their subjects to lift with the quadriceps the greatest weight they could maintain for five seconds (from 20

41 Ibid., pp. 833-35.
to 52.5 pounds). Daily increments of $1\frac{1}{2}$ pounds were added at consecutive sessions until a plateau was reached. Improvement in muscle strength ranging from 82 to 162 per cent was observed over periods of from 39 to 90 days. When the method was applied to patients, the impression was gained that similar results could be obtained with either brief exercises or the DeLorme technique. The findings of Rose and his associates may be compared with those of Hettinger and Muller in relation to the following points:

1. No hypertrophy was found by Rose after brief exercises. Hettinger found a constant relationship between muscle strength and muscle cross-section during the training period.

2. Rose obtained gains in symmetrical muscles of the unexercised extremities almost identical with those obtained in the exercised muscles (except when the unexercised extremity was in a cast). Hettinger used symmetrical muscles to check the results of different exercise schedules.

3. No attempt was made by Rose to evaluate the endurance factor in single brief muscle contractions.  

**Rasch and Morehouse Study.** Rasch and Morehouse's study was designed to measure the effectiveness of isometric and isotonic exercises in the development of muscular strength, and hypertrophy.

The subjects for this study were forty-nine students from the junior class of the College of Osteopathic Physicians and Surgeons in Los Angeles. Twenty-four subjects performed isotonic exercises and twenty-five subjects performed isometric exercises. Groups were matched on basis of height and weight.

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44 Liberson and Asa, loc. cit.

The muscle groups exercised were: (1) elbow flexor group and (2) arm elevation group. Tests of strength were performed both in a position similar to that in which subjects were exercised and also in an unfamiliar position. In addition a third test using a different technique was used.

The girth of the upper arm was measured at the greatest prominence of the biceps when the upper arm was raised to shoulder height, the elbow flexors fully contracted, and the palm down.

Strain gauge dynamometer measurements of strength were obtained by means of a Baldwin SR-4 load cell.

To measure elbow flexion strength, the subject stood in an erect position grasping a stirrup handle, palm up, which was connected through a series of pulleys to a strain gauge dynamometer. His forearm and upper arm were perpendicular to the floor, close to his body but not braced against it.

To measure arm elevation strength, the subject stood with the arm to be tested next to the strain gauge. The upper arm was pendant from the shoulder, the elbow flexed and the hand turned to mid-position in the normal starting position assumed by an individual about to press a dumbbell to arm's length overhead.

To compare the effect on strength of changing the position of the subject from that in which he customarily exercised to one unfamiliar to him, the subject was tested in a position in which the strength of the elbow flexors could be measured, but one in which he did not exercise during the training period. In this test the subject:
lay supine on a plinth, feet braced against a footboard, knees extended, upper arm on the plinth, forearm and hand at an angle of 100 degrees measured from the position of the humerus, hand grasping the stirrup handle. The cable connecting the handle with the load cell was led over a wall pulley at an angle of 90 degrees to the subject's forearm. The subject then steadily contracted his elbow flexors as strongly as possible.

To determine the effect on strength of changing the method of testing to one which was not practiced during the training period, a modification of the Martin test was employed.

The subject lay supine on a plinth, feet braced against a foot-board, knees extended, upper arm on the plinth, forearm at an angle of 80 degrees as measured from the position of the humerus and the hand in line with the forearm. The subject grasped the stirrup handle, the end of which was hooked to a spring balance. The investigator held the handle of the balance in one hand and the body of the spring balance in the other. At the command, "ready," the subject maximally contracted the elbow flexors at a steady rate. Simultaneously, the operator pulled on the handle of the balance in the opposite horizontal direction. Tension was developed without jerking and was steadily increased until the resistance of the subject was overcome and the forearm pulled into extension. At this breaking point the command, "stop," was given and the maximum reading on the scale recorded.

The training program for the isotonic group consisted of progressive resistance exercises, with the resistance furnished by plate-loading dumbbells.

Each subject determined the weights with which he could perform a maximum of five elbow flexions (curls) and five arm elevations (presses). The exercises were performed in the standing position. Five such flexions or elevations constituted a set. The exercise period consisted of three sets of presses and three of curls, each set being followed by a 3-minute rest period. The length of these rest pauses was found to be

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46 Ibid., p. 30.
47 Ibid.
optimal by Clarke, Shay and Mathews . . . Loads were increased in accordance with the subject’s improved ability to move them. Exercises were practiced 3 days a week: Monday, Wednesday and Friday. Each Wednesday the girth of the flexed upper arm of each subject was measured and the strength of the flexors and arm elevators was tested by use of the strain gauge dynamometer. 

The training program for the isometric group was determined as follows:

Preliminary observation showed that subjects in the isotonic group required about 15 seconds to complete a single set of isotonic exercises and that they arbitrarily selected a weight equal to approximately two-thirds of the amount required to perform a single movement. On this basis a training program which consisted of the subject’s exerting and maintaining for 15 seconds an isometric strain equal to two-thirds of his maximum strength was established for the isometric group. The positions assumed for these exercises were identical to those assumed for the strain gauge tests. The subjects performed three isometric elbow flexions (curls), each separated by a 3-minute rest period. The effort was not perfectly isometric but nearly so, since, as a result of compression of the spring in the scale, a strain of 70 pounds against the scale produced a movement of less than \( \frac{1}{2} \) inch.

The subjects trained on Monday, Wednesday and Friday. They were tested on the strain gauge each Monday and during the three weekly training periods used two-thirds of the tension recorded. Tension was thus increased in accordance with increases in strength as a result of training. Neither the supine nor Martin type exercise was performed during the training period.

The Experimenters report the following results:

(1) In the elbow flexion exercises, the mean strength for the isotonic group significantly increased by 14.38 pounds in the exercised arm and 11.58 in the unpracticed contralateral arm. However in the isometric group there were no significant changes in strength in either the exercised arm or in the unpracticed contralateral limb.

\[48\] Ibid.

\[49\] Ibid., p. 31.
During the rest period there was a significant mean increase of 1.92 pounds in the strength of the unpracticed contralateral arm in the isotonic group, and no significant change in strength in the exercised arm was recorded.

In the isometric group the exercised arm showed nonsignificant losses after the rest period.

(2) In the arm elevator exercises, the subjects in the isotonic group showed a significant mean increase of 25.33 pounds in strength in the exercised arm and 24.54 pounds in the unpracticed contralateral arm. The isometric group showed a significant mean increase of 12.88 pounds in strength in the exercised arm and a nonsignificant mean increase of 7.92 pounds in the contralateral arm. At the end of the rest-period the mean strength of the isotonic group showed no significant change; however, the mean strength in the isometric group decreased significantly by 11.64 pounds in the exercised arm, but no significant change was noted in the unexercised arm.

(3) The changes in strength recorded during the unpracticed tests presented a very different picture. In the supine elbow flexion test subjects in the isotonic group showed a significant mean increase of 3.37 pounds in strength in the exercised arm and 2.83 pounds in the unpracticed contralateral arm. Subjects in the isometric group showed no significant increases. After the rest period, the isotonic group showed significant mean increases of 4.96 pounds in strength in the exercised arm and 4.19 pounds in the unpracticed contralateral arm. The isometric group showed no significant increases in strength in either the exercised or the contralateral arm.

(4) In the modified Martin test, in which the subjects resisted the pull of a spring scale against the partially flexed elbow, both groups showed significant mean increases in strength following exercise. In the isotonic group there was a mean increase of 5.00 pounds in the strength of the exercised arm and 2.83 pounds in the unpracticed contralateral limb. At the end of the rest period, neither the isotonic nor the isometric group showed significant changes in strength in the exercised arm, but the isotonic group showed a significant increase in the strength of the contralateral limb.

(5) Hypertrophy: As a result of the elbow flexion and arm elevation exercises, the mean hypertrophy of the exercised arm increased significantly in both groups. There was an increase of 1.22 cm in the girth of the fully flexed upper arm and an increase of 0.34 cm in the unpracticed contralateral arm. In the isometric group there was a mean increase of 0.59 cm in the girth of the exercised arm and a mean increase of 0.40 cm in the unpracticed contralateral arm. At the end of the rest
period there were significant changes in the girth measurements in the isotonic group. The girth of the exercised arm decreased a mean of 0.60 cm, whereas the girth of the unpracticed contralateral limb decreased a mean of only 0.15 cm. In the isometric group there were no significant changes in the girth of the exercised arm; however, the girth of the contralateral arm increased a mean of 0.18 cm, which was significant.

Healy Study. Alfred Healy's study was designed to compare the strength and the range of motion developed by isometric and isotonic programs for children afflicted with the spastic type of cerebral palsy.

He used five boys, who ranged in age from 8 to 16 years, as subjects in his study. Both the isometric and isotonic programs were administered to each subject—-one program to each leg. In both exercise programs, wall-type pulley weights were used, with the pulley rope attached to the ankle of the subject. The subject, seated on a table, exercised the most afflicted leg by extending it against the resistance offered by the pulley-weights.

DeLorme's "progressive resistance exercises" were used as the isotonic program. During each daily session each subject performed thirty executions as follows:

First set of 10 executions: Use $\frac{1}{2}$ of 10 E.M.
Second set of 10 executions: Use $\frac{3}{4}$ of 10 E.M.
Third set of 10 executions: Use 10 E.M.

A three-minute rest was allowed between one set and the next.

50 Ibid., pp. 31-32.

For the isometric program, the investigator determined the weight with which the subject could perform a maximum of one execution, carrying the lower leg to maximum extension. The isometric daily program consisted of one lift for which two-thirds of the one-execution maximum was used. This weight was carried from the starting position to maximum extension, held in this position for six seconds, and then returned to the starting position.

Both programs were administered to the five subjects three times a week for eight weeks. The one- and ten-execution maximums were redetermined after every sixth daily workout.

Tests to determine the strength of the extensor muscles of the lower leg and range-of-motion at the tibiofemoral joint were administered to all subjects at the beginning of the eight-week period, after every sixth daily workout, and at the conclusion of the eight-week period. A spring scale was the instrument used in the strength tests, and a goniometer was used for the range-of-motion measurements.

The patients in both the isometric and isotonic groups showed statistically significant increases in strength and range-of-motion over the program period of eight weeks. The differences between the gains for both strength and range-of-motion when the two methods are compared is not statistically significant.\textsuperscript{52}

The author offers the following criticisms of his study:

\textsuperscript{52}Ibid.
The factors that influence the physical performance of a handicapped child are difficult to control. Two factors that may have influenced the results of the present study are presented here.

The weight-training programs were applied to separate legs on the same individual. Therefore, the influencing factor of the dominant cerebral hemisphere might have resulted in superior results being obtained for the dominant leg. Since the physical-development curve of handicapped children is not one of a uniformly steady increase when they participate in an intensified-rehabilitation program, there is also the possibility that they had a predisposition to exhibit success in this particular experiment because they were in an accelerated developmental period.

The fact that the results of this study may not be attributed solely to the weight-training program does not negate its value. It remains for other investigators to determine what part of the total contribution is made by the numerous factors which influence the development of strength. If the involvement of a cerebral palsied spastic will permit him to participate in a weight-training program, the author is convinced that strength gains will be achieved by using either static-contractions or concentric-contractions.

Lorback Study. Lorback's study compared the effectiveness of short periods of static contraction to standard weight training procedures. His isometric training program consisted of a two-thirds of maximum static contraction held for six seconds once per training period.

Sixty male subjects were selected from a group of ninety-four students enrolled in weight lifting sections of the required physical

53 Ibid., pp. 394-95.

education program at the Pennsylvania State University. These students were divided into two equated groups of thirty subjects each on the basis of initial grip strength.

The muscle groups tested were those involved in right and left hand grip strength, neck flexion, right and left elbow flexion and extension, right and left knee flexion and extension. Grip strength was tested by use of hand dynamometers; knee extension by a back and leg dynamometer; neck flexion, elbow flexion and extension and knee flexion by use of a pulling assembly and a tensiometer. The girth of each subject's neck, right and left biceps, thighs and calves was measured. After the groups had been equated, one group was designated Group A, and the other Group B.

Group A trained with weights, repeating the contractions involved in each exercise ten times per training period. For the hand flexion exercise, Group A squeezed hand exercisers as hard as possible for ten repetitions. For neck flexion, repeated contractions were carried out against a weight attached to a harness which fitted over the head. For elbow flexion and extension, biceps curls were practiced with a barbell. For knee flexion and extension, deep knee bends were done with a barbell resting on the shoulders. Group A trained with resistance loads which required them to exert their full efforts to complete ten repetitions for each muscle group.

Group B trained using contractile pulls at two-thirds of their tested maximum strength for six seconds only, per muscle group, per training period. They used the same apparatus and procedures as
were used in testing. Each subject in both groups trained three times per week.

The experimental time period of twelve weeks included two weeks for preliminary testing and equating the two groups, eight weeks for training and one week each for intermediate and final testing. The intermediate test was administered at the end of the fourth week of the experiment to determine the amount of strength gained, if any, by each muscle group. When the results showed an increase in strength, the resistances for Group B were adjusted to two-thirds of the new maximum. At the end of the eighth week of training, all subjects were again tested and measured, using the same procedures as in the preliminary test. The results of all tests and measurements were recorded for each subject.

The data were analyzed to determine the amount of improvement each group made between the preliminary and final tests; and to compare the amount of improvement made by Group A to the amount of improvement made by Group B.

After analyzing his data, the investigator was able to report these findings:

1. Both groups gained significantly in muscle girth.

2. There was no significant difference between the two groups in girth of any of the muscle groups measured in the final test.

3. Both groups gained significantly in strength indicating that both training programs were effective for developing strength of the muscle groups involved.

4. The two methods of strength training were approximately equal in effectiveness with the exception of knee flexion.
Group B, utilizing the two-thirds maximum contraction method for six seconds per training period, gained a significantly greater amount of strength than did Group A in the muscle groups involved in knee flexion. The investigator did not place great importance on this finding as deep knee bends are not generally accepted as an adequate exercise for knee flexion, in that the raising and lowering of the weight is primarily a function of the extensor muscles.  

IV. SUMMARY

Sixteen studies were reviewed in this chapter investigating the effects of various methods of isometric and isotonic exercises. Nine of the studies reviewed were concerned only with isometric exercises. In these studies seven investigators concluded that significant increases in muscle strength may be obtained through the use of isometric exercises. One of these studies was concerned only with the maintenance of newly acquired strength. In this case it was found that isometric contractions are effective in maintaining a newly acquired strength level when exercised once every two weeks. In another study it was concluded that isometric contractions of the abdominal muscles are effective in reducing the waistline of college women.

Seven studies compared the effects of isometric exercises with isotonic exercises. Five of these investigators concluded that isometric and isotonic exercises were equally effective. Two investigators concluded that the results obtained through isotonic exercises were slightly superior to those obtained through isometric exercises.

55 Ibid., p. 64
CHAPTER III

DESCRIPTION OF PROCEDURE

I. INTRODUCTION

A two-factor experimental design was used in this study. The two factors investigated were method of exercise and frequency of exercise. The two methods of exercise studied were isometric and isotonic and were compared for their effectiveness when employed at frequencies of five, three, and two days per week. Six experimental groups consisting of fifteen subjects each were used. Three experimental groups used isometric exercises and three experimental groups used isotonic exercises. The six experimental groups were numbered as follows:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Isometric Method</th>
<th>Isotonic Method</th>
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<tbody>
<tr>
<td>5 days per week</td>
<td>Group I</td>
<td>Group II</td>
</tr>
<tr>
<td>3 days per week</td>
<td>Group III</td>
<td>Group IV</td>
</tr>
<tr>
<td>2 days per week</td>
<td>Group V</td>
<td>Group VI</td>
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</table>

Groups I and II followed an isometric and isotonic training schedule five days a week. Groups III and IV followed an isometric and isotonic schedule three days a week. Groups V and VI followed an isometric and isotonic schedule two days a week. The duration of all six training programs was six weeks.
II. SELECTION OF SUBJECTS

Subjects used in this experiment were ninety male students enrolled in the physical education activity program at Louisiana State University. The subjects were naive regarding exercise programs and experiments of this type. They ranged in age from seventeen to twenty-five years, with a mean age of eighteen.

The data for experimental group I were collected during the 1958 summer session. In addition to the isometric training program, the subjects participated in their regularly assigned golf or tennis class. The data for experimental group II were collected during the 1959 summer session. The subjects in this group were enrolled in weight lifting classes, formed as a part of the regular physical education activity program of the University. The training programs of experimental groups I and II were conducted five days a week, Monday through Friday.

The data for experimental groups III and V were collected during the second nine weeks of the first semester of the 1958-59 school year. In addition to the isometric training program, experimental group III participated in a badminton class meeting at ten o'clock on Monday, Wednesday, and Friday mornings. In addition to the isometric training program, experimental group V participated in a golf class meeting at two o'clock on Tuesday and Thursday afternoons.

Experimental groups IV and VI were composed of students enrolled in weight lifting classes scheduled during the first
semester of the 1959-60 school year. The subjects in experimental group IV were selected at random from six classes meeting at ten, eleven and two o'clock on Monday, Wednesday and Friday, and at nine, ten and eleven o'clock on Tuesday, Thursday and Saturday. The subjects in experimental group VI were enrolled in a weight lifting class meeting at two o'clock on Tuesday and Thursday afternoons.

The subjects in all six groups were volunteers and enrolled in the program after the nature of the experiment had been explained to them at an introductory meeting.

III. TESTING APPARATUS

A special testing device was constructed for this study to measure the combined extensor strength of the legs and back. This apparatus is described in detail in Appendix A. Pictures of this device and other equipment used in testing are shown in Figures I and II, also located in the Appendix.

As the present study was designed to compare the effectiveness of isotonic and isometric methods of exercise and since the testing apparatus was to be used for isometric training as well as testing, it was desirable to have a test that would duplicate an isotonic exercise as closely as possible. The completed apparatus measured essentially the same muscle groups as are used in the execution of "full squats" in heavy resistance exercises.

1"Full squats" consists of deep-knee bends with a plate-loaded barbell resting across the shoulders.
Another feature of the completed apparatus was that it allowed the position of the subject to be duplicated for each reading in a series of measurements that extended over weeks. The apparatus was adjustable to the height of the subject and to the width of his shoulders. This allowed the experimenter to reproduce the same position of the subject in each testing session.

The combined extensor strength of the subjects' leg and back muscles was registered on a pressure gauge located on the floor in front of the apparatus where both the subject and experimenter could observe its readings. The gauge was graduated in ten unit increments from zero to 1,000 and was manufactured to register one pound per square inch of cylinder cross sectional area. Since the exact poundage was not required as the unit of measurement in this study, the units registered on the gauge were the ones recorded and treated statistically.

Reliability of the apparatus was checked by correlating the best two out of three trials that the subjects obtained on the first day of testing. The coefficient of correlation was .92.

The apparatus consisted of a platform located on top of a hydraulic lifting mechanism. The platform and lifting mechanism were located inside a rectangular parallelepiped. Directly above the platform were two shoulder bars, adjustable to the varying shoulder widths of the subjects. The platform could be raised a maximum of seventeen inches by means of the lifting mechanism. This allowed the experimenter to adjust the height of the platform to the varying heights of the subjects.
IV. TESTING PROCEDURE

On the first day of the experiment each subject was instructed to stand upon the platform of the testing apparatus and assume a good standing posture. Each subject was instructed as to what constitutes a good, mechanically sound, standing posture and was given sufficient time to practice this position.

Once the subject had assumed a sound position he was instructed to maintain this position until his shoulders came into contact with the shoulder bars and then to "give" only at the knees until the desired degree of flexion at the knee was obtained. The experimenter then raised the platform until a standard 120° angle was obtained between the upper and lower legs of the subject. Carpenter found this angle to be most conducive to maximum leg lift.

The height that the platform was raised was measured with a standard yard stick. This height was determined for each subject and once determined it was standardized for the remainder of the experiment.

The subject was allowed to experiment with the spread of his feet during the first three practice sessions, and then after he had decided the spread that he desired to use, this position was recorded and duplicated at each session during the experiment.

\[^{2}\text{Alleen Carpenter, ''A Study of Angles in the Measurement of the Leg Lift,'' The Research Quarterly, 9:70-72, October, 1938.}\]
After each subject had assumed the correct testing position, as defined by proper segmental alignment of the back and hips, standard spread of the feet and 120° flexion at the knees, he was ready to be tested. The subject was at this time located between two immovable objects: (1) the shoulder bars and (2) the hydraulic mechanism. After compression of the sponge rubber shoulder pads, any muscular contraction was strictly isometric.

When the subject indicated that he was ready, he was instructed to make a maximum effort to straighten his legs, while keeping his hips and back in a locked position.

The intensity of the contractile effort was directed downward through the hydraulic mechanism and registered on the pressure gauge. The maximum reading on the gauge which the subject could hold momentarily was recorded. Quick spurts of energy resulting in spuriously high readings were not recorded. The subject held his maximum effort as long as he could, or up to six seconds. Some subjects had difficulty in holding his maximum effort for six seconds, with the pressure registered on the gauge gradually declining before the end of this time limit; however, in all cases at the end of six seconds, the contraction was still above sixty per cent of maximum. The six-second interval was timed by a standard metronome regulated for one tick per second.

A description of the equipment used in testing and the development of the testing procedure is given in Appendix B.

In order to equate the varying speed with which the subjects learned the techniques of testing on the apparatus, it was decided
to use the best score made by a subject during the first five training
days as his initial score. It was assumed that after five days' practice the subject would have learned the technique and a score
would be obtained representative of the individual's initial level
of strength. After the experiment was under way, the experimenter
found that this assumption was basically true and that most subjects
obtained a representative score during the first two or three days.

To be consistent with the above policy and to allow for random
fluctuations of scores, the best score made during the last five
training days was used as the final score. The difference between
the initial and final scores was used to determine the effects of the
six training programs.

V. ISOMETRIC TRAINING PROCEDURE

The isometric training program of the three isometric groups
consisted of one maximum static contraction, held for six seconds
on the testing apparatus. The isometric training procedure was the
same as the testing procedure previously described. In addition to
the isometric training program, the isometric groups participated in
their regular physical education activity classes.

The activities in which each group participated are indicated
below:

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group I</td>
<td>6</td>
<td>Tennis</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Golf</td>
</tr>
<tr>
<td>Experimental Group III</td>
<td>15</td>
<td>Badminton</td>
</tr>
<tr>
<td>Experimental Group V</td>
<td>15</td>
<td>Golf</td>
</tr>
</tbody>
</table>
In a previous investigation, a control group was used in conjunction with a different problem—to measure the training effects of uncontrolled daily activity and of participation in physical education activity classes upon isometric strength performance. In this study the control group participated in a tennis class. Tennis was selected as the activity to be tested because it is generally believed that tennis is the most vigorous of the activities participated in by the isometric groups. In this study thirteen subjects were tested for two days at the beginning of the experiment and then they participated in their regular activity classes for six weeks. At the end of the training period, they were again tested for two days. The same testing apparatus was used for these measurements as was used in the present experiment. The best score made during the two days of testing, both before and after the experiment, was the score used. The difference between the initial and final tests was used to determine the effects of the training program.

The difference between the initial and final scores of this group was -45 units. Within the limits of this study, it was concluded that participation in tennis activity classes does not stimulate significant improvement in isometric strength performance.

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4 Ibid., pp. 42-43.
5 Ibid., p. 46.
6 Ibid., p. 50.
VI. ISOTONIC TRAINING PROCEDURE

The experimental exercise selected for the three experimental groups using isotonic exercises was "full squats." This exercise consists of full-knee bends with a plate-loaded barbell resting across the shoulders. This exercise was selected because it employs approximately the same muscle groups used by the isometric groups and the muscle groups employed on the testing apparatus.

The three isotonic groups were enrolled in regular weight lifting classes offered at Louisiana State University. In addition to the experimental exercise, the programs of these groups consisted of five other exercises: bench presses, two arm curls, bent-over rows, leg lifts on stall bars and sit ups. These additional exercises were selected because they exercised different muscle groups than those used in the "full squats" and those tested on the testing apparatus.

The training schedule used in the isotonic program was the one suggested by Capen. Capen states that of the four programs of weight training that he studied, those that utilized the heaviest weights that would permit a maximum number of five executions were superior to the other programs in his study.

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8Ibid., p. 141.
The following procedure as described by Capen for his study was the one used in the present experiment:

5 E.M. \(^9\) \( \times 3 \). The subject selected the heaviest weight with which he could perform a maximum number of five executions. The subject would then perform three sets with this selected weight, performing as many executions as possible in the second and third bouts. When a sufficient gain in strength allowed five executions to be accomplished during each of the three sets, a new 5 E.M. was determined. A three-minute rest period was taken between sets.\(^10\)

In addition to the weight training exercises, the isotonic groups performed the same isometric exercises as did the isometric groups. The subjects in the isotonic groups were tested at each training session on the testing apparatus. This tended to equate the isometric and isotonic groups in the amount of practice that each group received on the testing apparatus. Therefore, it may be inferred that any practice effect resulting from repeated trials on the testing apparatus was equally distributed in the experimental groups exercising at the same frequency per week.

**VII. COLLECTION OF DATA**

At the beginning of the experiment, each subject was provided with a score sheet on which he recorded his name, age, and number of the experimental group to which he had been assigned. Also recorded on this sheet was a description of the subject's

\(^9\) The terminology, five execution maximum or 5 E.M., means the heaviest weight that can be used successfully performing an exercise a maximum number of five times.

exercise position—spread of the feet and elevation of the platform.

The data were collected in the form of the maximum strength scores that each subject achieved on the testing apparatus.

The scores obtained by the six experimental groups were recorded at each training session. The best score obtained during the first five testing sessions was used as the score most representative of the initial strength of the subjects. The best score obtained during the last five days of the experiment was used as the final strength score.
CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

I. INTRODUCTION

The effects of two methods of exercise, three frequencies of exercise and the interaction between these two variables in the improvement of muscle strength performance was investigated in this study. In order to investigate the relationships and interrelationships between these two variables, a two-factor experimental design was selected.

The data collected in this experiment were in the form of initial and final strength scores and are shown in Tables IV through X, located in Appendix C. The improvement scores, which were obtained by subtracting the initial score from the final score of each subject, are also shown in these tables.

II. RELATIONSHIP OF INITIAL PERFORMANCE TO IMPROVEMENT IN STRENGTH

A coefficient of correlation was computed between the initial strength scores of the subjects and their criterion (improvement) scores to determine the relationship between these two distributions. The coefficient obtained was .02. This indicates that in the present study the initial strength scores of the subjects did not measure the potentiality of the individual to profit from the six training programs.
III. ESTABLISHING THE SIGNIFICANCE OF THE MEAN IMPROVEMENT SCORES

The mean improvement scores obtained by the six experimental groups are shown in Table I. The significance of these mean improvement scores was determined by computing an $F$-test between the initial and final strength scores of experimental group VI, which performed isotonic exercises two days a week. The $F$-ratio obtained in this analysis was 4.79, which was significant at the 1 per cent point. As the mean improvement score of experimental group VI was less than that of any other group, and since the degrees of freedom were the same for all groups, it may be inferred that the mean improvement scores of all groups were significant at the 1 per cent point.

TABLE I
MEAN IMPROVEMENT SCORES OF SIX GROUPS OF COLLEGE MEN EMPLOYING DIFFERENT EXERCISE PROGRAMS

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Isometric</th>
<th>Isotonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 days</td>
<td>147.33</td>
<td>143.33</td>
</tr>
<tr>
<td>3 days</td>
<td>127.33</td>
<td>130.00</td>
</tr>
<tr>
<td>2 days</td>
<td>100.67</td>
<td>80.67</td>
</tr>
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</table>
IV. ESTABLISHING THE SIGNIFICANCE OF THE DIFFERENCE IN MEAN IMPROVEMENT SCORES

As shown in Table I, the six experimental groups showed marked differences in the amount of strength acquired through the six training programs. In order to determine the significance of the differences in the mean improvement scores of the six groups, a simple analysis of variance was computed. The results of this analysis are summarized in the lower half of Table II. As shown in this table, the F-ratio for the mean square between groups was 4.69, which was significant at the 1 per cent point. This indicates that two or more of the experimental groups, as represented by their mean improvement scores, differed significantly in the amount of strength that they acquired.

TABLE II

ANALYSIS OF VARIANCE OF IMPROVEMENT SCORES OF SIX GROUPS OF COLLEGE MEN EMPLOYING DIFFERENT EXERCISE PROGRAMS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
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<tr>
<td>Method of exercise</td>
<td>11.38</td>
<td>1</td>
<td>11.38</td>
<td>.531</td>
</tr>
<tr>
<td>Frequency of exercise</td>
<td>471.22</td>
<td>2</td>
<td>235.61</td>
<td>11.000</td>
</tr>
<tr>
<td>Interaction</td>
<td>20.18</td>
<td>2</td>
<td>10.09</td>
<td>.471</td>
</tr>
<tr>
<td>Between groups</td>
<td>502.78</td>
<td>5</td>
<td>100.57</td>
<td>4.69</td>
</tr>
<tr>
<td>Within groups</td>
<td>1799.05</td>
<td>84</td>
<td>21.42</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2301.83</td>
<td>89</td>
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</table>
V. FURTHER ANALYSIS OF VARIANCE OF IMPROVEMENT SCORES

In order to determine the source of variation between the six groups, a two-part analysis of variance as described by Edwards\(^1\) was used. The between groups sum of squares in this design may be analyzed into three components—two main effects and an interaction effect. The two main effects in this experiment were method of exercise and frequency of exercise. The interaction effect was the various interactions of the main effects. The results of this analysis are summarized in the upper half of Table II.

The Interaction Effect of Method of Exercise and Frequency of Exercise. As shown in Table II, the F-ratio for the interaction mean square was 0.471. To have been statistically significant at the 5 per cent point, the F-ratio would have had to equal or exceed 3.11. Therefore, it may be stated that the variation between the six experimental groups was not the result of an interaction effect.

The Effects of Isometric and Isotonic Methods of Exercise. As shown in Table II, the F-ratio for the method of exercise mean square was 0.531. To have been statistically significant at the 5 per cent point, the F-ratio would have had to equal or exceed 3.96. As this F was not significant, it may be stated that there is no significant difference in the effectiveness of isometric and isotonic exercises.

The Effects of Exercises Performed at Different Frequencies Per Week. As shown in Table II, the F-ratio for the frequency of exercise mean square was 11.00. This F-ratio was statistically significant at the 1 per cent point, indicating that the main factor contributing to the variability between groups was the frequency of exercise variable.

In order to determine the source of the variation between groups resulting from the frequency of exercise variable and to determine the effectiveness of exercises performed at frequencies of five days a week, three days a week, and two days a week an F-test was used.

An F-test was computed for the difference in the mean gains of the groups exercising five days a week and three days a week, five days a week and two days a week, and three days a week and two days a week. The F's obtained in this analysis are shown in Table III.

The Effects of Exercises Performed Five Days a Week and Three Days a Week. As shown in Table III, the F-ratio for the difference in the mean gains of the experimental group exercising five days a week and the experimental group exercising three days a week was 2.42. This F-ratio was not statistically significant. In order for this F to have been significant at the 5 per cent point, it would have had to equal or exceed 4.02. Therefore, it may be stated that there is no significant difference in the amount of strength acquired through exercises performed five days a week and the amount of strength acquired through exercises performed three days a week.
The Effects of Exercises Performed Five Days a Week and Two Days a Week. As shown in Table III, the $F$-ratio for the difference in the mean gains of the experimental group exercising five days a week and the experimental group exercising two days a week was 20.49. This $F$-ratio was significant at the 1 per cent point. It may be stated, therefore, that the amount of strength acquired through exercises performed five days a week is significantly greater than the amount of strength acquired through exercises performed two days a week.

TABLE III
THE DIFFERENCES IN MEAN IMPROVEMENT SCORES OF COLLEGE MEN EXERCISING AT FREQUENCIES OF FIVE, THREE, AND TWO DAYS A WEEK

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Difference</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 days--3 days*</td>
<td>16.66</td>
<td>2.42</td>
</tr>
<tr>
<td>5 days--2 days</td>
<td>55.66</td>
<td>20.49**</td>
</tr>
<tr>
<td>3 days--2 days</td>
<td>38.00</td>
<td>9.00**</td>
</tr>
</tbody>
</table>

*This row compares the strength gains achieved through exercises performed at frequencies of five days a week and three days a week.

**These $F$'s are significant at the 1 per cent point.
The Effects of Exercises Performed Three Days a Week and Two Days a Week. As shown in Table III, the F-ratio for the difference in the mean gains of the experimental group exercising three days a week and the experimental group exercising two days a week was 9.00. This F-ratio was statistically significant at the 1 per cent point. It may be stated, therefore, that the amount of strength acquired through exercises performed three days a week is significantly greater than the amount of strength acquired through exercises performed two days a week.
CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

The purpose of this study was to compare the effectiveness of isometric and isotonic methods of exercise, when performed at frequencies of five, three, and two days per week, in the improvement of muscle strength performance.

Six experimental groups consisting of fifteen subjects each were used in this study. Three experimental groups used isometric exercises and three experimental groups used isotonic exercises at frequencies of five, three, and two days per week.

Ninety male students enrolled in physical education activity classes at Louisiana State University were used as subjects.

The isometric training program of the three isometric groups consisted of one maximum static contraction, held for six seconds on the testing apparatus. In addition to the isometric training program, the isometric groups participated in their regular physical education activity classes.

The experimental exercise selected for the three isotonic groups was full-knee bends with a plate-loaded barbell resting across the shoulders. A resistance was selected for this exercise that would permit a maximum of five executions. Three sets of exercise bouts were used, with a three-minute rest period between sets. In addition to the weight training exercises, the isotonic
groups performed the same isometric exercises as did the isometric groups. The subjects were tested for maximum strength at each training session.

The difference between the initial and final strength tests was used to determine the effects of the six training programs.

II. CONCLUSIONS

Within the limitations of this study, the following findings are reported:

1. Significant improvements in muscle strength performance may be achieved through the use of isometric methods of exercise.

2. The addition of isotonic exercises to a "one maximum isometric contraction" exercise program does not significantly affect the amount of strength improvement obtained through the use of isometric exercises alone.

3. There is no significant difference in the amount of strength acquired through exercises performed five days a week and the amount of strength acquired through exercises performed three days a week.

4. The amount of strength acquired through exercises performed five days a week and three days a week is significantly greater than the amount of strength acquired through exercises performed two days a week.
III. SUGGESTIONS FOR FURTHER STUDY

In light of the findings in this experiment, the following recommendations are made for future study:

1. Consideration should be given to the differentiation of the effects of physiological development and motor learning in the observed improvements of muscle strength performances. In the present study, it was not possible to differentiate these two effects.

2. The effects of isometric and isotonic exercises when performed for a much longer period of time than in the present study should be determined; i.e., up to one year.
SELECTED BIBLIOGRAPHY


APPENDIX
APPENDIX A

DESCRIPTION OF TESTING APPARATUS

The testing apparatus used in this study was designed by this writer, with the help of Mr. Nathaniel R. Terry, instructor in the mechanical engineering machine shop at Louisiana State University. Pictures of this device are shown in Figures I and II.

The apparatus consisted of a rectangular frame, platform, and hydraulic mechanism with a pressure gauge attached.

The supporting framework of the apparatus was constructed of one and one-half inch steel pipes welded together to form a rectangular parallelepiped, eight feet tall, three feet wide and two and one-half feet deep. Two adjustable shoulder bars were constructed of two-inch steel pipes, twenty-six inches in length, connected at each end to a two-inch "T" joint. The joints were fitted over the front and rear supports of the frame and were free to slide in and out. This freedom of movement permitted the adjustment of the shoulder bars to the varying shoulder widths of the subjects. The shoulder bars were padded with sponge rubber to protect the shoulders of the testees.

The hydraulic mechanism consisted of the lifting mechanism from an old discarded dentist's chair, including the foot pedal and release valve. A wooden platform one and one-half feet long
and three feet wide, on which the subjects could stand, was constructed across the top of this mechanism. The platform could be raised by the use of a footpedal located at the side of the mechanism and could be lowered by the use of a release valve.

A standard yardstick was taped to the left front support of the rectangular frame and a pointer was extended from the platform to the yardstick. At the lowest position of the platform the pointer indicated the zero inch mark on the yardstick. The platform could be raised to a maximum height of seventeen inches.

A Star-Supersteel pressure gauge was attached to the hydraulic cylinder of the lifting mechanism. The gauge was extended out from the testing apparatus by three feet of copper tubing. It was located on the floor in front of the apparatus.

The gauge was graduated in ten unit increments from zero to 1,000 and was manufactured to register one pound per square inch of cross sectional area.
This picture shows a front view of the testing apparatus. The subject shown on the apparatus is Robert McDonald, a member of the L.S.U. football team. This writer is shown in the process of raising the platform by means of a foot-pedal located at the side of the apparatus and of adjusting the segmental alignment of the subject.

The platform, in normal operation, was level. As shown here, however, one end is lower than the other due to loose connections. This condition did not exist during the course of the experiment. Features of the apparatus and equipment shown on the subject are described in the text.
APPENDIX B

DEVELOPMENT OF TESTING PROCEDURE

In the development of the testing procedure used in this study, several problems were encountered.

In preliminary trials it was found that the shoulders of most subjects were not tough or strong enough to bear the pressure developed against them by the opposing forces of the stationary shoulder bars and the contracting muscles of the legs. In order to alleviate this condition, one inch of sponge rubber was taped to each shoulder bar, and a pair of standard football shoulder pads were placed on the shoulders of the subjects to spread the pressure over a broader area. Standard bath towels as issued to each physical education activity student were placed on each shoulder under the shoulder pads for additional pressure absorption. When the shoulders of the subject were brought into contact with the shoulder bars, there was one inch of sponge rubber, a pair of football shoulder pads, and a bath towel between each shoulder and the cross bars. Because of this combination of absorbents, the subject received a minimum of pain or discomfort from the pressure on his shoulders.

Some subjects found it difficult to learn the correct position on this apparatus and were disturbed by sore backs resulting from too forceful an effort in a mechanically incorrect position, therefore as a teaching aid, a one by six wooden plank was placed against the
back parallel to the spinal column and was held in position by a wide leather belt. Most subjects felt that the plank and belt helped them—the belt tended to relieve the pressure on the lower back and the board helped to stabilize the position of the back and prevent it from bowing under pressure. The chief value of this plank and belt combination to the experimenter was that he could use the vertical position of the plank to instruct the subjects as to the correctness of their back and hip alignment.

Two belts, two planks, and an ample supply of towels were available and enabled one subject to be getting ready while another was being tested. The time required to test one subject was determined by the time it took the subject to put on the shoulder pads, step up on the apparatus, be raised to the standard elevation, execute the six-second effort, be lowered again, and then dismount from the apparatus. This procedure required a maximum of sixty seconds for the slower subjects and ranged all the way down to approximately twenty seconds.
FIGURE 2

ILLUSTRATION OF CORRECT TESTING POSITION ON TESTING APPARATUS

USED IN THE MEASUREMENT OF STRENGTH OF COLLEGE MEN

This picture shows a side view of the testing apparatus, and the position of the subject when ready to be tested. The pressure produced by the subject's efforts to extend his legs was registered on the pressure gauge located on the floor in front of the apparatus.

A detailed description of the testing position and the development of the testing procedure is given in the text.
### APPENDIX C

**ORIGINAL DATA**

**TABLE IV**

**IMPROVEMENT SCORES OF SIX GROUPS OF COLLEGE MEN EMPLOYING ISOMETRIC AND ISOTONIC EXERCISES AT DIFFERENT FREQUENCIES PER WEEK**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Subject</th>
<th>Method</th>
<th>Sum and Mean for Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 days per week:</td>
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<td>Isometric</td>
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<td>170</td>
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<td>2</td>
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### TABLE IV (continued)

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TABLE V
THE INITIAL, FINAL AND IMPROVEMENT SCORES OF COLLEGE MEN
PARTICIPATING IN ISOMETRIC EXERCISES FIVE DAYS A WEEK

<table>
<thead>
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<tr>
<td>15</td>
<td>450</td>
<td>590</td>
<td>140</td>
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</tbody>
</table>

| Sum     | 7370          | 9580        | 2210        |
| Mean    | 491.33        | 638.67      | 147.33      |
**TABLE VI**

THE INITIAL, FINAL AND IMPROVEMENT SCORES OF COLLEGE MEN PARTICIPATING IN ISOTONIC EXERCISES FIVE DAYS A WEEK

<table>
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<td>670</td>
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</tr>
<tr>
<td>15</td>
<td>540</td>
<td>680</td>
<td>140</td>
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<p>| Sum     | 8580          | 10730       | 2150        |
| Mean    | 572.00        | 715.33      | 143.33      |</p>
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**Sum**

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**Mean**

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### TABLE VIII

The initial, final and improvement scores of college men participating in isotonic exercises three days a week

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<tr>
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<td>720</td>
<td>120</td>
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| Sum     | 8370          | 10320       | 1950        |
| Mean    | 558.00        | 688.00      | 130.00      |
TABLE IX

THE INITIAL, FINAL AND IMPROVEMENT SCORES OF COLLEGE MEN PARTICIPATING IN ISOMETRIC EXERCISES TWO DAYS A WEEK

<table>
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<th>Improvement</th>
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Sum       | 7800          | 9310        | 1510        |
Mean      | 520.00        | 620.67      | 100.67      |
TABLE X

THE INITIAL, FINAL AND IMPROVEMENT SCORES OF COLLEGE MEN

PARTICIPATING IN ISOTONIC EXERCISES TWO DAYS A WEEK

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Sum

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Mean

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The author was born July 21, 1932 in Hamburg, Arkansas. He received his elementary and secondary education in the Hamburg schools and graduated from Hamburg High School in 1950.

In September 1950, he enrolled at Arkansas A. & M. College, Monticello, Arkansas and received his B.S. degree in June 1953 with a major in physical education and a minor in the social sciences.

In July 1953, he entered the Officer Candidate Course of the United States Marine Corps and received his commission as a Second Lieutenant in October 1953. After six months of infantry training in the Basic School at Quantico, Virginia, he served for 1 1/2 years as a platoon leader and then as executive officer in a light anti-aircraft artillery battery.

He was released from active duty with the Marine Corps in August 1955. Following his release, he taught and coached for two years at El Dorado Springs High School in El Dorado Springs, Missouri. At El Dorado Springs, he was director of Physical Education for Men, head coach in football and track, and assistant coach in basketball and baseball.

In June 1957, he enrolled at Louisiana State University, Baton Rouge, Louisiana and began advanced work in Health and Physical Education, and Education. During the academic years of 1957-58, 1958-59, and 1959-60, he served as a Graduate Teaching Assistant in the Department of Health and Physical Education.
In August 1958, he received his Master of Science degree with a major in Physical Education. In September 1958, he began work on his Doctor of Education degree, majoring in Physical Education and minoring in Education.
EXAMINATION AND THESIS REPORT

Candidate: Jerry N. Barham

Major Field: Physical Education

Title of Thesis: A Comparison of the Effectiveness of Isometric and Isotonic Exercises When Performed at Different Frequencies Per Week

Approved:

[Signatures]

Major Professor and Chairman

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

July 22, 1960