A Comparison of the Effects of an Isometric Program, a Weight Training Program and an Isometric-weight Training Program on Strength Development

Michael D. Plinske

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A COMPARISON OF THE EFFECTS OF AN ISOMETRIC PROGRAM, A WEIGHT TRAINING PROGRAM AND AN ISOMETRIC-WEIGHT TRAINING PROGRAM ON STRENGTH DEVELOPMENT

BY

MICHAEL D. PLINSKE

A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Department of Physical Education, South Dakota State College of Agriculture and Mechanic Arts

August, 1963
A COMPARISON OF THE EFFECTS OF AN ISOMETRIC PROGRAM, A WEIGHT TRAINING PROGRAM AND AN ISOMETRIC-WEIGHT TRAINING PROGRAM ON STRENGTH DEVELOPMENT

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

A. C. Berndgaard
Thesis Adviser

A. C. Berndgaard
Head of the Major Department
ACKNOWLEDGMENTS

The author wishes to express his appreciation to Professor Glenn E. Robinson and Dr. A. C. Bundgaard, thesis advisers, for their guidance and suggestions throughout this study.

Appreciation is also extended to Dr. M. Thomas Woodall and other staff members for their help.

The author wishes to express his gratitude to those students who participated in the study.

MDP
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CHAPTER I

INTRODUCTION

Many different methods of increasing strength have been tried and developed through the years, and there are many and varied reasons to account for this search for increased strength. An individual may wish to gain strength so as to help in the completion of his daily tasks without fatigue; he may wish to strengthen muscles which might give him better appearance and posture; or he may wish to develop strength to be used in some sport or recreational activity. One of these reasons, or any one of a number of reasons, has prompted the urge and desire in man to develop the best method of strength development.

Isometric contractions have recently taken the spotlight in this search. With just a few minutes of time each day devoted to simple isometric exercises, research has indicated an individual can develop strength as quickly as with other methods of training. This is very difficult for some people to understand, but there are many studies which have been completed showing such effects. The one method of training that is usually compared to isometric contractions is weight training, or isotonic contractions. In this study the author used these terms synonymously. Using resistance, or weights, to increase the work load has proven to be a very effective method of developing strength. Many individuals with the same reasons and purposes for developing strength have used this method of resistance.
exercises.

Because of the importance strength plays in our lives, and because it is important to find the best method, both isometric contractions and isotonic contractions have been compared, reviewed, and tested against each other as effective methods. Which method seems to be the best is as yet undetermined, although many put complete faith in one program or the other. Research has indicated that one method of training will be significantly better in some areas of strength development, and the reverse will be true about other phases. It was the author's opinion that if both methods proved beneficial and increased strength so significantly, then a combination of the two methods might prove even more significant. Because of the importance of finding the best possible method of developing strength, knowledge, and information concerning a program of increasing strength, the author felt this study would be important.

**Need for the Study**

Research has shown that strength development is one of the most important factors of success in athletics and in everyday living. Studies concerned with isometric contractions and isotonic contractions have shown that both programs will increase strength significantly. Because isometric exercises increase strength as well as do isotonic exercises, it would seem that an isometric program would be better, or be more favorable, because of the small amount of time needed to do the exercises.
The author hoped to show that a combination of isometric and isotonic exercises would increase strength more significantly than either program carried out separately. The results of this study could prove helpful to coaches and physical educators as they select and set up programs of training, both for the athlete and the physical education student.

**Statement of the Problem**

The purpose of this study was to determine and compare the effects of an isometric program, an isotonic (weight-training) program, and an isometric-isotonic combination program on strength development of male students at South Dakota State College. Three classes in the required program of Physical Education were used as experimental groups, and each class was given a specific program to follow.

It was the author's hypothesis that the isometric-isotonic combination program of training would increase strength more significantly than either of the other programs. The author also felt that the isometric program, as well as the isotonic program, would increase strength, but neither would be more significant than the other.

**Delimitations**

1. This study was limited to freshman male students who had enrolled in weight-training classes at the beginning of the winter quarter.

2. The subjects were urged not to participate in other activities which might increase strength.

3. Students who were out for a sport at the time were excluded from the study.
4. The training period consisted of a six-weeks program with two meetings per week.

5. The specific exercise program for each group was determined by the author.

6. Failure to attend class regularly eliminated subjects from the study.

Definition of Terms

1. Isometric contraction—a method of exercise without movement; a method of developing functional strength through static contraction of the muscles in the position in which the muscle is to be used (1).

2. Isotonic contraction—a contraction in which a muscle shortens against a load, resulting in movement and the performance of work (2).

3. Weight training—the use of weights to increase resistance to the muscle as it moves through a range of motion.

4. Strength—is the capacity of the whole body or of any of its parts to exert force (3).

5. Physical fitness—a person's capacity to perform and endure many activities. Person possesses a sound body with essential features of strength, endurance, flexibility, neuromuscular control, and relaxation (4).
CHAPTER II

REVIEW OF LITERATURE

There have been numerous methods of training developed and tried through the years, and many have been successful in achieving the desired results. The problem which has arisen concerns the method that could be considered the best in achieving desired training results. Research has been completed concerning isometric exercises and progressive resistance exercises or weight training to show which method might be considered better. These studies have shown conflicting results, and the majority of the research showed no significant difference between the two methods.

Salter made this statement about improving strength:

There is some controversy concerning the most efficient method of producing a rapid improvement in muscle strength (Delorme, 1945; Amussen, 1949; Ionesco, 1949; MacJusen, 1954; McMorris and Elkins, 1954), many clinical exercise routines having an empirical rather than an experimental basis. Since there is no generally accepted routine, it might be assumed that the optimum method is still to be formulated. In outlining an exercise schedule, the following variables have to be considered: whether the contractions should be isometric or isotonic; whether they should be maximal or submaximal; the duration of each contraction; the repetition rate and the total number of contractions per session, and the total number and spacing of sessions (5).

Karpovich had this to say about muscle training:

Even though muscle training has been practiced since times immemorial, and obviously with remarkable success, one may be surprised to discover that even now there is no complete agreement as to the best method for muscle training. The usually accepted idea has been that one has to give all he has in order to get more. This chapter indicates that such a philosophy is not necessarily true. It seems possible to
get maximum gains without investing maximum effort. The effects of muscle training are: changes in structure, in strength, and in endurance (6).

Lorback performed experiments whereby he compared short periods of static contraction to standard weight training procedures in development of strength. This study showed that both groups gained strength, but the group using static contractions showed a significant improvement in strength of knee flexion. However, Lorback also concluded that an isometric program for developing strength was not more significant over a program of weight training (7).

Along this same line, however, Joslin found that a program of isometric exercises did increase strength significantly over a program of isotonic or resistance type exercises where the muscle is just able to overcome the resistance and shorten. It was also shown that the control group, which had participated in a basketball unit, did not differ from the resistance group. It was mentioned that the resistance exercises used in the study were of no value. This was probably caused by the lack of initiative in the partner-type procedure used to produce the resistance (8).

In an experiment comparing static and concentric muscle contractions, Rodgers found that both methods would increase strength, but there was no significant difference between the two methods. Four tests were administered to the groups: sit-ups, push-ups, pull-overs, and curls (9).

Rasch made this statement in the Journal of Applied Physical and Mental Rehabilitation:
Strength may be increased by the use of either isotonic or isometric exercise. The cause of the development of increases in strength is in dispute, but appear to be greater when tension is developed frequently during the source of the training period (10).

Morehouse and Rasch had this to say about the development of strength:

Muscles grow larger and stronger only when required to perform tasks that place loads on them which are over and above previous requirements. This is the "overload principle," which is the rationale for all progressive resistance exercise systems. Exercises in which muscles are made to contract slowly with maximal intensity, and in which the contraction is held for a few seconds yield the greatest results (11).

Hoffman, Broussard, Roy, and Drury reported that "a muscle must be over-loaded to cause it to increase in strength and size, and the 'Overload Factor' is achieved to a greater degree in Functional Isometric Contraction than in any other way" (12).

Lyne conducted a study using static contractions. The subjects performed the exercises with maximum effort for a duration of six seconds. Training once weekly with these static exercises significantly increased a newly acquired level achieved through eight weeks of weight training (13).

Salter used four different isometric and isotonic groups in a study comparing different rates of repetition for the exercises. It was found that all of the groups increased strength, but the groups did not differ significantly. The groups performing more repetitions did not increase more significantly than the groups with fewer repetitions. This was found to be true in both the isometric and isotonic groups (14).
Karpovich made this statement about developing strength:

The only way to develop strength of muscles is to exercise them against gradually increasing resistance. For this purpose, one can use springs, weights, or the weight of the body itself. Even though the same method of training is used, the rapidity and the ultimate degree of development in different persons will be different (15).

Murray and Karpovich had this to say about strength development:

One may meet many people who, while desiring to develop strong muscles, reject the idea of using weight. Instead of lifting dumbbells or barbells they use push-ups, sit-ups, chin-ups, etc., or use a set of springs, metal or rubber. Occasionally pulley weights are used because somehow they are different from other weights; but whether it is a barbell, or the weight of your own body or a spring, the physiological effect is the same (16).

Muller conducted a study using single daily isometric contractions continued for six seconds and utilizing only two-thirds of maximum strength. The study showed that this form of exercise will produce the best results in gaining muscular strength (17).

Nettinger has said that the maximum increase in muscle strength is obtained with one training per day. Increasing this stimulus even up to seven times a day would not increase strength more rapidly (18).

Hoffman stated that "to obtain best results, it is best to subject the muscle to a maximum contraction for from 9-12 seconds, and all around strength will be quickly attained" (19).

Muller stated in regard to measuring muscular strength that "the maximal strength possible in a certain position during a movement is much lower than the strength in the same position reached with a static contraction" (20).
Councilman has mentioned that

A carefully planned program of resistance exercises, which (1) includes the use of barbells and dumbbells, (2) considers the strength and condition of the person at the time, and (3) allows for proper progression according to his increase in strength, can do more to develop strength and power than any training method yet devised (21).

Liberson and Asa concluded from their study that brief isometric exercise produced a more rapid increase in strength than the method of progressive resistant exercises with weights, as advocated by DeLorme (22).

Liberson and Asa also stated that

Isotonic and isometric training programs have been compared in the development of strength, with conflicting results. However, the majority of the studies indicate there's no significant difference between the two methods in total strength development (23).
CHAPTER III

PROCEDURES

Source of Data

The purpose of this research was to compare the effects of three different training programs on strength development. Three physical education classes composed of freshmen students at South Dakota State College were used as experimental groups. The author set up and conducted the training program for each of the classes.

The class using only isometric contractions consisted of 19 subjects. The class using a combination of isometric contractions and weight training consisted of 18 subjects. The third class used only weight training exercises and consisted of 18 subjects.

The author refers to the three experimental groups in the following pages as: isometric group--Group A; isometric weight training combination group--Group B; weight training group--Group C.

The length of the training program was six weeks. Classes met 2 times per week.

Testing Procedure

To obtain data for this experiment, an initial and final strength test was administered to the subjects. Three class periods before the beginning of the training program were devoted to administering different strength tests. Three periods after the conclusion of the training programs were used to administer the final tests.
Hettinger said:

To determine maximum strength, it is necessary to measure in isometric contractions only. Muscle tension must be maintained, without movement. It is not feasible to measure muscle strength in isotonic contractions, which means movement of the muscle because movement changes the length of the muscle, and strength changes with the increase or decrease in length (24).

The following tests were used to measure strength development:

1. McCloy's Strength Index Revision
   a. Hand manuometer—measure grip strength
   b. Leg dynamometer—measure leg strength
   c. Back dynamometer—measure back strength
   d. Full-ups—measure arm and shoulder strength
   e. Dips—measure arm and shoulder strength

2. Sit-ups (2 minutes)—measure abdominal strength
3. Sargent jump—measure explosive power (25)

Descriptions of these tests are found in Appendix A.

Testing Period

The tests were administered in the same order for both initial and final results. The author arranged the tests in such a manner that the same muscle groups were not involved during two successive tests. The author and his assistants were trained in the testing procedures for the tests. Pretests were given to other subjects to establish reliability of testors. Results of the initial and final strength tests were recorded on individual record sheets.

Training Program

Each training program was set up so that only a limited amount of time was allowed for doing the exercises. The author conducted
exercises in all of the experimental classes, and it was possible to make certain the subjects were warmed up properly and ready to perform. The calisthenic exercises were not used to develop strength but if these exercises did develop strength, all experimental groups had the same opportunity. A list of the calisthenics used is found in Appendix D.

The following exercises were used in the isometric contraction program:

1. Press lock-out
2. Press start
3. Rise on toes
4. Pull
5. Parallel squat
6. Curl
7. Dead lift
8. Quarter squat

See Appendix B for a full description of exercises.

This order of performance was always followed for the same duration of time in each training period.

The experimental group C using the weight training program was also conducted in such a manner that all of the exercises had to be completed in a limited amount of time. Each subject was given a data sheet with recorded exercises and the starting weight to be used. This starting weight was determined, before the training program began, by having the subjects perform an exercise using maximum weight so that only one repetition could be performed. After the maximum weight was found, the author multiplied this weight times 40 per cent to determine the starting weight. The subjects were to do eight repetitions or the amount of weight was decreased. If the exercise could
be performed so that the number of repetitions reached 10-12, the
subject were instructed to increase the amount of weight (26).

The following exercises were used in the weight training pro-
gram:

1. Bench press
2. Squats (quarter)
3. Rise on toes
4. Curl
5. Up-right row
6. Bent-row

A description of each of these exercises is found in Appendix C.

The following time schedule was set up for each program so that
only a certain amount of time was allotted to perform the training
program.

1. Experimental group A using Isometric Contraction only.
   (Description of class procedure can be found in Appendix D)
   a. Beginning of class period--5 minutes of calisthenics.
   b. 10-12 minutes for isometric contractions.
      In this amount of time, all of the subjects were able
to complete 8 exercises.
   c. 20 minutes of passive activity where the students par-
ticipated in ping pong and shuffleboard.

2. Isometric contractions and weight training combined--
group B. (Description of class procedure can be found in
Appendix E)
   a. Beginning of class period--5 minutes of calisthenics.
   b. 10-12 minutes for isometric contractions.
   c. 20 minutes for weight training only.

3. Experimental group C using weight training only. (Descrip-
tion of class procedure can be found in Appendix F)
   a. Beginning of class period--5 minutes of calisthenics.
   b. 30 minutes of weight training exercises.

These three programs were conducted during different times of
the day, because the same room was used to conduct the research and
other physical education classes. The room used for the training
program was equipped with five isometric racks which could be used for the exercises. The subjects were divided into groups of four according to height so that the height of the isometric bar would not have to be moved. It was stressed, however, that the same position be used each time for a particular exercise.

To begin any of the exercises, the author would give commands. The first command was "position of exercise." The first subject in each group would then take the proper position for the exercise. The next command was "half-exercise, press." This command was used to make certain the subjects did not lunge on the bar, or begin a maximum contraction too quickly. The author also felt the subjects would get a good grip on the bar while concentrating on a maximum exertion. The last command was "exercise." The author began counting verbally for a duration of 8 seconds.

The experimental group B using both isometric contractions and weight training exercises followed the same general procedure. The exercises performed were all the same as used by the other two experimental groups. It was necessary to make sure that the same amount of time was used in both groups doing the isometric exercises. The weight training exercises were the same in the two groups, B and C.
CHAPTER IV

ANALYSIS OF DATA

Introduction

The purpose of this study was to compare the effects of three different training programs on strength development. Each group was compared statistically to determine which training program contributed significantly to the development of strength as measured by the McCloy Strength Index Revision, Sit-up test, and the Vertical Jump test.

Reliability

As a prediction of strength factor, the McCloy Strength Index Revision has a reliability of .96 (27). All of the tests used in this study were administered by the same testor in both the initial and final tests. Pretests were used to instruct the testors in the proper procedure of giving the tests.

Design of Experiment

The subjects used in this study were students who had enrolled in physical education weight training classes. Group A included isometric contractions; Group B included isometric contractions and weight training; and Group C included weight training. The groups were tested for grip strength (right and left combined), leg lift, back lift, sit-ups, vertical jump, and arm strength. The initial and final tests were given before and after a 12-session training program.
The mean gain scores for each group on each test were statistically analyzed by the analysis of variance technique (28).

If an F ratio greater than 3.19 was found, this indicated that one group had a mean gain score that was, at the .05 level of confidence, significantly greater than at least one other group. Then, following the "least significant difference" procedure, using a "t" test, the investigator was able to determine which groups had mean gain scores that were significantly different.

**Findings**

Table 1 shows the mean gain scores that were achieved by each group for a certain test. Each mean gain was compared with the score obtained by each other group; if there was a significant difference among the mean gain scores obtained, a "t" test was applied to determine which group had improved significantly over other groups.

A group mean was determined by summation of differences of the initial and final test results divided by the number of subjects in that group.

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<td>9.2</td>
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<td>Group B</td>
<td>8.3</td>
<td>8.4</td>
<td>16.9</td>
<td>5.3</td>
<td>.6</td>
<td>159.5</td>
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<td>Group C</td>
<td>5.0</td>
<td>8.9</td>
<td>69.2</td>
<td>3.3</td>
<td>1.4</td>
<td>149.6</td>
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Tables 2 through 7 represent the statistical analysis of each individual test.

Table 2. Analysis of Variance Results for Arm Strength

<table>
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<tr>
<td>Treatments</td>
<td>2</td>
<td>2,981</td>
<td>1,490.5</td>
<td>.55</td>
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<tr>
<td>Within</td>
<td>52</td>
<td>1,419,137</td>
<td>2729</td>
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Arm strength was determined by using the formula \((\text{chins} + \text{dips}) \over (10 + H - 60)\). An F ratio of .55 was obtained for this test. This was not significant at the .05 level of confidence. The null hypothesis was accepted that there was no difference between the three groups in developing arm strength.

Table 3. Analysis of Variance Results for Vertical Jump

<table>
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<td>13.67</td>
<td>6.835</td>
<td>1.8</td>
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<tr>
<td>Within</td>
<td>52</td>
<td>195.71</td>
<td>3.76</td>
<td></td>
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The obtained F ratio of 1.8 was not significant at the .05 level of confidence; therefore, the null hypothesis was accepted that there was no difference between strength gains.
Table 4. Analysis of Variance Results for Leg Lift

<table>
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<td>25,470</td>
<td>12,735</td>
<td>2.99</td>
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<td>Within</td>
<td>52</td>
<td>221,564</td>
<td>4,261</td>
<td></td>
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The leg dynamometer was used to measure strength gains for this test. After comparing the three groups, an F ratio of 2.99 was obtained. This was not significant at the .05 level of confidence and, therefore, the null hypothesis was accepted and no significant difference in mean scores was assumed.

Table 5. Analysis of Variance Results for Grip Strength

<table>
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<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean of squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>2</td>
<td>179</td>
<td>89.5</td>
<td>.25</td>
</tr>
<tr>
<td>Within</td>
<td>52</td>
<td>18,638</td>
<td>358.4</td>
<td></td>
</tr>
</tbody>
</table>

The hand manuometer was used to measure grip strength. The right-hand strength results were combined with the left-hand strength results to obtain a total grip strength score. The F ratio of .25 was not significant at the .05 level of confidence. The null hypothesis was accepted and the difference in mean scores was not accepted as being real.
Table 6. Analysis of Variance Results for Back Lift

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean of squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>2</td>
<td>573</td>
<td>286.5</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>52</td>
<td>53,319</td>
<td>1,025.3</td>
<td>.03</td>
</tr>
</tbody>
</table>

The instrument used to measure these results was the back and leg lift dynamometer. In this test the belt was not used. The obtained F ratio of .03 was not significant at the .05 level of confidence and, therefore, the null hypothesis was accepted.

Table 7. Analysis of Variance Results for Sit-Ups

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean of squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>2</td>
<td>1,579</td>
<td>789.5</td>
<td>14.3</td>
</tr>
<tr>
<td>Within</td>
<td>52</td>
<td>2,861</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

The obtained F ratio of 14.3 was significant at the .05 level of confidence and, therefore, the null hypothesis was rejected and the difference in mean gain scores was assumed to be real.

Following the "least significant difference" procedure, using a "t" test, the author found:

1. Group B significantly improved over Group A.
2. Group C significantly improved over Group A.
3. Group B did not improve significantly over Group C.

The mean gains for Groups B and C were significantly greater than Group A.
A "\( t \)" score of 2.01 had to be reached to reject the null hypothesis. A comparison of "\( t \)" scores is shown in Table 8.

Table 8. A Comparison of "\( t \)" Scores

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>--</td>
<td>2.41*</td>
<td>2.20*</td>
</tr>
<tr>
<td>Group B</td>
<td>2.41*</td>
<td>--</td>
<td>.20</td>
</tr>
<tr>
<td>Group C</td>
<td>2.20*</td>
<td>.20</td>
<td>--</td>
</tr>
</tbody>
</table>

* Significant at the .05 level of confidence.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The basic purpose of this research was to compare the effects of three different training programs on strength development. An isometric contraction program, a weight training program, and an isometric-weight training program were compared for strength improvement.

The subjects used in this study were freshmen students participating in the physical education service program. There was a total of 55 subjects used to make up the three experimental groups. Each group met twice a week for a period of six weeks.

During this program, each experimental group followed the specific schedule of exercises set up for that group. Only a limited amount of time was allowed to complete the exercises each day.

The following strength tests were administered at the beginning and end of the training program: McCloy's Strength Test Revision, Sit-up test (2 minutes), and the Sargent Jump test. The following items were used for comparison of strength gains: grip (right and left combined) strength, leg lift, back lift, vertical jump, sit-ups, and arm strength (chins + dips) ($\frac{W}{10 + H - 60}$).

The data taken from the tests were recorded and statistically analyzed to determine whether one experimental group had significantly gained strength over either of the other groups. The initial
and final test scores of each group were used to determine the gains. The results were then compared to the results received from the other groups. The difference, when significant, indicated a change in muscular strength which might be attributed to one of the experimental groups used in the program.

Conclusions

Conclusions resulting from the administration of three different programs for developing strength were as follows:

1. There was no significant difference between the three experimental groups in developing arm strength.

2. There was a significant difference between the groups in developing abdominal strength. Group B, using isometrics and weight training combined, and Group C, using weight training, both increased significantly over Group A, using isometrics.

3. No one group improved significantly over any one of the other groups in developing strength for the vertical jump.

4. There was no significant difference in leg strength development for any of the groups.

5. After combining both the right and left grip, it was found there was no significant improvement among the three groups.

6. Back lift results showed that there was no significant difference among any of the groups as far as developing strength of the back.
Recommendations

Based on indicated results and experience gained from conducting this study, the following recommendations were made by the author:

1. That further studies be conducted using a longer training program.

2. That studies be conducted varying the training program so that the number of meetings and the time allowed be changed.

3. That further studies be conducted using a larger sample of subjects for each of the groups.

4. Additional studies be completed where the subjects are controlled as far as outside physical activities are concerned.

5. That further studies be done using different strength tests which are administered at varying intervals during the training program.

6. Similar studies be carried out to determine the effects of these programs on developing endurance and cardiovascular fitness.

7. That research be conducted concerning weight gain as a result of one of these programs.

8. That further studies be done in regard to increased or decreased muscular size as a result of one of the programs.

9. That further studies be carried out using groups which have had experience using the isometric type of exercise or the weight training type of exercise so that a maximum effort is being brought out continuously.
LITERATURE CITED


APPENDIX A

DESCRIPTION OF TESTS

McCloy's Strength Index Revision

Grip Strength

The hand manuometer was used to measure the grip strength of the right and left hands. The manuometer was held between the thumb and the forefinger of the right hand and placed in the palm of the subject's hand. The manuometer was placed in the hand in such a manner that the convex edge was between the first and second joints of the fingers and the rounded edge was against the base of the hand. The dial of the manuometer was placed face down in the hand. The subjects were allowed any body movement in which the hands and arms did not touch any part of the body. A total of two trials was allowed in each hand with the highest score being recorded.

Leg Strength

Leg strength was measured by use of the standard back and leg dynamometer. This instrument is calibrated in pounds and measures a maximum lift of 2500 pounds. The belt was not used to administer this test.

Each subject was instructed to hold the handle with both hands together in the center, palms down, and in close to the body at the waist. The subject stood upon marked areas of the bench used in this test, with the knees slightly bent. The chain was fastened in place, and the subject attempted to straighten his knees by lifting. The best results were produced when the subject almost had the knees straightened. The best score of two trials was recorded.

Back Strength

Back strength was also measured by the standard back and leg dynamometer.

The subjects stood erect upon the bench with the hands on the front of the thighs and fingers extended down. The tester attached the chain so that the handle level was just below the finger tips. The subject grasped the bar with one palm forward and the other palm backward. He was instructed
to bend forward at the hips, keeping the head up and the back and legs straight. The best score of two trials was recorded.

Pull-Ups

The subjects were instructed to hang from a horizontal bar, using a grip in which the palms were turned away from the body, and perform as many pull-ups as possible. The subject was to pull upward until his chin passed above the bar and then lower himself until the arms were straight. Half-counts were awarded if the individual failed to do the pull-up correctly, or if he could only pull half way up. Only four half-counts were allowed.

Dips

Parallel bars were used on which to perform the dips. The subject stood at the end of the parallel bars, grasping one bar with each hand. He then jumped up to position in which the arms were straight. Getting to this position was counted as one dip. The subject then lowered his body until the angle of the upper arms and forearm was less than a right angle. The subject then returned to the straight arm position. This was done as many times as possible. Again half-counts were used if the movement was not complete, or if the subject could not go all the way down or up.

Sit-Ups

This test was timed so that it lasted only 2 minutes. The total number of sit-ups done in this time was the recorded score.

The subjects were instructed to lie down on the floor. The hands were placed behind the neck and clasped. The legs were then pulled up so that the feet were placed just below the buttocks. A partner would then hold the subject's feet during the exercise. The subjects were told when to start and when to stop.

Sargent Jump

A specially constructed measuring device was used which consisted of a 42-inch by 24-inch chalk board ruled off horizontally at 1-inch intervals. A yardstick, which could be
moved up and down, was installed vertically in the middle of the board. Hooks were placed on the back of the chalk board to allow it to be placed on a wall so that the bottom of the board was approximately 7 feet 6 inches from the floor.

The subject stood erect facing the wall, reached up with the right hand (depending on the side he wanted to jump from) and with the fingers extended pushed the yardstick as high as he could reach with the middle finger. Upon lowering his arm the subject faced sideways to the wall directly under the board. The arm extended upward was toward the inside. The subject then grasped a piece of chalk. Assuming a crouched position, the subject jumped as high as possible and made a mark at the highest point of the jump with the chalk. Three trials were awarded, with the best jump being recorded.
APPENDIX B

DESCRIPTION OF ISOMETRIC EXERCISES

Press Lockout

Set the bar at a height about three inches below the lockout position, arms fully extended overhead. Grasping the bar with hands about shoulder width apart, look straight ahead, tighten leg, hip and back muscles and push on bar as hard as possible for 8 seconds.

Press Start

Set the bar about chin height. Use same grip as Exercise No. 1. Again tighten legs, hips and back muscles, look straight ahead and push on bar as hard as possible for 8 seconds.

Rise-on-Toes

Set the bar at a height where it will rest just touching or a little above your neck and shoulders when you are standing in front of it in an erect position. Keep the knees and hips locked tight, the back straight, and the head slightly turned back. Hold hands on bar at a comfortable position. Rise on the toes and push on the bar as hard as possible for 8 seconds.

Pull

Set the bar at a height where it will be six or seven inches below the waist. Use same grip as in Exercises No. 1 and 2, rise on toes slightly, lock up slightly, bend the arms at the elbows and pull up as hard as possible with the arms and legs for 8 seconds.

Parallel Squat

Set the bar at a height where it will rest on the back of the neck and shoulders when you are in a squat position with the thighs parallel to the floor. Place the hands on the bar in a comfortable position and rise, pushing with the legs as hard as possible for 8 seconds.
Curl

Set the bar at elbow height. Grip the bar with palms up and elbows at side. Spread feet comfortably, curl the arms and lift the bar as hard as possible for 8 seconds.

Dead Weight Lift

Set the bar at a height where it will be about two inches below the knees when you are holding it with hands about shoulder width apart. Keep the head up, the hips down, and the back flat. Push down hard with the legs and pull up as hard as possible with the arms for 8 seconds.

Quarter Squat

Set the bar at a height about four inches below the height it would be if you were standing erect, with the bar across the back of the neck and shoulders. Grip the bar with the hands in a comfortable position and push up with the thighs as hard as possible for 8 seconds. Keep the head up, the back flat, and the heels on the ground.
APPENDIX C

DESCRIPTION OF WEIGHT TRAINING EXERCISES

Bench Press

The subject assumed a position lying on a bench. Two partners would then pick up the weight and place it in position so that the subject could press it. The weight was pushed up until the arms were straight and then lowered to the chest.

Squats

The subject stood with the weight on the shoulders and hands. He would then squat down. It was important that the subject kept his back straight and his head up.

Rise-on-toes

Subject stood with the weight on the shoulders and hands. A 2-inch by 3-inch board was then placed on the floor by his feet. The subject would then place the toes of his feet over the top of this board. He would then rise up as high as possible, flexing the calves, and then lower.

Curl

Subject stood with the weight in front of the thighs and with the palms forward. The weight was raised to the chest by flexing the arms (folding the forearms against the upper arms). The elbows remained stationary as the weight moved in the arc.

Up-right-row

Subject stands with the weight hanging at arms length. The palms are toward the legs with the hands close together. The subject then flexed the arms so the elbows moved laterally up and outward, and the weight was raised up to the chin. The weight was then lowered.

Bent-row

Subject stands so that the lower body and the upper body form a 90 degree angle. The feet are apart, the legs are straight and the head is up and forward. The subject picks the bar up off the floor and lifts it to a position so that it touches his chest. The bar is then lowered but it does not touch the floor.
APPENDIX D

GROUP A--PROGRAM

Isometric Contraction

1. Calisthenics (5 minutes)
   a. Side-straddle hop
   b. Trunk-twister
   c. Sun-worshipper
   d. Wind-mill
   e. Arm circles
   f. Running-in-place

2. Isometric contraction exercises (10 minutes)
   a. Press lockout
   b. Press start
   c. Rise-on-toes
   d. Pull
   e. Parallel squat
   f. Curl
   g. Dead weight lift
   h. Quarter squat

3. Passive exercise (20 minutes)
   a. Ping pong
   b. Shuffleboard
APPENDIX E

GROUP B--PROGRAM

Isometric Contractions and Weight Training

1. Calisthenics (5 minutes)
   a. Side-straddle hop
   b. Trunk-twister
   c. Sun-worshipper
   d. Wind-mill
   e. Arm-circles
   f. Running-in-place

2. Isometric contraction exercises (10 minutes)
   a. Press lookout
   b. Press start
   c. Rise-on-toes
   d. Pull
   e. Parallel squat
   f. Curl
   g. Dead weight lift
   h. Quarter squat

3. Weight training exercises (20 minutes)
   a. Bench press
   b. Squats
   c. Rise-on-toes
   d. Curl
   e. Up-right-row
   f. Bent-row