The Effect of Isometric Contraction and Calisthenic Exercises on Strength Development of Male College Freshmen

Dennis L. Shefcyk

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THE EFFECT OF ISOMETRIC CONTRACTION AND CALISTHENIC EXERCISES ON STRENGTH

DEVELOPMENT OF MALE COLLEGE FRESHMEN

BY

DENNIS L. SHEFCYK

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
THE EFFECT OF ISOMETRIC CONTRACTION AND
CALISTHENIC EXERCISES ON STRENGTH
DEVELOPMENT OF MALE COLLEGE
FRESHMEN

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 con­
clusions of the major department.

A. C. Bundgaard
Thesis Adviser

A. C. Bundgaard
Head of the Major Department
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CHAPTER I

INTRODUCTION

The lack of physical fitness of Americans is a problem of major concern to people throughout the United States. Former President Eisenhower called the attention of the nation to our youth's fitness by establishing his Council on Youth Fitness in 1956. His concern was brought about by the results of the Kraus-Weber survey which indicated that American children were far behind European youth in basic levels of muscular fitness. President John F. Kennedy has acted vigorously to change the image of the so-called "soft Americans" and has advocated physical fitness for all citizens. President Kennedy called his first presidential conference on the Physical Fitness of Youth in February, 1961, and since then he has appointed Charles "Bud" Wilkinson as a special consultant on the fitness of youth. Wilkinson and his staff have worked closely with the American Association for Health, Physical Education and Recreation who had developed a youth fitness test which the council officially adopted for use. A survey conducted with this test revealed that more than ten million of our forty million school children failed the test (1). In addition to the survey conducted by Wilkinson he has stated:

This nation possesses the resources to insure every girl and boy will reach maturity with a strong, straight body, free from all medical remedial defects. We possess the educational know-how to give each child an understanding of the necessity for regular exercise and every young American the incentive to maintain his proper body weight and muscle tone throughout life (2).
The economic progress, the technological advances and the scientific breakthroughs that we have in our country can in part be the reason for the "softness" of Americans. These improvements have changed the American way of living, thus eliminating many of the physical exertions which once were a normal part of the average working day (3).

Something must be done to improve the physical fitness of our youth and the best place to begin is in our school physical education classes. These classes must be designed to meet the individual needs of the students in the class.

Need for the Study

With the growing concern for the improvement of physical fitness it is imperative that the physical educators know the best means of developing and maintaining physical fitness in our adults as well as the students. The American people are constantly looking for a quick and easy way of doing things and because of this physical educators must develop a concise, effective physical fitness program that will be brief and simple to administer.

Most physiologists and physical educators agree that strength is one of the most important significant components of physical fitness. Many studies have proven that strength may be developed by using the progressive resistance technique through weight training exercises. More recently another means of developing strength has been proven equally effective. This method has been called static or isometric
contractions, brought to our attention by two German physiologists, Hettinger and Mueller (4). Weight training as a means of increasing strength needs costly equipment and special facilities and very few people are able to use these facilities at the same time. While weight training is restricted to small groups during the same period, isometrics may be used by a large number of participants because it takes but six to ten seconds for each exercise. However, for most of the exercises some type of equipment must be used which can be constructed easily and inexpensively.

Weight training has been accepted by most authorities as an excellent means of training for the improvement of strength, but the problem of time and facilities confines its use to a small group at one time. The isometric method has been proven by many researchers to be as effective as weight training for the development of strength and this development of strength is obtained in a shorter period of time when using isometric exercises.

Many of our secondary schools do not have weight training because of the lack of facilities and time. They feel that if too much time is devoted to the development of strength there would not be sufficient time available for the teaching of skills of other activities. With the use of dual and individual isometrics the physical education instructors could administer the exercise in a short period of time and without the need of special equipment. These exercises could be administered any place, outdoors or indoors, and sufficient time could be spent on carry-over leisure time activities and athletics.
In the past most carry-over activities have been started with calisthenic exercises as a warm-up for activity. The question arises as to which will produce the most strength, static, dual isometric exercises or calisthenics. This could be important in teaching procedures if the isometric contraction method produced more strength than the calisthenics warm-up period.

Statement of the Problem

The primary purpose of this study was to determine the effects of isometric contractions and calisthenic exercises on muscular strength development of college freshman.

Delimitations

1. This study was limited to two freshman service classes of volleyball at South Dakota State College, Brookings, South Dakota. One group used isometric exercises with volleyball while the second group used calisthenic exercises with volleyball.

2. The training period consisted of two workouts per week for six weeks of training. The selected battery of dual and individual isometric exercises was administered to the experimental group between testing periods.

3. The subjects were instructed not to take part in any other forms of training during the study.

4. The study was limited to those not engaged in athletics.

5. The majority of the subjects were not acquainted with the testing instruments and methods used.
Definition of Terms

1. Physical fitness — The development and maintenance of a sound physique and of sound functioning organs, to the end that the individual realizes his sound capacity for physical activity, unhampered by physical drains or by a body lacking in physical strength and vitality.

2. Muscular strength — The maximum tension a muscle can apply in a single contraction.

3. Isometric contraction — A contraction in which a muscle is unable to shorten, the total tension developed eventually being dissipated as heat. No movement is produced and no work is performed.

4. Static contraction — A contraction in which muscle tension is sustained throughout the period of activity.

5. Isotonic contraction — A contraction in which a muscle shortens against a load, resulting in movement and the performance of work.

6. Calisthenics — Exercises for the development or flexibility of the body in which no type of equipment is necessary.
CHAPTER II

REVIEW OF RELATED LITERATURE

An investigation of literature concerning strength development through the use of isometric and resistive exercises revealed a considerable number of the studies. The results of these studies provided pertinent information from reliable authors and served as background for this study.

Values of Muscular Strength

Strength has always been an important asset to man and beast throughout history. The strength of men determined who would rule the world in man's early struggles and in many instances it meant whether a man lived or died. Strength is not as important today as a means of survival.

In a study completed by Jones, he discovered there was a positive relationship between strength and prestige factors and psychological and social adjustment. This study also indicated that boys with high Physical Fitness Index scores were generally chosen by five school educators to possess those traits that they would like to see in their own son (10).

McCloy stated that adequate muscle strength is a prerequisite to other things.
It is a prerequisite to superior performance in any form of sports. It is still more prerequisite to such gymnastic stunts and self-testing activities as apparatus work and tumbling. It is the prime prerequisite of a youthful carriage as resiliency, of poise and body balance, and of a positive and graceful posture. Lack of muscular development results in undue body fatigue, in depletion of energy by midmorning or early evening. The overweak relatively seldom do the constructive work of the world (11).

Hoffman and his co-workers agreed that muscular strength increases coordination and control, speed, endurance, power, and is an important quality of a champion athlete and that it helped to prevent injuries and it also increased balance (12).

Since strength is an important aspect of performance, coaches and physical educators are interested in the best means of developing strength and maintaining it. The theories of training for strength have changed throughout the past years. Prior to World War II trainers and coaches were opposed to the use of weight training and in most instances they felt that weight training made the athletes slow and "muscle bound." However, during World War II many trainers served in the Armed Forces and worked the reconditioning of men whereby they gained experience in the therapeutic applications of weight training (progressive resistance exercise) and they found it was not harmful. After this, many coaches and trainers incorporated weight training into their athletic programs (13).

Weight training had been used as a means of training athletes until news broke out in 1960 that the Pittsburgh Pirates Baseball Club was using a "secret" training routine. It was learned that this
training method was a type of short resistance exercise using
isometric contractions (14). Since then the isometric contraction
method of training has spread to all points of the United States.
This type of training is by no means new. Studies were being con-
ducted as early as 1936 on dynamic strength (15). Charles Atlas has
advertised "Dynamic Tension" for many years (16). The terms dynamic
and static are not used by present day trainers and physical educators
and these terms have been replaced by such names as isometric and iso-
tonic. Hettinger and Muller completed a study in 1953 using isometric
contractions for strength development of the elbow flexors and exten-
sors. Their findings indicated a significant increase in strength.
This study had a tremendous effect on the entire field of physical
conditioning because it provided an easier means of muscle development
with the lowest expense of time and energy (17).

Karpovich wrote about the different terminology used to desig-
nate muscular contractions.

The terminology applied to various types of muscular con-
traction is well differentiated only philologically. In practice
there is some unavoidable deviation from the true meaning of
words. Muscle is said to contract isometrically when its length
does not change. In order to record tension developed in iso-
metric contraction, however, a slight shortening is allowed.
When maximum tension is desired, the muscle is allowed to shorten
by as much as 10 percent of its original length.

Muscle shortening during contraction, while the load re-
mains the same, is known as isotonic contraction. In practice,
however, this concept is frequently violated, and contraction
involving shortening of a muscle may be called isotonic (18).
Rasch said that the physiological differences between isometric and isotonic exercise are not well understood. In explaining isometric he stated:

When a muscle contracts isometrically the contractible units begin to change, but since net length must remain constant an increasing stretch of the series of elastic components develop. At full isometric tension the series of elastic may be stretched by four percent or more of the length of the whole muscle. Fundamentally, then, there is no such thing as a purely isometric contraction. True isometricity may hold for the length of the muscle, as a whole, but actually any isometric contraction of the activated contractile pulling against an increasing load offered by the developing tension of the stretched series elastic material (19).

After the Hettinger-Müller study was released many other studies were instituted to investigate the validity of their findings. Some of the results of the studies were in disagreement, but the majority of evidence seems to indicate that substantial strength gains can be obtained through isometric exercises of short duration (20).

**Development of Muscle Strength**

Karpovich reviewed Müller's reports on the impact of muscular training. These reports indicated that a single isometric contraction held for six seconds daily and applying only two-thirds of maximum strength would be the best means in gaining muscular strength. The author also found in Müller and Hettinger's study that the repetition of contractions is no more effective than a single contraction (21).

To determine the most efficient method of producing a rapid improvement in muscle strength Salter studied twelve male and eight female subjects between 17 and 48 years of age. The author divided
the subjects into five groups and all groups trained four days per week for four weeks. The groups included in Salter's study were two isometric groups, one group having 15 exercises per minute and the other group two exercises per minute. The two isotonic groups also followed the same training procedure as the isometric. The remaining group was the control group. A total of 30 contractions was made in each group either at the rate of two or 15 per minute. The results of this study showed a significant improvement in muscle strength in all training procedure, but there was no significant difference between the different methods (22).

In discussing the number of training stimuli necessary for maximum muscle strength improvement Mettinger said that the maximum increase was obtained with one training stimuli per day.

Administering the same stimulus up to seven times a day did not increase muscle strength any more rapidly. Also several maximum contractions one after the other (as many as twelve contractions in one-second rhythm) did not increase the strength any faster than only one contraction. It therefore seems that the muscle, after one training stimulus during any one day is unresponsive to any further training stimulus on the same day. When training sessions were held only each second day the increase in strength was about 80 percent; with two training sessions per week the increase was about 60 percent; and when training sessions were held only once a week about 40 percent of the improvement in strength was obtained as compared with the once a day regime; and one training stimulus every 14 days produced no change at all in the muscle strength (23).

Rodgers found in his study comparing the amounts of strength development with isotonic contractions against static contractions that the static group exceeded isotonic group in all administrations of his
tests with the exception of one. The author worked with 19 men at State University of Iowa enrolled in a weight-training class. His strength test included sit-ups, push-ups, pullovers, and curls, which were administered at the beginning of the experiment and at the ends of the second, fourth, and sixth week. The isotonic group engaged in the usual weight-training method, training three times per week for 30 minutes. The static group also trained three times per week for 30 minutes holding weights in prescribed positions for six seconds. Although the static group exceeded the isotonic group in most of the tests the differences between the gains were not statistically significant (24).

Wolbers and Sills reviewed a report by Hettinger and Muller which dealt with one practice period a day whereby the muscles were held in static contraction for a period of six seconds. This technique showed as much increase in strength as longer periods up to full exhaustion of 45 seconds and more frequent practices up to seven per day. Sills and Wolbers found that by using static muscle contractions the experimental group made better gain in leg lift, grip test, and back lift than the control group. The author concluded that static muscle contractions of six seconds will cause a significant gain in strength (25).

Hopkins conducted a study on physical fitness in a volleyball class at the University of Illinois. The author had an experimental group of 16 adults and compared it with the control group of six men.
The experimental group met for one hour, five days a week for six months. During the one hour the experimental group met they had ten minutes of calisthenics and 50 minutes of volleyball. The control group was subjected to the initial and final test and then followed their regular daily routine. From the results of Hopkins' strength test he found that there was an increase in back and leg strength. The author also found an increase in the strength of arms and the shoulder girdle (26).

Asa worked on a study to determine the effects of isometric exercise on strength development of the abductor muscles of the hand and forearm. Eighteen subjects were used in this study and divided at random into three of the following groups: Group A used isotonic progressive resistance exercise, Group B used a single isometric exercise, and Group C used a single isometric exercise repeated 20 times daily with a 20 second rest between exercises. Two groups went through their exercise routines four times a week for 12 weeks and the other group exercised four times a week for four weeks. The author found that Group C, the repetitive isometric group, gained a higher degree of strength than the others, but Group B was higher than Group A. All subjects in all groups showed a significant increase in strength. Asa concluded that isometrics required less time, needed very little or no equipment, and were easily adapted to a variety of situations. He recommended that isometrics should be considered when prescribing an exercise program for the increase of muscle strength (27).
A study was conducted by Rarick and Larson to determine the best method of performing isometric exercises. They attempted to test the Hettinger-Mueller method of developing static muscular strength with post-pubescent boys and to compare the effectiveness of single six seconds at two-thirds maximum tension with higher levels of tension held for progressive longer time periods each day. The author used two experimental groups and one control group. The experimental groups were given exercises, the difference being the amount of tension employed to the wrist flexion of the right hand. The subjects were boys in the eleventh and twelfth grades. Strength scores were made at the conclusion of a four-week period of training and again four weeks after the termination of the exercise program. Their findings revealed:

1. Both of the experimental groups had gains during the experimental period. The strength of the group utilizing the 80 percent tension with a progressive number of exercise bouts increased slightly greater at the end of the training period and declined less than the group employing the six second method.

2. Gain of the two experimental groups was significant at the one per cent level at the end of the training period.

3. In comparing the groups, the experimental groups showed a significantly higher strength score than the control group. The difference between the experimental groups was not significant.

4. The group with 80 per cent tension was still significantly superior to the control group after four weeks of training. However, there was no difference between the group using two-thirds tension and the control group. The difference between the two experimental groups was again not significant (28).
Wagner stated that most coaches agree weight training is an excellent means of training but the problem of time and facilities confines its use to a select group. He put his cross country team and his physical education classes through a group of isometric exercises and he believed that they benefited as much from this program as they would have from a weight training program. He added that the resistance can be against the wall, the bleachers, with a partner, or just the individual himself. The recommended duration of strain should be approximately six seconds with at least 75 percent effort (29).

Kittleson in his study used 20 boys and 13 girls who were enrolled in the sixth grades at Arlington and White, South Dakota, Public Schools. The students were given static contractions, isometric and isotonic exercises and these exercises were administered by the classroom teacher. The teacher was trained by the author in correct administration of the exercises. The students used the exercise five days a week and they performed these exercises in a regular classroom for a period of five minutes a day for ten weeks. No equipment, no physical education uniforms, and no type of calisthenics were used in the exercises. The author administrated the McCloy Strength Test at the beginning and at the end of the training period. Data was kept for the total strength score and on individual items which included the right hand grip, left hand grip, back lift, leg lift, and arm strength, which included dips on the parallel bars and chin-ups. The results of the author's study showed that overall strength was significant in
both boys and girls. The boys gained significantly in the right hand grip, left hand grip, leg strength, and arm strength. The girls improved significantly in the right hand grip, leg lift, and arm strength tests (30).

Meadows sought to determine whether isotonic and isometric muscle contractions produced an improvement in a specific sport skill and strength in the arm, shoulder, back, and leg. The author worked with 84 members of the freshman and varsity football players at St. Cloud State College. They were tested on (1) speed and force of offensive football charge, (2) right hand grip, left hand grip, back lift, and leg lift strength tests, and (3) chin-ups and dips and the vertical jump. He used three groups, an isometric group, an isotonic group, and a control group composed of students from required physical education classes. Each group trained for a period of ten weeks, three times a week. His findings were:

1. In the comparison of the chin test the isotonic group compared to the isometric group showed significant difference at one percent level. Isometric group compared to control group showed no significant difference.

2. All three groups showed a significant difference at five percent level on dips, but within the groups the isotonic and isometric groups improved significantly at the one percent level of confidence.

3. In the comparison between groups on right grip and left grip, no significant difference was found.

4. In the leg lift, the isometric group as compared to the control group and the isotonic group compared to the control group showed a significant difference at one percent. There was no significant difference between the two experimental groups.
5. In the back lift all three groups improved at the one percent level of confidence (31).

Muller and Hettinger found that in order to gain strength the training stimulus need not be a contraction of maximal strength. They found that two thirds of maximal effort had the same training effect and that one-third or less was not effective. The next experiment he dealt with was to determine whether a longer sustained contraction, especially one held to complete exhaustion, would improve training. They found that the increase in strength gained in the course of the week by one daily contraction was not influenced by the length of contraction time. Another factor they found was that only one contraction per day was necessary and more than one contraction produced no better results. In summarizing their results Muller said:

There is no better way to increase muscular strength than by one short, about half-maximal, isometric contraction once a day. Contracting a muscle for a longer time, more strongly or more often does not improve the resulting increase in strength. In ordinary practice one would not use a half-maximal but a maximal contraction. This has three advantages:

1. One needs no dynamometer to measure the training strength. It can be exerted against any resistance at hand.

2. The training stimulus increases progressively with the increase in strength.

3. If a dynamometer is used each maximal training contraction is at once also a measurement of maximum strength (32).

Rasch, after reviewing studies on isometric and isotonic contractions stated:
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 it appears that the development of tension, and strength gains appear to be greater when tension is developed frequently during the course of the training program. The reason isometric training has been found effective may be that the tension is greatest during "zero-velocity" contractions. From the standpoint of thermodynamics, isotonic and isometric exercises are very similar, although a greater amount of heat is liberated during an isotonic contraction, this quantity being roughly parallel to the work done, but there are other physiological differences. Fatigue during isometric exercise is probably due to the stress on the nervous system. Clinical experience indicates that isometric exercises are useful in the therapeutic situation. Much further study of strength and development is needed before definite answers can be given to many of the problems concerned with it (33).

Liberson and Asa concluded that brief isometric exercises produced a more rapid increase in strength than the method of progressive resistance exercise and weights. Repeated isometric contractions produced a more rapid increase in strength and a greater increase in endurance than a single contraction. There have been many studies with isometric and isotonic against resistance and most of the studies indicate that there is a significant increase in strength development. The majority of the studies appear to indicate that there are no significant differences between the two methods used in strength development (34).
CHAPTER III

PROCEDURE

Source of Data

This study dealt with the changes in muscular strength as a result of six weeks of an isometric contraction training program and a calisthenics program. The two experimental groups participating in this study were two volleyball classes of male freshmen enrolled in physical education during the 1962-63 winter quarter at South Dakota State College.

For the purpose of this study any of the subjects who were currently participating in college athletics or had been participating in college athletics were excluded from this study. Of the 36 students in the calisthenics class, six were excluded because of athletic participation or injury. In the isometric contraction class there were 37 enrolled and seven of them were athletes, leaving a total of 30 subjects in the group.

Testing Procedure

During the first class meeting the author explained the purpose of the study and the subjects were instructed as to the type of exercise program they would be taking.

During the testing program the students were dressed in the regulation gym suits and tested during their scheduled physical education class.
The test used to measure strength of each subject was the McCloy Strength Test (35). The test battery was administrated by the author with the help of graduate students in the physical education department. Those assisting had gone through a number of practice sets prior to the administration of the test. In the back lift and leg lift test items the same assistant, who had had considerable experience, administered all of the initial and final tests. The full description of McCloy's Strength Test can be found in Appendix A.

The author also included the sit-up test to measure abdominal strength. The author used the sit-up item with legs bent as recommended by Mathews. In his study he concluded that the sit-up test should be administered with the legs bent in order to get a better measure of abdominal strength (36). A full description of the sit-up test will be found in Appendix B.

Because of the number of subjects in each class it was impossible to complete the test in one class period and so the remainder of the test was given during the second class meeting of the same week. One class was tested on Monday and Wednesday and the second group was tested on Tuesday and Thursday. The first day the following items were administered: right grip, left grip, back lift, pull-ups and dips.

During the second test period the subjects were given the leg lift and the sit-up test items in the same order, but the order of their test was recorded on the initial tests and the same order was followed on the final administration of the test.
The individual test items were demonstrated to the subjects prior to the administration of the test. During the demonstration and during the administration of each test item the subjects were encouraged to strive for a maximum effort.

Training

A six week training program began on January 21 and was completed February 28, 1963. The isometric group met at two o'clock on Monday and Wednesday and the calisthenics group met at nine o'clock on Tuesday and Thursday. The length of the training period was the same for both classes. The calisthenics group exercised for ten minutes and the isometric group exercised for the same amount of time.

The author taught the isometric contraction group and had control over the isometric exercises. The author instructed the teacher of the calisthenics class not to have any isometrics included during the ten minutes of calisthenic training. The calisthenics program varied according to the instructor's pre-arranged plan with the author. The author also asked that no running be required other than that necessary to play the game of volleyball. The subjects of both classes were asked not to take part in any other type of isometric contraction or weight training activities during this training period of six weeks. If a subject was absent for a class meeting he was required to make it up sometime during the same week. All subjects abided by this request.
In the isometric contraction group all subjects were briefed on the type of study the author was doing and each exercise was explained and demonstrated to the subjects. They were encouraged to perform the exercises with as much tension as possible and it was explained that there should be no movement during the exercise. Each partner should apply enough resistance to counteract the force applied by the subject doing the exercise with him. The subjects were paired with partners of the relative same size and strength so as to offer the proper resistance necessary to perform the exercises. The author used a stopwatch to time the length of the exercise. The subjects were instructed to hold the exercise for eight seconds to insure that the recommended six seconds would be performed by all subjects. The following commands were given throughout the exercises: "ready," with a pause, then the command, "exercise" and the count to eight. The command "halt" terminated the exercise. The subjects were checked constantly to see if they were applying pressure on their partners.

The author chose exercises to develop the major muscles of the arm, shoulder, back, abdomen and legs. The exercises were picked from studies by Wagner (37) and Kittelson (38).

A copy of the exercises given to the subjects can be found in Appendix C. In the exercises the subjects were instructed to keep their body in the prescribed position in order that the proper muscles would be exercised.
CHAPTER IV

TREATMENT AND ANALYSIS OF DATA

The purpose of this study was to determine what the effects were of a program of isometric contractions as compared with a program of calisthenics. Two volleyball classes participated in the investigation, one class performed isometric exercises and the other class performed calisthenics.

Both classes were measured in an initial test and a final test on the following strength items: (1) right grip strength, (2) left grip strength, (3) back lift, (4) leg lift, (5) chin-ups, (6) dips, and (7) sit-ups.

Before the administration of the items a test-retest rank order correlation was analyzed by the author and graduate assistants on the test items. For five subjects, the findings were as follows: right hand grip .98, left hand grip .88, back lift .97, leg lift .86, chinning .93, and dipping .88.

The difference between the mean gain scores for each class, on each of the test items, was determined and analyzed by the $t$ or critical ratio test to determine if significant differences were present.

$$ t = \frac{\text{Difference between means}}{\text{Standard error of difference between means}} $$

The standard error of the difference was determined by the following formula (39).
A $t$ ratio of 2.00 was needed to denote significance at the .05 percent level of confidence.

The raw scores were used in computing the mean gain for each class or group. In addition to the seven test items, arm strength was computed by the following formula (40).

$$(\text{Dips} + \text{Chin-ups}) \times \left(\frac{\text{Weight}}{10} + \text{Height} - 60\right)$$

Table 1. Isometric and Calisthenic Mean Gains, Standard Error of the Mean Differences, $t$ Values, and the Levels of Significance Computed from the Results of the Test Battery

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<th>Calisthenics mean gains</th>
<th>SE Dif Mns</th>
<th>$t$ Value</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right grip, lbs.</td>
<td>4.2</td>
<td>37</td>
<td>1.99</td>
<td>1.78</td>
<td>.10</td>
</tr>
<tr>
<td>Left grip, lbs.</td>
<td>4.07</td>
<td>1.17</td>
<td>1.88</td>
<td>1.49</td>
<td>.20</td>
</tr>
<tr>
<td>Back lift, lbs.</td>
<td>22.33</td>
<td>4.83</td>
<td>6.15</td>
<td>2.74</td>
<td>.01</td>
</tr>
<tr>
<td>Leg lift, lbs.</td>
<td>68.7</td>
<td>22.4</td>
<td>12.61</td>
<td>3.51</td>
<td>.01</td>
</tr>
<tr>
<td>Chins, no.</td>
<td>.72</td>
<td>.33</td>
<td>.23</td>
<td>1.64</td>
<td>.20</td>
</tr>
<tr>
<td>Dips, no.</td>
<td>3.77</td>
<td>2.7</td>
<td>.52</td>
<td>1.97</td>
<td>.10</td>
</tr>
<tr>
<td>Arm strength, pts.</td>
<td>110.48</td>
<td>79.64</td>
<td>15.78</td>
<td>1.88</td>
<td>.40</td>
</tr>
<tr>
<td>Sit-ups, no.</td>
<td>8</td>
<td>1.03</td>
<td>1.87</td>
<td>3.57</td>
<td>.01</td>
</tr>
</tbody>
</table>

In the analysis of the right hand grip the isometric group had a 3.7 mean difference as compared with the calisthenic group. The $t$ value for this test was 1.76, hence the null hypothesis was accepted that there was no statistical significant difference between the groups.
The isometric group showed a mean increase of 2.9 over the calisthenics group in the left hand grip strength. The t value of 1.49 of this test was not statistically significant and the null hypothesis was accepted.

There was a mean gain of 17.5 in the isometric group over the calisthenic group in the back lift. The null hypothesis was rejected at the .05 level of confidence and this showed a significant increase in back strength. The back lift was also significant at the .01 percent level.

The author found the isometric group had a mean increase of 46.3 over the calisthenic group in the leg lift. The t value of 3.51 was found to be significant at both the .05 and .01 percent level of confidence, and therefore the null hypothesis was rejected and the increase was assumed as significant.

The chin-up test showed a mean increase of .39 for the isometric group over the calisthenic group. The obtained t value of 1.64 was not significant at the .05 level and the null hypothesis was accepted as real.

A difference of 1.07 was found in the mean gain of the isometric group over the calisthenic group in dipping. The obtained t value of 1.97 was not significant at the .05 percent level of confidence and the null hypothesis was retained.

Arm strength, as measured by McCloy's formula and which is described in Appendix A, showed a mean increase of 30.84 by the isometric
The obtained $t$ value for sit-ups was 3.57. The isometric group had a mean increase of 6.97 over the calisthenic group. The $t$ value was significant at the .05 and the .01 percent level of confidence and therefore the null hypothesis was rejected.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The primary purpose of this study was to determine the effects of isometric contractions and calisthenic exercises on muscular strength of college freshmen as measured by the McCloy Strength Test.

The subjects were male freshmen students enrolled in the physical education service program at South Dakota State College during the 1962-63 school year. The two sections used in this study were volleyball classes which met twice weekly.

During the training period one group performed a routine of ten minutes of isometric exercises followed by participation in volleyball for the remainder of the period. The other group used the same time schedule, allowing ten minutes for calisthenic exercises prior to volleyball participation.

The McCloy Strength Test was administered to both groups before the training period began and at the end of the six weeks' training period. The test battery included right and left hand grip, back lift, leg lift, chin-ups, dipping, and sit-ups.

Data found from the initial and final tests was recorded and the difference between tests was determined. The mean gain score on each test item was found. The standard error of the difference between the means was then computed and the $t$ or critical ratio test was
applied to determine the significance of change between groups. If changes were significant, it was assumed to be attributed to the training program.

Conclusions

As a result of this study the following conclusions have been made from the data obtained:

1. The gain of the isometric group over the calisthenic group in the right and left hand grip was not statistically significant.
2. In the sit-ups, back lift and leg lift the isometric group had a statistically significant gain over the calisthenic group at the one percent level of confidence.
3. In the comparison of groups for chins and dips there was no significant increase.
4. In comparing the groups for arm strength the gain by the isometric group over the calisthenic group was not statistically significant.

Recommendations

1. That a similar study be made using a greater variety of exercises over a longer training period.
2. That a similar study be made using other methods in measuring muscular strength.
3. That a similar study be made with subjects doing exercises daily and compare it with groups doing exercises every other day, three times a week, twice a week, and once a week.

4. That further studies be made with different age groups using the same exercises in order to determine if maturity had any effect on strength development.

5. That a similar study be made with a group using a selection of exercises with resistance against a wall or some stationary object.
LITERATURE CITED


APPENDIX A

Description of the McCloy Strength Test

Height

Each subject wore his gym uniform and gym shoes when measured. The height was recorded to the nearest half inch.

Weight

The weight of each subject was recorded to the nearest half pound. Each subject was weighed in his regulation gym suit and shoes.

Grip strength

A hand dynamometer was used to measure the grip strength of both the right and left hands.

The hand dynamometer was placed in the subject's hand by the tester. The indicator of the dynamometer was placed face down in the palm of the hand to prevent the finger tips from stopping or moving the indicator. The rounded edge of the dynamometer was placed against the base of the hand and the convex edge was placed between the first and second joints of the fingers.

The subject was allowed to stand in any desired position during the testing procedure. When the subject was ready he was instructed to grip the dynamometer with as much tension as possible. The tester suggested that the subject bend his elbow slightly and move the arm downward in a sweeping arc as the dynamometer was squeezed. The hands and arms were not allowed to rest or touch against the body or any other object.
The right hand was tested first. Each subject was given two
tests for each hand. The subject's highest score was used in the
tabulation of the results.

**Back strength**

The back and leg dynamometer was the instrument used in the
measuring of strength for both the back and leg strength.

The subject stood erect on the dynamometer base with hands on
the front of the thighs, fingers extended downward, the feet approxi-
mately six inches apart, and with the center of the feet opposite the
chain. The investigator hooked the chain so that the handle level was
just below the finger tips. The subject was then instructed to grasp
the handle firmly at the ends of the bar with one palm forward and the
other backward. The subject was then instructed to get into lifting
position with the back slightly bent at the hips. The instructions
were to keep the head up with the eyes directed straight ahead, the
legs straight, and the feet flat on the platform.

When the subject was in the correct lifting position, he was
instructed to lift as steadily and as forcefully as possible without
j jerking. At the end of the lift, if the subject’s back was not
straight, the test was repeated.

Each subject was given two lifts and the handle was readjusted
preceding each trial. The best trial was used as the score.
Lege strength

The back and leg dynamometer, mentioned in describing the back lift, was used to measure leg strength.

The leg strength test was administered without the use of a belt. The subject was instructed to stand on the platform with the feet approximately six inches apart and with the center of the feet in line with the chain. The bar was then grasped by both hands, palms down, close to the center of the bar and with the bar resting at junction of the thighs and the pelvis.

When the subject was in the proper position he was instructed to bend the knees to an angle of approximately 120°, which was measured each time by the tester. The chain was fastened and the angle was checked again. The subject was checked to see if his arms and back were straight, his head erect, and his chest up. The subject then lifted steadily until the legs were straight or as nearly straight as possible at the end of the lifting effort. The best score of the two trials was recorded.

Pull-ups

In the administration of the pull-up test the only equipment needed was a suspended bar. The subjects were instructed to jump up and grasp the bar using a forward grasp in which the thumbs and palms faced away from the body, letting the body hang with elbows straight. If the subjects' feet touched the floor while hanging from the bar,
they were instructed to bend their knees. The subject then pulled himself upward until his chin was over the bar, then lowered himself until his arms were straight. Subjects were not permitted to kick or jerk and the investigator held his arm extended in front of the subject to prevent swinging or jerking.

The subject was given credit for each time he pulled his chin above the bar and he was urged to do as many as possible. If the full chin-up was not completed, the subject was given a half-count for such maneuvers as not pulling his chin completely over the bar or for failure to go down until the arms were straight. A maximum of four half-counts were permitted.

Dipping test

This test was administered on regular gymnasium parallel bars. The subject stood at the end of the bars and they were adjusted to the subject's approximate shoulder height. The subject was instructed to grasp one bar in each hand. He then jumped to a position in which the arms were straight. (This counted as one dip.) The subject lowered his body until the angle in front of the elbows was less than 90°. On the first dip the investigator determined the proper distance the body should be lowered and held his fist at that point. The subject then touched the fist on each of the repeated trials. After lowering the body the subject returned to straight arm position and repeated this as many times as possible.
If the subject did not go down to proper bent arm angle or all the way up to straight arm position, he was given half-credit. Up to four half-credits were allowed in this test.
Description of Sit-up Test

The subject was instructed to lie supine on floor, face up, with hands clasped in back of head. The subject's knees were bent and his feet were placed approximately 18 inches apart flat on the floor. The feet were held down on the floor by a partner. The subject was then instructed to touch his right elbow to his left knee and then return to supine position and touch his left elbow to his right knee and continue this routine as many times as possible.

Each subject had a two-minute time limit in which to do as many sit-ups as possible. If the subject released his hands from the back of his head, did not touch his knees with elbow, or did not go back to supine position, that sit-up was not recorded.
APPENDIX C

Description of Isometric Exercises

1. **Forward deltoid press**
   Subject stands facing partner with arms kept straight, inclined downward. Partner holds down arms at wrist. Then subject and partner exchange exercise.

2. **Back deltoid press**
   Partners stand back to back with heels about two feet apart. Keep arms straight, inclined downward. Both push against partner, hands on command.

3. **Lateral deltoid press-ups**
   Subject holds arms straight out to side shoulder height. Partner holds down at wrist. Do both arms. Then subject and partner exchange exercise.

4. **Lateral deltoid press-down**
   Subject and partner stand side to side at arms length. Each place hand on each other's shoulder, and push down on partner's shoulders. Do both arms.

5. **Forward lateral press**
   Subject stands facing partner at arms length. Both place hands on each other's shoulder, keeping arms straight and press down.

6. **Biceps press**
   Subject stands with arms at side with forearm bent to 90° angle. Hold palms up and lift up with partner holding down at wrist. Subject and partner exchange exercise.

7. **Triceps press**
   Subject stands with arm at side with forearm bent to 90° angle. Hold palms up and push down with partner holding up. Subject and partner exchange exercise.

8. **Pectoralis press**
   Subject stands with arm to shoulder height, flex elbows. Palms are placed together at chest and push directly against each other.

9. **Fore-arm exercise**
   Subject stands with arms bent to 90° angle and squeezes hands into a fist as hard as possible in a gripping fashion.
10. **Sit-ups press**
Subject lies down on back, hands behind head. Partner kneels above and pushes forward on chest as subject tries to sit up. Subject and partner exchange exercise.

11. **Back hyperextension**
Subject lies face down, hands behind head. Partner kneels above and offers resistance on shoulder blades as partner tries to lift back. Subject and partner exchange exercise.

12. **Hamstring and quadriceps press**
Subject lies face down with legs bent at 90° angle. Partner sits on back of legs and subject forces legs forward. On hamstring press with partner, hold back at ankles. On quadriceps press the subject forces legs toward buttocks with partner pushing away. Subject and partner exchange exercise.

13. **Abdominal press**
Subject lies on back on the floor and raises feet approximately twelve inches off the floor. Hold, keep legs straight.

14. **Leg press in-and-out**
Subject lies with back on floor with legs approximately twelve inches off floor and legs spread. Push in with partner holding in, then push out with partner holding legs in. Subject and partner exchange exercise.

15. **Upper and lower leg press**
Subject gets partner on back. Stay up on toes with legs bent between 120° and 130° angle and hold.