Title: THE EFFECTS OF FUNCTIONAL ISOMETRIC AND DYNAMIC TRAINING PROGRAMS ON DYNAMIC AND STATIC STRENGTH

The purpose of this study was to compare two progressive weight training programs—functional isometric and dynamic—to determine their effects on dynamic and static strength. Sixteen healthy male college subjects were randomly divided into two training groups. Group A utilized the progressive dynamic weight training program, and group B used the progressive functional isometric weight training program. Both groups trained two times per week for eight weeks on the squat and bench press exercises. Two dynamic and two static strength tests were administered at the beginning, middle, and end of the experimental training period. The test data were statistically treated using a paired t test and groups by trial analysis of variance. The .05 level of significance was
chosen for accepting or rejecting the null hypotheses. The results of this study indicate that both progressive dynamic weight training and progressive functional isometric weight training for eight weeks increased dynamic and static strength. Neither training program increased strength at a greater rate than the other program.
The Effects of Functional Isometric and Dynamic Training Programs on Dynamic and Static Strength

by

Ronald Myles Johnson

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Redacted for Privacy

Associate Professor of Physical Education

in charge of major

Redacted for Privacy

Head of Department of Physical Education

Redacted for Privacy

Dean of Graduate School

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Typed by Lyndalu Sikes for Ronald Myls Johnson
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THE EFFECTS OF FUNCTIONAL ISOMETRIC AND DYNAMIC TRAINING PROGRAMS ON DYNAMIC AND STATIC STRENGTH

I. INTRODUCTION

Man uses strength in many different ways. Most commonly, man utilizes muscular strength in everyday practical labor. The practical uses of strength may vary from extremely mild by a sedentary person to intense for a person performing heavy manual labor. In the case of practical muscular strength, usually no special effort is made to develop or increase strength beyond that gained through normal activity.

The individual who utilizes strength only in everyday situations may not discern any need for strength training except when illness or injury occur, and rehabilitation is necessary. During therapy the intensity of training is low, and the individual involved is only striving to bring the affected muscle back to the previous level of performance.

A person participating in recreation may or may not use specific forms of strength training during an activity. In either case, the individual may be increasing strength beyond everyday levels and may become more aware of the relationship between strength and physical activity.
Another way man applies strength is in athletics. This has been true since the foundation of sport, but only recently has the need for developing strength in almost all areas of sport been recognized. Strength training in most sports acts only as a supplement to other specialized training; however, sports such as weightlifting, or field events in track utilize some form of strength training as the primary training program. The individual involved in athletics frequently has a full comprehension of the need for muscular strength in performing his particular activity.

A small proportion of men and women are involved in competitive athletics and the intense training programs it demands. Here the most specific programs of strength training undergo use in sports such as weightlifting and track by highly trained athletes for long periods of time.

The effectiveness of training methods has been studied basically in two ways: First, by practical application, usually with athletics; and second, through pure research under laboratory conditions and controls. Practical experience and application in many areas of sports training is one step ahead of pure research as training programs are often found to be effective before it is determined why. Practical application and research must operate hand in hand in studying strength development.
Most strength researchers readily accept that both static and dynamic training methods bring about increases in strength. However, absolute optimal training programs for these two methods of training have not been established. Some studies (11, 29) show that dynamic training is the superior method for increasing strength. Other studies (1, 2, 15, 44, 46, 66) state that static training is superior to dynamic training. But a majority of studies (12, 21, 25, 26, 27, 33, 36, 56, 59, 61) dealing with a comparison of static and dynamic training methods establish that no significant difference exists between the two methods for effectiveness in increasing strength. Coleman's work (25, 26, 27) is unique in that his studies attempt to equate intensity of training by equalizing load, duration of contraction, trainability of subjects, and range of motion. His findings indicate that static and dynamic training methods produce identical changes in strength when the intensity of training for both methods is equal. A question arises, though, as to the effect of static training on strength at other than the angle of training. Gardiner (35), DeVries (34), and Bender and Kaplan (5) have given some evidence that suggests isometric strength gains are very specific to the angle of training. Berger (9), Martens and Sharkey (45), and Shephard (63) have done research that indicates that static training does not strongly influence dynamic strength and that dynamic training is not correlated with gains in static strength. However, Rasch (57), Rasch and Pierson
(58), and Bender and Kaplan (5) disagree saying that a correlation exists between dynamic training and static strength.

Other questions which could be asked along with what methods or programs increase strength the fastest are 1) What are the effects of various training programs and methods on strength? 2) What long term effects do established training programs have on increasing strength? and 3) What effect do specialized strength training programs (i.e., functional isometrics) have on highly trained individuals as they approach the maximum level of performance? These questions should be asked and answered in order to bring empirical knowledge and scientific research closer together. This study compares two specific weight training programs in an attempt to discover whether the programs increase static or dynamic strength and whether either program is more effective than the other for increasing strength parameters tested.

**Purpose**

The purpose of this study was to compare two progressive resistance weight training methods - dynamic weight training and functional isometric weight training - to determine their effect on dynamic and static strength. The null hypotheses tested were:

**Hypothesis one:** At the conclusion of the eight week experimental period no significant difference in dynamic or
static strength will result from dynamic or functional isometric training.

Sub hypothesis one: At the conclusion of the eight week experimental period a significant difference in strength parameters tested will result from the dynamic weight training program.

Sub hypothesis two: At the conclusion of the eight week experimental period a significant difference in strength parameters tested will result from the functional isometric weight training program.

**Definition of Terms**

**Dynamic (isotonic) Contraction.** A dynamic contraction is a muscle contraction against a load during which the contractile force of the muscle is greater than the load. The muscle fibers shorten so that skeletal movement occurs and work is accomplished.

**Dynamic Weight Training.** Dynamic weight training utilizes a barbell or dumbell of varying loads during exercise. The muscle is forced to undergo repeated dynamic contractions through a full range of motion so that a training effect takes place.

**Isometric (static) Contraction.** An isometric contraction is a muscle contraction during which the load is greater than the force that the muscle generates. The fibers contract, but do not shorten.
Technically, no work is accomplished, and the energy of the muscle is dissipated as heat.

**Isometric Training.** Isometric training occurs when the muscle undergoes repeated isometric contractions against an immoveable load so that a training effect takes place.

**Functional Isometric Weight Training.** Functional isometric weight training is a concept of training based upon a combination of dynamic and static contractions. The subject first moves a weight through a short range of motion (dynamic contraction) and then holds the weight for a predetermined number of seconds (static contraction). Repeated repetitions are performed so a training effect takes place.

**Repetition.** Repetition is the number of times a dynamic or isometric contraction is repeated in a given exercise program. One repetition maximum (1 RM) is the maximum load a muscle is able to contract against. The 2 RM is the maximum load a muscle is able to contract against for two repetitions, etc.

**Set.** A set is one series of repetitions without a rest in a given exercise. A set may be repeated for any predetermined number of times.
**Delimitations**

The delimitations of this study are as follows:

1. The study involved 16 male subjects with previous weight training experience.

2. The study included a dynamic weight training program and a functional isometric weight training program.

3. The study included training only in the squat and bench press exercises.

4. The study included static and dynamic strength testing procedures.

5. The study was limited to eight weeks.

**Limitations**

The primary limitation to this study was the dynamic testing procedure. Dynamic testing is subjective because it is a trial and error method of evaluating strength.
II. REVIEW OF RELATED LITERATURE

Introduction

Theories and knowledge concerning the acquisition of muscular strength have not changed drastically since DeLorme (30) first presented his ideas on progressive resistance weight training in 1945. Despite a myriad of studies since then, there are no "one minute a day" miracle training methods which enable a person to acquire great muscular strength with little effort. Sport is often looked upon as a proving ground for the current training methods, and due to contemporary advancements, gains have been made in athletic performance as evident by improvements in sports records. However, these gains are not always due to great advances in training knowledge. The gains are also due to the increased amount of time, effort, and dedication which modern society allows athletes to put into sport.

Although controversy exists among researchers since DeLorme (30) concerning progressive weight training methods, generally the problem has not been whether or not various training methods are effective in gaining muscular strength, but rather which type of training produces an increase in muscular strength most rapidly. This is true for both dynamic and static training programs. Training methods using the progressive overload principle will bring about
increases in strength, but researchers continue to seek information about how the overload principle can be utilized for optimal results. A review of literature will include: dynamic training, static training, a comparison of dynamic and static training, functional isometric training, and isokinetic training.

Dynamic Training

Dynamic or isotonic contraction is a muscle contracting against a load, and the contractile force of the muscle is greater than the load. The individual muscle fibers shorten as does the whole muscle, skeletal movement occurs, and work is done. When this type of contraction is utilized in an exercise sequence, dynamic training takes place.

DeLorme (30) was one of the first researchers to investigate the effectiveness of dynamic resistance training. Using three hundred patients from an orthopedic hospital, he found that strength in atrophied quadracepts muscles could be increased significantly through isotonic weight training. The subjects exercised for seven to ten sets of the 10 Repetitions Maximum five times per week and one set of the 1 Repetition Maximum once a week. DeLorme (30, 31) introduced the concept of increasing the load as the muscle becomes stronger, better known as the progressive overload principle. The technique then became widely accepted. In 1950, Chui (20) and Capen (18) published
studies supporting the theory of the overload principle. In addition to this, DeLorme made an important distinction between training for muscular strength and training for muscular endurance. He stated that strength is best gained by using a heavy load while doing few repetitions, whereas muscular endurance is best gained by using light weight loads for many repetitions (30). The two methods are not interchangeable due to specificity of training.

DeLorme's technique (30, 31) was to increase the weight each set using different percentages of the 10 RM (Repetitions Maximum) until the subject was doing one set of the 10 RM. The weight was increased when the subject could do the 10 RM weight easily. Several investigators (49, 48, 37) compared this technique to one where the subject began with the 10 RM and took off weight as fatigue set in.

McMorris and Elkins (49) compared two groups using opposite methods. The first group increased in weight doing 10 repetitions with twenty five percent of the 10 RM, 10 repetitions with fifty percent of the 10 RM, and one set with the total 10 RM. The second group started with one set of the 10 RM, then did 10 repetitions with seventy five percent of the 10 RM, 10 repetitions with fifty percent of the 10 RM, and 10 repetitions with twenty five percent of the 10 RM. Both methods of training improved strength, but neither method proved to be significantly different.
McGovern and Luscomb (48) compared groups using different loads for 10 repetitions. The first group did one set of 5 repetitions using fifty percent of the 10 RM and one set of the 10 RM. The second group did one set of the 10 RM and one set of 10 repetitions with fifty percent, seventy five percent, and one hundred percent of the 10 RM. Although each group made gains in strength, there was no significant difference between groups.

The findings of Hellegrant and Houtz (37) were contrary to those of McMorris and Elkin, and McGovern and Luscomb. They compared DeLorme's technique with one where resistance is decreased as fatigue sets in and found there was better improvement from the overload technique used by DeLorme.

Following these studies, many researchers began to question the optimal number of sets, number of repetitions, and intensity of work required to increase muscular strength. Capen (19) compared four programs of varying numbers of sets and repetitions and found 3 sets of the 5 RM three times per week to be best for increasing strength. This was significantly different from 3 sets of 5 RM five times per week.

Berger then began a long series of studies (6, 7, 8, 10, 14) to determine the optimal training program for increasing strength. Berger (6) first tested 177 male college students using various combinations of one, two, and three sets and 2, 6, and 10 repetitions.
The nine groups trained on the bench press and were tested on the bench press for the 1 RM. He found that during three weekly exercise sessions for a period of twelve weeks, that the best results for increasing muscular strength were obtained with 3 sets of 6 repetitions per session.

In a similar, but slightly expanded study, Berger (8) used 199 college students who trained three times per week for twelve weeks. In this study the groups all used one set of either 2, 4, 6, 8, 10, or 12 repetitions. The exercise used in training was the bench press. Pre- and post tests were given for the 1 RM bench press. Of the various groups studied, 4, 6, and 8 repetitions were found to increase strength faster when using one set for a twelve week period.

Later Berger (10) again compared training programs of varied sets and repetitions in three groups. The subjects trained three times per week for nine weeks. Group one did 6 sets of the 2 RM; group two did 3 sets of the 6 RM; and group three did 3 sets of the 10 RM. This time Berger found that all groups made significant increases in strength, but no one group made faster progress than the other two. Berger suggests that these results might differ in a longer study. O'Shea (53) conducted an almost identical study for six weeks which varied only in the number of sets and the exercise used. Thirty college students were divided into three groups and trained using the deep knee bend. Testing utilized 1 RM deep knee bend and
knee flexion with a tensiometer. The first group did 3 sets of the 10 RM; the second group did 3 sets of the 5 RM; and the third group did 3 sets of the 2 RM. All groups produced an increase in both static and dynamic strength. No significant difference was found between groups.

Four years after Berger (10) and O'Shea (53) concluded their studies, their findings were confirmed by Withers (66). In this study, three groups using varying sets and repetitions trained two times per week for nine weeks on the curl, squat, and bench press. The first group performed 3 sets of the 7 RM; the second group did 4 sets of the 5 RM; and the third group did 5 sets of the 3 RM. The test procedure used was to do a 1 RM using the three training exercises. Withers found that all groups made significant gains in strength, but no group attained improvement significantly different from any other group.

Berger (7, 14) also examined the effects of varied load as opposed to varied repetitions in different training groups. In the first of these two studies (7) he had subjects in two groups train for twelve weeks using the bench press. The first group did 10 repetitions with ninety percent of the 10 RM two times per week and the 10 RM once per week. The second group did the 10 RM three times per week. Both groups made increases in strength, but neither group was significantly different from the other. Berger came to the conclusion
that training with this sub-maximal load was as effective as training with a maximal load. In a much later study, the same author (14) increased the intensity of work for one group which did 10 repetitions using maximum load on each repetition. Essentially, the 24 subjects were doing a rapid series of ten 1 RM with no rest between repetitions. The second group did the 10 RM. Berger found that the group using maximum load on each repetition made faster increases in strength.

**Static Training**

Static training occurs when a static contraction, or a series of static contractions are done in an effort to increase muscular strength or muscular endurance. During a static or isometric contraction the individual muscle fibers contract, but do not shorten; therefore the muscle itself does not shorten. All this takes place because the load is greater than the contractile force of the muscle. Consequently, no skeletal movement takes place. The individual fibers do not need to shorten in order to develop tension. Technically no work is done, and the energy which the muscle uses is dissipated as heat.

The first clinical work done in the area of isometric training was that of Hettinger and Muller (16, 38) in 1953. From their German laboratory came reports of an increase of five percent per week in static strength when doing one daily isometric contraction with two thirds maximum tension for four to six seconds. Their work
involved 71 separate experiments over a period of eighteen months. All training and testing was in the form of isometric work on a spring scale. Their observations were made on forearm flexors and extensors.

This formula for increasing strength was simple as compared to DeLorme's progressive resistance exercise method. Many investigations involving isometric and isotonic training were to follow which would test the validity of Hettinger and Muller's original work.

Much later Hettinger (39) explained more about his studies and about the research being conducted in Germany on isometric training. By this time some of the findings first presented by Hettinger and Muller (16, 38) had been revised slightly. Hettinger stated that the percentage increase per week in static strength relative to initial values was dependent upon which muscle group was being trained. For example, the forearm flexors could only gain one percent per week, the biceps two percent per week, the triceps three percent per week, the gluteus maximus four percent per week, and the gastrocnemius muscles up to six percent per week (39). Hettinger still claimed that one four to six second contraction per day with a load as low as forty to fifty percent maximum, or one, 1 second contraction per day with a load of one hundred percent maximum was enough to
obtain the maximum training effect. This was claimed to be as effective as many maximum contractions per day.

Muller (16, 50), and Muller and Rohmert (51, 60) reported that analysis of their data revealed average weekly increases in strength were directly related to the intensity of the training load. The more intense the load, the more pronounced the increase in strength. Muller also stated that the rate of increase in strength and theoretical maximum or limit strength was great. The rate of increase per week became less as the subject came closer to his theoretical maximum.

Many investigators have found that isometric training can be used to increase, muscular strength. Those researchers comparing only various isometric training programs include: Rarick and Larson (55), Meyers (47), Cotton (28), Muller (52), Byrd and Hills (17), and Gardner (35).

Rarick and Larson (55) tested Hettinger and Muller's findings concerning static training. They did a four week study with thirty male subjects in which they compared two groups using different static loads and intensities. The first group did one daily 6 second contraction with a two-thirds maximum load. The second group did five to eight daily 6 second contractions with eighty percent maximum. Rarick and Larson reported that several daily static contractions produced as much as two and one half times the increase in strength as the once daily 6 second contraction.
Meyers (47) compared different isometric training methods using 33 male college students. The study lasted six weeks and the subjects trained using the forearm flexor muscles. In comparing one group which performed three 6 second contractions three days per week with a group which performed twenty repeated 6 second maximum contractions three days per week, he found that 20 repeated 6 second contractions were significantly different from three for increasing static strength.

Cotton (28) tested the effect of various static loads on increasing muscular strength in high school students. Forearm flexor muscles were trained using one isometric contraction per day with either twenty five percent, fifty percent, seventy five percent, or one hundred percent maximum static load. The contraction was continued until exhaustion. All groups except the group using twenty five percent maximum load made increases in static strength. Cotton therefore concluded that an exercise load of fifty percent maximum or more using one contraction per day would increase strength.

In 1971, Muller (52) stated as before that a one second maximum contraction per day is as efficient for gaining strength as any method requiring a higher intensity of training. He claimed that static training is best for obtaining strength because maximum tension is produced. Muller also found that strength levels near a subject's
theoretical maximum can be maintained with a maximum isometric contraction of one second once every two weeks.

Testing grip strength, Byrd and Hills (17) found increases in strength and endurance due to isometric training. They trained six male subjects for a period of four weeks with daily maximum grip strength contractions lasting until strength was reduced to fifty percent maximum due to muscle fatigue.

Gardner (35) also found that strength increased due to static training, but discovered that static strength is gained only at the specific angle of static training. Gardner (35) did an extensive study in which three groups doing isometric knee extensions trained at three different angles. Each group did three, six second contractions with two-thirds maximum three times per week. One group trained at 115 degrees, one at 135 degrees, and one at 155 degrees. All groups were tested statically at each of the three angles. Gardner found that each group made gains in strength, but only at the angle used in training. He states that "isometric technique may not be ideal for improving dynamic skill performances where strength is required through a considerable range of motion" (35). Bender and Kaplan (4) supported Gardner's conclusion that static strength is gained only at the angle of static training when they looked at the effect of injury or surgery on muscle strength. They noted that an injury may affect the muscle only at a specific angle, and the muscle must be trained
at that angle for rehabilitation. DeVries (38), and Bender and Kaplan (5) agree with the idea that isometric or static strength is specific to the angle at which the muscle has been trained.

Many other investigators have found both static and dynamic training programs to be effective when comparing the two to determine which method is most efficient. However, those studies will be considered in the following section on comparison studies.

**Comparison of Dynamic and Static Training**

Since dynamic and static training methods have been shown to be effective in increasing muscular strength, many research studies have been undertaken to determine which method of exercise produces strength faster. Of the twenty two studies reviewed by this author which compare dynamic and static training methods, two studies indicate that dynamic training was more effective for increasing strength; six studies indicate that static training was more effective; and fourteen studies indicate that neither method increased strength differently from the other method.

The two studies which found dynamic training to increase strength faster than static training were conducted by Darcus and Salter (29), and by Berger (11). In their study which was completed shortly after Hettinger and Muller's work (38), Darcus and Salter (29) trained two groups of six subjects on pronation and supination
of the hand for up to 28 days. One group did 30 maximum isometric contractions per day, five days per week. The other group did 30 isotonic contractions per day, five days per week. The subjects were then tested both isometrically and dynamically. Both groups were shown to have made increases in strength. In further analysis of their data, Darcus and Salter found that dynamic training caused greater strength increases than did isometric in this particular training program for five to twenty eight days. Berger (11) tested the effects of four different exercise programs on vertical jumping ability. Group number one did one set of deep knee bends for the 10 RM. Group two did one set of deep knee bends with sixty percent of the 10 RM for 10 repetitions. Group three trained quadracepts statically using two different positions and doing one maximum contraction for six to eight seconds at each session. All groups trained for three sessions each week for a period of seven weeks. Berger concluded that dynamic overload training was more effective for increasing vertical jumping than static training or vertical jumping.

Much evidence is available that would indicate static training brings faster increases in muscular strength than does dynamic training. Baer (2) divided 63 subjects into four isotonic and two isometric groups in studying flexor muscles of the hand. The first group trained isotonically doing 10 repetitions per minute with a load of 28.6 pounds. The second group trained isotonically doing 30
repetitions per minute with 34.2 pounds, and the fourth also trained isotonically doing low resistance work for 10 repetitions per minute with 3.25 pounds. The fifth and sixth groups trained isometrically doing 10 contractions per minute with 24.5 and 50.0 pounds tension respectively. After six weeks of training, Baer reported that the group which trained isometrically doing 10 repetitions per minute with 50.0 pounds tension produced strength increases significantly different from the other five groups.

Mathews and Kruse (46) trained 120 college students using dynamic and static methods. Four static groups did three 6 second maximum contractions two, three, four, or five days per week. Four dynamic exercise groups did a three-sixteenth maximum contraction to exhaustion on a Kelso-Hellebrandt ergometer two, three, four, or five days per week. All groups exercised the elbow flexor muscles for four weeks. The groups were tested isometrically, and the static groups had the most subjects who made gains in isometric strength. Also, the increases in strength became greater as the exercise groups increased the frequency of exercise.

Asa (1) studied the effects of isometric and isotonic training on three groups using an abductor muscle of the finger. All three groups trained four days per week for twelve weeks. One group trained by doing one 6 second maximum isometric contraction daily. The second group did twenty 6 second maximum isometric contractions
daily, and the third group exercised isotonically. All training programs produced gains in strength when tested isometrically. However, the group that did 20 maximum isometric contractions daily made greater increases in strength than the other two groups.

Liberson and Asa (44) trained twenty six individuals comparing DeLorme's method (30) to one 6 second maximum isometric contraction daily and twenty 6 second maximum isometric contractions daily. The subjects trained for twelve weeks using isolated finger muscles. After both isometric and isotonic testing, these researchers found that the isometric groups made progress significantly different from the isotonic group using DeLorme's method. And that twenty 6 second isometric contractions per day were more effective than one 6 second maximum contraction for increasing strength.

Bowers (15) trained sixty one male subjects in four groups. The first group was a control group which did not train. The second group trained isometrically using the elbow flexor muscles doing five maximum contractions per day. The third group trained using a method Bowers called "static" training. This was not isometric training, but involved moving the elbow joint through a complete range of motion using only the antagonistic muscles as resistance. One repetition took 15 seconds and was repeated five times per day. The last group trained using a method Bowers called "auto-suggestion". The subject simply flexed the desired muscles for 15 seconds five
times per day. All groups trained three days per week for six weeks. The groups were tested isometrically and all three exercise groups increased in strength. Of the three exercise groups, the isometric group was found to be significantly different from the "static" or "autosuggestion" groups for increasing strength. The control group made no gains in strength.

Whitley and Smith (66) reported static training better than dynamic training for increasing strength. Both training methods increased speed of limb movement. Four groups of twenty six subjects trained twice per week for ten weeks. They tested lateral arm movement isometrically for strength and also dynamically for speed of movement. The first group was a control group which did no training; the second group simply did free arm swing movements six times per workout through the range of motion. Subjects in the third group, called the isometric-isotonic group, did one, six second maximum isotonic contraction at each of six angles throughout the range of motion every training period. They were then allowed to train isotonically on different body parts for general musculature. The fourth and last group did dynamic overload training for six repetitions each workout. This was accomplished by adding weight to a free-swinging lever arm which moved through the range of motion. Both the dynamic and isometric-isotonic groups increased in speed of movement and strength, but after isometric testing, the
isometrically trained group made significantly different increases in strength from the dynamic overload group.

Many of the studies cited which found static training more efficient for gaining strength also used isometric testing procedures exclusively. This subject will be treated later in the review, as several investigators (5, 9, 45, 58, 63) have done research in this area of testing procedure.

Despite the research that favors one or the other training method, a majority of the studies reviewed reported no significant difference between various static and dynamic exercise programs for increasing muscular strength.

In 1955, Salter (61) conducted a four week study in which she compared isometric and isotonic training of the forearm supinator muscles. The isometric training groups did one, four second contraction up to maximum tension. The isotonic groups did a four second repetition using a load of seventy five percent maximum. Two groups trained isometrically doing two or fifteen contractions per minute respectively. Salter decided to use only isometric testing although she states that isometric testing may show greater progress in those groups which trained in an isometric manner. All four training groups made increases in strength, but no method was shown to be more effective than the other three groups.
In a later study, Rose and associates (59) compared DeLorme's (30) overload technique with isometric contractions using leg extensions. Ten subjects in the DeLorme group trained five days per week, and twenty six subjects in the isometric group did one 5 second maximum isometric contraction five days per week. Testing was done using a combination of dynamic and static movement in which the subject did a partial leg extension and held it for five seconds. Rose reports that both groups made increases in strength, but neither method of training was significantly different from the other for increasing strength.

Rasch and Morehouse (56) conducted a six week study involving arm curls and military presses. Two groups were used, one for dynamic training and one for static. The dynamic group did 3 sets of the 5 RM in each exercise and the static group did three 15 second isometric contractions with two-thirds maximum. The results showed no significant difference between groups for increasing strength. However, Rasch and Morehouse indicate that there is no satisfactory way to equate the energy expenditure in isotonic and isometric exercise.

Dennison and colleagues (33) attempted to determine how dynamic and static training affected the ability of twenty male subjects to do chin ups and dips. One group trained dynamically on chin ups and dips doing 5 sets of the 10 RM two times per week. The second
group performed sixteen different exercises doing one maximum
isometric contraction of 6 seconds in each exercise twice per week.
After eight weeks of training, the two groups had almost identical
test scores in chin ups and dips with no significant difference between
groups.

Berger (12), in another of his many studies, attempted to deter-
mine whether static or dynamic training was better for increasing 1
RM bench press strength. This was a twelve week study in which he
compared one static weight training program with nine dynamic
weight training programs. All groups were tested three times per
week on the 1 RM bench press. The dynamic groups used a variety
of sets and repetitions while the static group did a six to eight
second maximum isometric contraction at two different positions
within the bench press range of motion. Berger's analysis shows that
static training was better than dynamic training with 2 sets of the 2
RM. Static training was as effective as dynamic training with 2 sets
of 6 RM, 1 set of the 10 RM, 2 sets of the 10 RM, and 3 sets of the
10 RM, but was not as good as dynamic training with 3 sets of the 6
RM. Berger concluded that neither method was significantly different,
but that the static training permits more sessions per week because of
lack of fatigue and therefore could be more effective. Later, Berger
and Henderson (13), in studying the relationship of static and dynamic
training to power with sixty six subjects, showed that neither dynamic
leg strength nor static leg strength is more related to power than the other. They state that "Although there was no significant difference in the relationships of static and dynamic strength to power, this would not indicate that static strength can be predicted with high accuracy from dynamic strength or vice versa" (13).

Gertsen (36) studied the effects of isotonic and isometric training on therapeutic patients with weakness of the quadriceps and hamstring muscles. The subjects trained one side of the body isometrically and the other side isotonically. Bersten found that muscular improvement was the same after isometric or isotonic training.

Chui (21) devised a study similar to that of Whitley and Smith (66) in that he tested the effects of different training methods on both strength and speed of movement. Chui worked with ninety six subjects divided into four groups. The groups trained on, and were tested on six different exercises: military press, bench press, curl, squat, stiff leg dead lift, and sit ups. The four groups consisted of 1) a control group, 2) an isometric group, 3) rapid dynamic group, and 4) slow dynamic group. The isometric contraction group did three sets of one contraction in each of the six exercises. The contractions lasted for six seconds and were done with the 10 RM load. The rapid dynamic group did three sets of the 10 RM in each exercise as rapidly as possible through the complete range of motion. The slow dynamic group also did three sets of the 10 RM in each exercise,
but did each repetition more slowly, taking four seconds per repetition. All groups were tested with a cable tensiometer for static strength, and were also tested for speed of movement times in each exercise. The programs lasted for nine weeks with the subjects training three days per week. Chui found that all groups except the control group made increases in strength or speed of movement.

Belka (3) compared static training, dynamic training, and a combination of the two methods on dominant wrist flexor muscles. He used five subjects in each of four groups. Groups consisted of a control group, a static training group, a dynamic training group, and a combination of static training and dynamic training group. The exercise groups trained daily for five weeks. The static group did 6 sets of 3 contractions. Contractions lasted for 3 seconds, and the subjects did two sets of each of three different angles. The dynamic group did 6 sets of 3 RM through the entire range of motion. The combination group did 3 sets of static work and 3 sets of dynamic work exactly like the static and dynamic training of groups one and two. No training was done by the control group. Belka utilized both static and dynamic tests for measuring strength and found no significant difference among exercise groups in strength increases.

Coleman (25, 26, 27) has reported three investigations similar to Belka's in that each study attempted to equalize trainability of the subjects, load used in each method of training, duration of exercise,
and range of movement for both the dynamic and static groups.

In the first study reviewed, Coleman (25) compared isometric and isotonic exercise on contralateral limbs. Four groups were used with each group doing different exercise programs involving elbow flexion. Sixty three male subjects participated in this eleven week study and trained three days per week. The subjects were placed in one of four groups. Group number one trained isometrically on the right side and isotonically on the left side. Group two trained isometrically on the left side and isotonically on the right side. In group three, one half of the subjects used the isometric method on the right side and did nothing on the left side, while the other half of the group used the isotonic method on the left side and did nothing on the right side. In group four, one half of the subjects trained isotonically on the right side and did nothing on the left side, while the other half trained isometrically on the left side and did nothing on the right. Isotonic training consisted of 2 sets of curls for the 5 RM each training session. Total contraction time came to forty seconds per session. The isometric method consisted of two contractions of twenty seconds with the same load as used in the isotonic exercise program. The total contraction time was again forty seconds per session. All four groups were tested both statically and dynamically.

Coleman concluded that isotonic and isometric training are equally effective when the intensity is the same for both methods. He
suggests that programs which compare maximum with submaximum contractions, or that compare long and short contraction times, or strength at different exercise angles are not accurate because the intensity of training is not the same.

Coleman (26, 27) conducted two additional studies which were very similar to the first. These studies also looked at elbow flexion in contralateral limbs and tried to equalize intensity of training by equalizing load, duration, and trainability of subjects. In both studies, Coleman found that there was no significant difference between the two methods of training. He concluded that gains in muscular strength following isometric and isotonic training occur at a similar rate when intensity of training is equal.

Several other studies which have not actually compared different training programs may shed some light on the methods of dynamic and static training. Rasch (57), and Rasch and Pierson (58) tried to determine the relationship between isometric tension and different types of isotonic movement. Rasch (57) found no significant difference between isometric and isotonic strength scores for elbow flexion following a six week program of isotonic curls and presses. He concluded that isometric scores can predict isotonic strength. Later, Rasch and Pierson (58) tested the relationship between isotonic, isometric, and breaking point strength scores of forearm flexors. They again found that isometric, isotonic, and breaking point strength
tests gave similar results, with no significant difference between scores.

Bender and Kaplan (5) supported the above findings when they attempted to determine if dynamic strength can be evaluated isometrically. One hundred twenty eight male subjects were tested isometrically to see if the researchers could predict failure in a similar isotonic task. The isotonic exercise chosen was chinning for 1 RM. The results showed that failures in the dynamic exercise could be predicted by previous isometric tests. Subjects who failed to do the 1 RM chin up were trained to increase strength. Those who eventually became successful in the 1 RM chin up also reached the predetermined isometric levels predicted for chinning success. However, because the isometric testing occurred at three different angles and it was found that failure could occur at any one angle, Bender and Kaplan stated "that failure in a given movement may be caused by a lack of strength only at a specific region in the range of motion, and that some external assistance in passing through that region can produce success" (5). This conclusion substantiates the idea that isometric strength occurs only at or near the angle of training.

Berger (9), Martens and Sharkey (45), and Shephard (63) do not agree that isometric test scores can predict dynamic strength and vice versa, or that isometric training can increase dynamic strength. Berger (9) found that dynamic strength increases more than static
strength when the training involved dynamic contractions. He also found that static strength improved more by training statically than dynamically. In addition to this, Berger concluded that 1) a static strength test is not as accurate as a dynamic strength test for measuring changes in strength resulting from dynamic training, and 2) a dynamic strength test is not as accurate as a static strength test for measuring changes in strength resulting from static training.

Martens and Sharkey (45) computed correlations between dynamic strength, dynamic endurance, static strength and static endurance of forearm muscles in twenty subjects. They found that the four different areas correlated were not significantly related. They recommended that dual strength tests be used when static and dynamic training are to be compared.

Shephard (63) makes an important distinction between isometric training and testing, and isotonic training and testing. He states that they are not interchangeable, and that isometric training results in isometric strength, while isotonic training results in isotonic strength.

**Functional Isometric Training**

Functional isometric training is a system of training that utilizes isotonic movement followed by isometric contraction. This type of training system was first discussed in detail by Hoffman (42).
Hoffman calls his advanced course of functional isometric contraction a system of training where a barbell is moved through a partial range of motion and then held isometrically for a given number of seconds. This type of training is done in a power rack where a loaded barbell is placed in the desired position resting on steel pins (Figure I). Additional steel pins are placed approximately two inches above the barbell. The subject lifts the barbell to the top pins (isotonic contraction) and holds that position (isometric contraction) for a predetermined number of seconds. Hoffman then outlines detailed positions of many weight training exercises for which this training method can be used. Most of these exercises deal with competitive weight lifting exercises, or exercises for other athletics. Despite a detailed account of the value of this training method, most of Hoffman's book consists of only practical experience in competitive athletics. No scientific studies are cited although mention is made of scientific work in this area. Hoffman states that the functional isometric training method would revolutionize weight training (42).

O'Shea (58) has dealt with functional isometric training in some detail. He states that functional isometric training may be of value in developing 1) the central nervous system in achieving maximum muscle tension, 2) explosive power, 3) maximum force in selected muscle groups, and 4) greater ligament and tendon strength in joints. O'Shea suggests that for competitive athletics, functional isometric
Figure I. Power Rack
training should be carried out two to three days per week along with other isotonic training two times per week.

The physiological effects of this type of training have yet to be established. Because the weight is positioned at the optimal angle of strength for each exercise, a very intense training program is used. The subjects can also see daily changes in strength because they are training with weights and not just doing a pure isometric contraction on a static bar. Some questions which should be investigated further are: Does this type of functional isometric training cause static strength increases only at the angle of training? Does functional isometric training cause an increase in dynamic strength? These questions will be considered in the Discussion of Results.

**Isokinetic Training**

Another method of strength training is isokinetic training. Isokinetic training is a system which utilizes increased resistance with any increase in muscle contraction tension. In this way the muscle is exerting maximum tension throughout the full range of motion. Because of this, the speed of movement is slow. This type of resistance is often accomplished by a hydraulic plunger attached to an exercise machine or by a type of centrifugal clutch.

Studies by Hinson and Rosentswie (40, 41) look at electromyographic comparisons of isokinetic, isometric, and isotonic
contractions. In the first study (40) they state that isokinetic con-
tractions elicited greater muscle action potentials than isometric or
isotonic contractions. However, in their second study Hinson and
Rosentswieg (41) state that no type of contraction elicits the greatest
muscle action potential for all subjects, but here indicate that iso-
metric contraction appears to produce the greatest potential. Thistle
and associates (64) actually tested training programs of isokinetic,
isometric and isotonic exercise in a study involving fifty one subjects.
This study indicates that isokinetic training was better for increasing
strength in an eight week study.

Summary

Research shows that both dynamic and static training methods
develop muscular strength. However, much confusion concerning
the optimal training program for increasing muscular strength
pervades the literature. In spite of the many studies in the areas
of dynamic and static training, the optimal method for each type of
training is not yet established. Some studies reviewed favor either
dynamic training or static training, but the majority of the research
indicates that there is no difference in the training methods for
increasing strength.

Much of the literature mentions the fact that the type of strength
increase is specific to the type of training, and that the correlation
between dynamic training and static strength, or between static training and dynamic strength is low. When both dynamic and static strength tests are utilized for measuring progress, this specificity of training method to type of strength increase should be evident.

Several investigators indicate that isometric strength is very specific to the angle of isometric training. If this is so, the usefulness of static training would be limited in situations where strength through a range of motion is called for. More research must be conducted to determine the relationship between dynamic movement during an activity and static strength.

Information available concerning functional isometric weight training merely describes the method of training. Scientific research exploring the effectiveness of functional isometric training is lacking. A review of the literature in fact revealed no research concerning functional isometric weight training. The present study attempts to determine the effectiveness of functional isometric weight training in increasing dynamic and static strength and to compare functional isometric training to a dynamic weight training program.
This study was conducted during winter term, 1973, at Oregon State University, Corvallis, Oregon. The facilities and equipment of the Exercise Physiology Laboratory and the weight training room of the Department of Physical Education were utilized for the testing and training. The purpose was to compare two progressive resistance weight training methods, dynamic weight training and functional isometric weight training, to determine their effects on dynamic and static strength. The null hypothesis tested was: at the conclusion of the eight week experimental period no significant difference in dynamic or static strength will result from dynamic or functional isometric training.

The statistical analysis for this study was conducted at the facilities of the Oregon State University Statistics Department. The tests selected for analysing the data was the paired t test and analysis of variance. The .05 level of significance was used in accepting or rejecting the hypothesis. The results were analyzed in graphs and the percentages of increase were calculated.

Subjects

The subjects for this study were sixteen healthy male college students ranging in age from nineteen to twenty seven years. The
mean age was 21.4 years. All subjects were volunteers from two advanced weight training classes and had a minimum of two terms of weight lifting experience. Prior to being assigned to one of the two experimental training groups (Group A or B), the subjects were paired on the basis of the dynamic pre-training strength test. This procedure minimized any statistically disproportionate strength difference that existed between the two test groups. Following the pairing, the subjects were then randomly assigned to either Group A, the dynamic test group, or Group B, the functional isometric test group, for the eight week experimental test period. Although there was a difference in absolute values between groups in the four pre-tests, the values were not significantly different.

Schedule

Monday, prior to the first week of the experimental training period, the subjects reported to the weight room for the dynamic strength test consisting of the bench press and squat. The subjects were briefed on the testing procedures and were tested on the bench press and then on the squat. Wednesday, all subjects reported to the Exercise Physiology Laboratory. An explanation of the static testing procedures was conducted, following which the subjects were tested first on shoulder flexion and then on knee extension. Friday, all subjects again reported to the weight room where information
sheets were distributed on the training programs to be followed. All aspects of the two training programs were described and demonstrated. At this time, one training period was provided for the subjects to familiarize themselves with their respective training program (see Training Methods, p. 47). Too, the subjects were requested not to engage in other strenuous activities for the duration of the study.

Following this initial week of testing and familiarization, the subjects trained one and one half hours two days per week for an eight week period. All training periods were closely supervised to insure that proper form and correct training procedures were followed.

During the fourth week of training, another testing session was conducted following the same procedures as in the pre-test. On Monday, the subjects were tested dynamically and on Wednesday, statically. The subjects resumed their regular exercise schedule on Friday.

Following the mid-study tests, the subjects continued to train two days per week for four more weeks. On the Monday following the conclusion of the eight week experimental training period, the final dynamic tests were given to all subjects. The tests followed the same procedures as the two previous sessions. Wednesday, the final static tests were given to all subjects again following previous testing procedures.
Statistical Design

G1

P1 Shoulder Flexion

P2 Knee Extension

P3 Bench Press

P4 Squat

T1  T2  T3

G1
Test Description and Procedure

In measuring the effects of two training methods on dynamic and static strength the following tests were utilized.

Dynamic Strength Tests

The 1 RM in both the bench press and squat were executed according to the Amateur Athletic Union rules for competitive weightlifting (65).

Bench Press. In executing the bench press, the subject was in a supine position, feet in contact with the floor. The subject lowered the barbell from an arms extended position down to the chest and back up to an arm extended position. In order for the attempt to be deemed a success, the bar touched the chest with no bounding; the buttocks remained in contact with the bench; and the arms extended evenly. The heaviest weight successfully pressed was recorded as the subject's 1 RM.

Squat. In executing the squat, the subjects lifted the loaded barbell off of the rack and onto the shoulders. For balance, the subject was allowed to place a two inch thick board under his heels. The subject squatted down until the tops of his thighs were parallel with the floor and then extended his legs and back in returning to the standing position. The heaviest weight squatted was recorded as the
subject's 1 RM.

**Equipment.** The equipment used consisted of a seven foot long Olympic standard barbell, weights, a rack for supporting the barbell until the subject placed the bar on his shoulders to execute the squat test, and a 14 inch high bench with vertical uprights to support the bar until handed to the subject for performing the bench press.

In testing for dynamic strength, the subjects were tested first on the bench press and then after a one half hour rest were tested on the squat. Prior to dynamic testing, all subjects were given a brief warm up with light weights. Each subject was allowed as many attempts as necessary to reach his maximum weight. (Most achieved maximum weight in three attempts.) The order of testing was set by the amount of weight each subject desired for his first attempt. The barbell was loaded with the lightest weight desired by any subject and was increased in weight until each subject had taken his first attempt. This process was repeated until all subjects reached their 1 RM.

**Static Strength Tests**

Static, or isometric strength, was determined using an aircraft cable tensiometer. Testing procedures were according to those described by Clarke (22, 23). Static strength was defined as the tension against a cable produced by a contracting muscle. The
tension of the cable was measured by the tensiometer. Subjects were tested at 180 degrees for shoulder flexion and at 115 degrees for knee extension.

**Shoulder Flexion.** For the shoulder flexion test the subject assumed a supine lying position with his knees flexed, feet flat on the testing bench and left arm resting on the chest (Figure II). The upper arm on the side tested, in this case the right side, was close to the subject's side with the shoulder flexed at 180 degrees and the elbow in 90 degrees flexion. A regulation strap was placed around the upper arm halfway between the elbow and shoulder joints. The pulling assembly ran vertically and was hooked to the table runner below the subject's arm. Each subject was held by a testor to prevent shoulder and hip elevation. The testor adjusted the joint angle of each subject being tested and made sure the cable was taut at the start of each pull.

**Knee Extension.** For the knee extension test the right knee was used. The starting position had the subject sitting and leaning backward with arms extended to the rear and hands grasping the sides of the table (Figure III). The right knee was in 115 degrees extension. A regulation strap was placed midway between the knee and ankle joints. The pulling assembly was attached to a hook at the lower end of the table. The subject was not allowed to lift the buttocks or flex the arms during the pull. The testor adjusted the joint angles of each
Figure II. Shoulder Flexion Test.
Figure III. Knee Extension Test.
subject and checked to be sure the cable was taut at the start of each pull.

**Equipment.** A standardized tensiometer, chain, strap, and cable were used throughout the testing. None of the equipment was used for any other research during the time this study was underway. A standard cable test bench was used for all static testing.

Both shoulder flexion and knee extension were tested the same day. First the shoulder flexion test was administered, and then after a rest period of one half hour, the knee extension test was given. The tests required two testors. Each subject was given two trials for each test, and rest was given between trials. The average of the two trials was recorded as the subject's static strength. Subjects warmed up with light exercise and stretching before taking the tests. The order of testing was determined during the first knee extension on a volunteer basis. After that, the same order was maintained. The subjects were not allowed to see the results until everyone had been tested. Instructions were given to all subjects at the same time.

**Training Methods**

**Dynamic Weight Training Program**

The dynamic weight training program consisted of two exercises; the squat (deep knee bend) and the bench press. In training, the
subjects performed these exercises exactly as tested, which was according to Amateur Athletic Union rules (65). In both the bench press and squat exercises, the subjects were required to do 5 sets of the 5 RM following a warmup with light weights. Time for rest was given between each set. When the 5 RM load became easy, the subject added weight until the new 5 RM was determined. For the bench press, the subjects exercised on the same bench that was used for testing.

**Functional Isometric Weight Training Program**

Functional isometric training was performed using a power rack on which the barbell was suspended at any desired position (Figure IV). A power rack consists of four 4 inch diameter steel pipes which extend vertically from floor to ceiling. The position of the upright pipes on the floor forms a rectangle forty four inches wide and ten inches deep. The pipes are drilled with holes every two inches, and a fourteen inch long steel pin can be placed through the holes in each of the two pipes on either side. These pins can then support a loaded barbell at any height parallel to the floor.

The subjects trained at two positions for the bench press and squat. The positions for functional isometric training were as follows:
Bench Press, Position Number One. The barbell was placed six inches below the level of full arm extension (Figure IV).

Bench Press, Position Number Two. The barbell was placed four inches above the level of the chest (Figure V).

Squat, Position Number One. The barbell was placed one half the distance between the height at full extension and the height in the squat position when the thighs were parallel to the floor (Figure VI).

Squat, Position Number Two. The barbell was placed at the height it would be when the subject was in a squat position with the tops of the thighs parallel to the floor (Figure VII).

Five sets of the 2 RM were repeated at each position. A repetition consisted of moving the barbell from the supporting pins to the top pins two inches above the bar (dynamic contraction), and then holding the barbell against the top pins for three to five seconds (static contraction).
Figure IV. Bench Press, Position Number One Functional Isometric Training.
Figure V. Bench Press, Position Number Two Functional Isometric Training.
Figure VI. Squat, Position Number One Functional Isometric Training.
Figure VII. Squat, Position Number Two Functional Isometric Training.
IV. ANALYSIS AND INTERPRETATION OF DATA

In order to evaluate the effects of functional isometric and dynamic weight training on dynamic and static strength, the null hypotheses were formulated. The techniques used to analyse the data were a paired t test and analysis of variance. The analysis for this study was conducted by the Oregon State University Statistics Department. A .05 level of significance was selected to test the results of the statistical analysis. The results were also analyzed in graphs and mean percentages were calculated.

Results

The summary of dynamic and static strength changes over the exercise period appears in Table I. Data generated were statistically treated using a paired t test. The t test within groups was used to determine if the groups differed significantly in dynamic or static strength. Results for both group A and group B were statistically significant at the .05 level in all strength parameters tested (Table II). These results required rejecting hypothesis one which states: no significant difference in dynamic or static strength will result from dynamic or functional isometric training. The results also required accepting sub-hypotheses one and two which state: a significant difference in the strength parameters tested will result from dynamic...
TABLE I. SUMMARY OF DYNAMIC AND STATIC STRENGTH CHANGES OVER EXERCISE PERIOD IN STRENGTH PARAMETERS TESTED.

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Initial Mean (lbs.)</th>
<th>Middle Mean (lbs.)</th>
<th>Final Mean (lbs.)</th>
<th>Average Change</th>
<th>Standard Deviation</th>
<th>Total % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Extension</td>
<td>A</td>
<td>214.25</td>
<td>227.12</td>
<td>279.0</td>
<td>64.75</td>
<td>182</td>
<td>64.88</td>
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<tr>
<td>Knee Extension</td>
<td>B</td>
<td>188.86</td>
<td>229.62</td>
<td>291.25</td>
<td>102.36</td>
<td>165</td>
<td>51.79</td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td>A</td>
<td>136.0</td>
<td>138.12</td>
<td>210.36</td>
<td>74.38</td>
<td>129</td>
<td>41.36</td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td>B</td>
<td>137.0</td>
<td>152.87</td>
<td>218.63</td>
<td>81.63</td>
<td>95</td>
<td>31.80</td>
</tr>
<tr>
<td>Bench Press A</td>
<td></td>
<td>191.25</td>
<td>201.25</td>
<td>208.13</td>
<td>16.88</td>
<td>45</td>
<td>14.87</td>
</tr>
<tr>
<td>Bench Press B</td>
<td></td>
<td>205.63</td>
<td>215.0</td>
<td>220.63</td>
<td>15.0</td>
<td>40</td>
<td>12.55</td>
</tr>
<tr>
<td>Squat A</td>
<td></td>
<td>284.38</td>
<td>314.37</td>
<td>333.13</td>
<td>48.75</td>
<td>80</td>
<td>24.46</td>
</tr>
<tr>
<td>Squat B</td>
<td></td>
<td>283.75</td>
<td>308.75</td>
<td>320.66</td>
<td>36.88</td>
<td>90</td>
<td>30.81</td>
</tr>
</tbody>
</table>
### TABLE II. SUMMARY OF t TEST RESULTS.

#### t Test Within Group:

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Group</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Flexion</td>
<td>A</td>
<td>$t = 5.087^*$</td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td>B</td>
<td>$t = 7.285^*$</td>
</tr>
<tr>
<td>Knee Extension</td>
<td>A</td>
<td>$t = 2.823^*$</td>
</tr>
<tr>
<td>Knee Extension</td>
<td>B</td>
<td>$t = 5.592^*$</td>
</tr>
<tr>
<td>Bench Press</td>
<td>A</td>
<td>$t = 3.211^*$</td>
</tr>
<tr>
<td>Bench Press</td>
<td>B</td>
<td>$t = 3.385^*$</td>
</tr>
<tr>
<td>Squat</td>
<td>A</td>
<td>$t = 5.638^*$</td>
</tr>
<tr>
<td>Squat</td>
<td>B</td>
<td>$t = 3.385^*$</td>
</tr>
</tbody>
</table>

#### t Test Comparing Groups:

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Group</th>
<th>t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Flexion</td>
<td>-</td>
<td>$t = 0.363$</td>
</tr>
<tr>
<td>Knee Extension</td>
<td>-</td>
<td>$t = 1.449$</td>
</tr>
<tr>
<td>Bench Press</td>
<td>-</td>
<td>$t = 0.278$</td>
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<tr>
<td>Squat</td>
<td>-</td>
<td>$t = 0.872$</td>
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* = Significant at .05 level.
TABLE III. ANALYSIS OF VARIANCE FOR DYNAMIC STRENGTH CHANGES FOR TWO SUBJECT GROUPS WITH THREE REPEATED MEASURES.

**Squat**

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>F</th>
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<tbody>
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<tr>
<td>Error</td>
<td>1031.85</td>
<td>7</td>
<td>-----</td>
</tr>
<tr>
<td>Within</td>
<td>248.14</td>
<td>14</td>
<td>-----</td>
</tr>
<tr>
<td>Treatments</td>
<td>7529.69</td>
<td>2</td>
<td>30.675*</td>
</tr>
<tr>
<td>Groups X Treatments</td>
<td>142.19</td>
<td>2</td>
<td>0.579</td>
</tr>
<tr>
<td>Error</td>
<td>242.78</td>
<td>14</td>
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<tr>
<td>Total</td>
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**Bench Press**

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<td>Within</td>
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<td>14</td>
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<tr>
<td>Treatments</td>
<td>1031.77</td>
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<td>Total</td>
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* Significant difference beyond .05 level.
TABLE IV. ANALYSIS OF VARIANCE FOR STATIC STRENGTH CHANGES FOR TWO SUBJECT GROUPS WITH THREE REPEATED MEASURES.

**Knee Extension**

<table>
<thead>
<tr>
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<tr>
<td>Between SS</td>
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<td>.047</td>
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<tr>
<td>Error</td>
<td>4270.99</td>
<td>7</td>
<td>------</td>
</tr>
<tr>
<td>Within</td>
<td>1520.20</td>
<td>14</td>
<td>------</td>
</tr>
<tr>
<td>Treatments</td>
<td>29125.77</td>
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<td>21.938*</td>
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<tr>
<td>Groups X Treatments</td>
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<td>1.148</td>
</tr>
<tr>
<td>Error</td>
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**Shoulder Flexion**

<table>
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<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between SS</td>
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<td>------</td>
</tr>
<tr>
<td>Group</td>
<td>1776.33</td>
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<td>.745</td>
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<tr>
<td>Error</td>
<td>1055.85</td>
<td>7</td>
<td>------</td>
</tr>
<tr>
<td>Within</td>
<td>910.93</td>
<td>14</td>
<td>------</td>
</tr>
<tr>
<td>Treatments</td>
<td>24444.33</td>
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<td>35.161*</td>
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<tr>
<td>Groups X Treatments</td>
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<td>.590</td>
</tr>
<tr>
<td>Error</td>
<td>479.97</td>
<td>14</td>
<td>------</td>
</tr>
<tr>
<td>Total</td>
<td>----</td>
<td>47</td>
<td>------</td>
</tr>
</tbody>
</table>

* Significant difference beyond .05 level.
and functional isometric training.

The paired t test was also used to determine whether either group made changes significantly different from the other in dynamic or static strength. Results comparing the groups were not statistically significant for any of the four strength tests (Table II).

The summary of dynamic and static strength changes is presented in Table I. The results of the analysis of variance for two subject groups and three repeated measures as applied to changes in dynamic strength are presented in Table III. No significant F value for difference between groups resulted in either the squat test or the bench press test; however, a significant F value for difference between trials resulted for both the squat test and bench press test. No significant groups-by-trial interaction value resulted for either test.

The results of the analysis of variance for two subject groups and three repeated measures as applied to changes in static strength are presented in Table IV. No significant F value for difference between groups resulted in either the knee extension or shoulder flexion tests; however, a significant F value for difference between trials resulted for both the knee extension test and the shoulder flexion test. No significant groups by trial interaction value resulted from either test.


Discussion

The findings of this study support established research that dynamic weight training increases strength. The significant difference in static strength as a result of dynamic training reinforces the work of Rasch (57), Rasch and Pierson (58), and Bender and Kaplan (5) who found a high correlation between dynamic training and static strength. The results also indicate that this eight week program of functional isometric training increases both dynamic and static strength. There is no previous research in the literature which supports these findings relating to functional isometric training.

The paired t test comparing group A with group B indicated no significant difference between groups at the .05 level of significance in either dynamic or static strength. This supports the work of many researchers (12, 21, 25, 26, 27, 33, 36, 56, 59, 61) who found no significant difference between dynamic and isometric training methods. However, because the studies reviewed did not compare dynamic weight training with functional isometric weight training, a direct parallel cannot be drawn. It can be stated therefore, that in this eight week study comparing dynamic weight training with functional isometric weight training, no significant difference between the two groups in increasing dynamic or static strength.
occurred. This is the most important finding of this study and holds implications for competitive strength athletes such as Olympic weightlifters, shot putters, hammer throwers, etc. Functional isometric weight training may be of importance in supplementing the strength athlete's normal strength training programs.

According to the F values for differences between groups and the groups-by-trial interaction values, the conclusion can be drawn that the groups did not differ in either dynamic or static strength responses to the treatments, and the differences did not vary within the two groups. However, the results show significant F values for difference between trials in all four strength parameters measured. The treatment effects would then suggest a significant difference between the dynamic and functional isometric weight training programs used in this study as contributors to dynamic and static strength.

These findings would account for a different rate of increase for the parameters tested as shown in Graphs I through IV. In the two static tests (Graphs I and II) the functional isometric group (group B) made more rapid initial increases in mean static strength between trial one and trial two than did the dynamic group. However, in the dynamic tests (Graphs III and IV), the dynamic training group continued with a greater increase in the mean dynamic strength between trials two and three than did the functional isometric group.
Graph II  Mean Increase for Shoulder Flexion

Mean Pounds Increase

Pre Test  Mid Test  Post Test
135  145  155  165  175  185  195  205  215  225  235

Group A

Group B

Mean Percentage Increase

Pre Test  Mid Test  Post Test
0  10  20  30  40  50  60  70  80  90  100
GRAPH III MEAN INCREASE FOR SQUAT

Pre Test  | Mid Test | Post Test
---------|----------|----------

Group A

Group B
GRAPH IV  MEAN INCREASE FOR BENCH PRESS

MEAN POUNDS INCREASE

MEAN PERCENTAGE INCREASE
An explanation of strength development provides a possible answer to the difference between trial variation for the strength parameters tested. Muscular strength increases in two ways: one, there is a change in the composition of the muscle fibers and in the ability of the individual muscle fibers to contract; two, there is increased effectiveness of the nervous system to utilize motor units during a contraction (54, 63). Training such as the functional isometric method utilized in this study may be more closely related to increased nervous control of muscular contraction than to a change in muscle fiber composition. If this is the case, then the results of this study may indicate that training which brings about a change in neuromuscular control causes a more rapid increase in static strength than training which brings about a change in muscle fiber composition. This rapid increase may be another reason (along with definite effect on increase of dynamic or static strength) why functional isometric weight training is important for supplementing the strength athlete’s training.
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to compare two progressive resistance weight training methods - dynamic weight training and functional isometric weight training - to determine their effects on dynamic and static strength. Sixteen male subjects were randomly divided into two groups. Group A utilized dynamic weight training and group B used functional isometric weight training on the bench press and squat exercises. Both groups trained two times per week for eight weeks. Dynamic and static strength tests were administered at the beginning, middle, and end of the experimental training period. The test data were statistically treated using a paired t test and analysis of variance. The .05 level of significance was chosen for acceptance or rejection of the three null hypotheses. Results of the study required rejecting hypothesis one which states no significant difference in dynamic or static strength will result from dynamic or functional isometric training and required accepting sub-hypotheses one and two which state a significant difference in the strength parameters tested will result from dynamic and functional isometric training.

Conclusions

The following conclusions have been drawn as a result of
findings in this study.

1. **As a result of an eight week program of dynamic progressive weight training, a significant difference in dynamic and static strength occurred.**

2. **As a result of an eight week program of functional isometric progressive weight training, a significant difference in dynamic and static strength occurred.**

3. **Neither training method produced a significantly different change in either dynamic or static strength than the other method.**

**Recommendations**

As a result of the findings of this study the following recommendations are suggested for further research.

1. **Further research involving functional isometric weight training should be conducted for a longer experimental period with a greater number of subjects.**

2. **Further research involving functional isometric weight training should be conducted using highly trained strength athletes such as shot putters, hammer throwers, discus throwers, or Olympic style weight lifters.**

3. **Further research should be conducted comparing functional isometric weight training with pure isometric training.**
APPENDIX


<table>
<thead>
<tr>
<th>Group A</th>
<th>Knee Extension Test (lbs.)</th>
<th>Shoulder Flexion Test (lbs.)</th>
<th>Squat Test (lbs.)</th>
<th>Bench Press Test (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BL</td>
<td>227</td>
<td>170</td>
<td>400</td>
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<td>SC</td>
<td>243</td>
<td>138</td>
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<td>105</td>
<td>240</td>
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<tr>
<td>SR</td>
<td>207</td>
<td>123</td>
<td>225</td>
<td>125</td>
</tr>
</tbody>
</table>

| Group B          |                            |                             |                   |                        |
| Functional       |                            |                             |                   |                        |
| BP               | 203                        | 175                         | 365               | 285                    |
| JH               | 237                        | 150                         | 345               | 280                    |
| RS               | 170                        | 138                         | 305               | 205                    |
| JA               | 210                        | 147                         | 295               | 195                    |
| SS               | 180                        | 135                         | 265               | 205                    |
| RJ               | 206                        | 110                         | 245               | 160                    |
| KW               | 180                        | 113                         | 240               | 185                    |
| TH               | 125                        | 108                         | 210               | 150                    |