THE EFFECT OF TWO NEAR MAXIMUM DYNAMIC LIFTS COMPARED TO EIGHT DYNAMIC LIFTS IN RELATION TO STRENGTH DEVELOPMENT

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CHAPTER ONE

INTRODUCTION

Weight lifting, or, more accurate, isotonic exercise, is a form of dynamic lifting that has a proven track record of being successful in creating additional skeletal muscle strength and hypertrophy. Weight lifting is especially successful if a series of progressive resistance exercises are used. Muscle overload is the term used when skeletal muscles are taxed beyond its normal level by responding to successive increases to resistance. It is known that if the skeletal muscle is exercised beyond its normal resting level for an extended period of time, a physiological adaptation occurs, increasing the muscles' contractile strength to meet the increased exercise demand (McAardle, Katch & Katch, 1991).

Delorme and Watkins are credited with developing a modern progressive resistance exercise in the early 1950s (Howley & Franks, 1997). Although not the first to use progressive exercise, they were the first to research and develop a progressive resistance exercise program using a specific number of sets and repetitions to develop skeletal muscle strength. Delorme and Watkins' program consisted of dynamically lifting a weight for ten repetitions in three separate sets, with each successive set increasing in the weight used from the last set before. Delorme and Watkins had each subject start the first set using a weight equal to one-third of a ten-repetition maximum. Then, they moved the weight upward to one-half of a ten repetition maximum for the second set and ended with a ten repetition maximum for the third set (McArdle et al., 1991).

Most beginning weight lifters follow the principle of progressive exercise using either free weights, weight machines, or some other type of resistive device that can create a dynamic muscle movement through a given range of motion. Likewise, the most advanced weight lifters use this same principle when exercising except that they usually vary the amount of sets and repetitions to get the results they seek. Some of the common variations include, split routines, circuit training, pyramid stacking and super sets to name only a few, with all possessing a unique difference when compared to the original Delorme and Watkins program (Bond, 1997).

Purpose Of The Study

The purpose of the study was to compare two different methods to stimulate overload to skeletal muscle tissue. The techniques used compared two progressive exercise programs over an eight-week period in the development of skeletal muscle strength. One routine was a standard progressive exercise program, which used eight repetitions in sets of three. The other routine was a new weight lifting program, which used two repetitions in sets of three lifting a weight equal to 90 percent of a single repetition maximum lift (1RM). It was hypothesized that the two-repetition program would be equal to a progressive exercise program using three sets of eight repetitions in reducing body fat. It was also hypothesized that the two-repetition program would be equal to the eight-repetition program in developing strength and muscle hypertrophy.

Statement Of The Problem

The problem of this study was to compare the effect of two near maximum dynamic lifts to eight dynamic lifts in relation to strength and hypertrophy development in skeletal muscle tissue.

Hypotheses

Hypothesis One: There will be no significant difference between a program using three sets of two dynamic lifts at 90 percent of a 1RM maximum weight and a program using three sets of eight dynamic lifts at 65 percent, 70 percent, and 75 percent respectfully, of a 1RM maximum on the loss of body fat or changes in body girth.

Hypothesis Two: There will be no significant difference of skeletal muscle strength development between a program using three sets of two dynamic lifts at 90 percent of a 1RM maximum weight and a program using three sets of eight dynamic lifts at 65 percent, 70 percent and 75 percent respectfully, of a 1RM maximum.

Delimitations Of The Study

This study was delimited to the following:

- The study was conducted on male and female subjects ages 19 to 25.
- Test subjects were free of any physical impairments and recent or current injuries.
- Each subject exercised at a predetermined weight that was based on the percentage of his or hers 1RM maximum strength test for each of the exercise performed.
- Free weights were used for all exercises with the exception of the Latissimus dorsi cable pull-down and the triceps' cable push-down.
- All test subjects had to complete a four-week, pre-training period.
- All subjects were limited to exercise at 60 percent of a 1RM maximum for the 1st set and 65 percent of a 1RM maximum for the 2nd and 3rd sets during the fist four weeks.
- Total testing time was 12 weeks, which included a four week pre-conditioning period followed by an eight-week testing period.

Limitations

The study limitations included:

- No monitoring of daily activities was administered to control for any weight lifting done outside of the study.

- Subjects were not tested before or during the study for muscle enhancing drugs or for muscle building supplements.
- Subjects were not randomly selected. Instead, they were recruited from students enrolled in weight lifting classes taught by the researcher, and from the university weight rooms.
- Subjects were not screened for body somatotype or race.
- No invasive techniques were used to measure skeletal muscle development and hypertrophy.

Assumptions

The following assumptions were inherent during the study:

- All test subjects were free of any muscle enhancing drugs.
- All subjects answered the questionnaire accurately and honestly about past/present experience and drug/supplement use.
- All subjects made a maximum effort when attempting all lifts.
- Subjects adhered to the program assigned to them and used the proper form and exercise techniques when doing the exercises.
- Subjects did not participate in any other strength building program during this study.

Need For The Study

Current exercise programs using progressive exercise to promote strength development have inherent problems within them. Injuries can occur when exercisers try to increase the weight lifted, number of sets done, and well as the number of days worked in a week. Often these increases are attempted before their bodies are ready for it in hopes of promoting increased muscle strength and hypertrophy. These problems tend to manifest themselves when strength development becomes stagnate due to skeletal muscles adjusting to the weight being used from workout to workout. This stagnation, or plateau, in strength development, usually arises in the 12^{th} to 14^{th} week and remains stagnate until skeletal muscle hypertrophies, creating extra tissue to be available to achieve higher levels of force (McArdle et al., 1991).

Multiple problems arise due to this stagnation period, from participants who decide to stop lifting weights, all the way to those who attempt to lift weights at levels that are far too heavy. Exercisers think that if they lift more weight they will promote more stress. However, exercise professionals know that there is more to developing muscle hypertrophy than merely doing more work. Zatsirosky pointed out that there are many variables which effect how muscle tissue develops over time. This can include the amount of weight lifted, to the amount of training days that follow a competition -- even the amount of days of rest prior to competition, all have an effect on how skeletal muscles develop (Zatsiorsky, 1995). Adding more sets and repetitions in attempt to get past this plateau only increases the time and work needed to do an exercise program. By adding this extra work and time, the risk for overuse injuries will increase.

Considering the variety of weight lifting routines touted by some muscle magazines such as, single-day splits, supersets, and plyometrics with weights, it can be seen that a problem exists with exercisers who theorize if a little more work is better, then a lot more is best. Creating a lifting technique that can replace or be incorporated into existing programs may help to reduce the plateau effect, thereby eliminating some of problems and risks people take to increase individual muscle strength and hypertrophy.

Definitions

The following terms are used within this study:

- **Concentric Movement**: Shortening of a muscle tissue (McAardle et al., 1991).
- **Dynamic Exercises**: Using skeletal muscle to forcibly move an object through a joint's full range of motion (McAardle et al., 1991).
- **Eccentric Movement**: Lengthening of muscle tissue (McAardle et al., 1991).
- **Hypertrophy**: The enlarging of skeletal muscle cell tissue (Zatsiorsky, 1995).
- **1RM Maximum Lift**: The maximum amount of weight a person can lift one time through a given full range of movement (Bond, 1997).
- **Overuse injury**: When skeletal muscle is exercised without sufficient rest and recuperation, a state of fatigue develops that can lead to tissue damage due to the skeletal muscle keeping up with the demands being put upon it (Jones, Reynolds, Rock & Moore, 1993).

- **Progressive Overload**: Exercising with a given weight for a number of repetitions then increasing the weight or repetitions in successive sets to create an overload of muscle tissue (McAardle et al., 1991).

- **RM (Range of motion):** The amount of distance a muscle can move at a joint or juncture on the body (Liemohm, 1993).

- **Technique**: Specific form and timing used to execute a given exercise.

CHAPTER TWO

REVIEW OF LITERATURE

The purpose of this study was to determine if completing a weight lifting exercise routine using two repetition lifts in sets of three would be as beneficial as eight repetition lifts in sets of three when trying to develop skeletal muscle strength and hypertrophy. Literature in the following areas was reviewed: history of the development of the progressive overload weight lifting method, the skeletal muscle system and its adaptation to stresses, current exercise physiology on muscle and nerve development, and the benefit of a near maximum lift compared to a multiple progressive lift.

Historical Overview

When looking at any exercise program designed to promote skeletal muscle strength, familiarity with the guiding principles of strength development should be understood. Developing muscle strength has been around since there was a need for one person to be stronger than another for sport or combat. Writings from ancient Greece tell of a man named Milo of Crotona (600 B.C.-500 B.C.), who everyday would lift a newborn bull up onto his shoulders and walk around. As the bull aged, he continued this daily routine until finally, when the bull was fully-grown, legend has it he carried the bull across the stadium during the Olympic Games (Westcott, 1993). Whether the story was true, it is irrelevant for the study. What is important to note is that at least since 500 B.C. athletes have known that in order to get stronger they needed to create a working stimulus over a given period of time. Since then, a multitude of ideas have been employed with the sole purpose of developing strength. Go to any health food store and there are volumes of books and magazines touting ideas that range from eating large quantities of meat or protein to never having sex, all with the purpose of increasing strength.

Up until the early 1940s, calisthenics were mainly used to produce strength and endurance gains in gymnasiums throughout Europe (Hooks, 1974). It was during this time weight lifting became a recognized sport in the United States, when gyms and organizations dedicated to the promotion of bodybuilding and weight lifting started to emerge. These organizations promoted weight lifting as a viable means to get stronger, but each had its own unique idea of how to train (Morehouse & Rash, 1958).

It was not until the early 1950s that an actual weight lifting program was published, which was based on research. The published program used progressive resistance exercises developed by Delorme and Watkins, who were attempting to find a method to increase muscle strength for soldiers rehabilitating from injury (Howley & Franks, 1997). Delorme and Watkins discovered that if a patient lifted a given weight for 10 repetitions for three different sets while increasing the weight from set to set, gains would be seen in muscle strength. They also discovered that the optimum level of intensity was to start with a weight equal to one-third of a 10 repetition maximum for the first set, then progress to one-half of the 10 repetition maximum for the second set, and ended with a true 10 repetition maximum for the third set (Howley & Franks, 1997).

Progressive resistance is the type of exercise most commonly used by people who work out with free weights, weight machines, or some other type of resistive device, which can create a dynamic muscle movement throughout a given range of motion. Weight lifting exercises usually consist of eight to 10 repetitions per set, with three or more sets being done per exercise session. These exercise sessions can then be repeated one or more times per week, usually with a day of rest in between to promote optimum strength and muscle hypertrophy (Weider, 1996). These are the very techniques developed by Delorme and Watkins and since this type of training is still being used with success today, one could argue that it is the definitive true method.

Other techniques have been developed since the Delorme and Watkins progressive program, including methods such as, split routines, supersets, circuit training, and pyramid loading just to name a few (Howley & Franks, 1997). Although authorship for each of these techniques is uncertain, they do appear to have a common denominator: they were developed by individuals who had many years of experience who were experimenting with various training programs to develop greater gains in strength and muscle hypertrophy.

The Muscular System And Its Adaptation To Stress

Lifting weights is an effective way to increase skeletal muscle strength and hypertrophy because it follows the basic rules of muscle adaptation. It is known that skeletal muscle will adapt physiologically to the stresses placed upon it, if the stresses are intensive and repetitive enough. Weight lifting is unique because it will target a specific muscle group causing specific physiological responses to occur quicker than if several muscle groups were targeted at the same time. By targeting specific muscle groups, concentrated stress can be placed on the muscle being trained (McAardle et al., 1991).

From an exercise physiology standpoint, this type of muscle stress is known as muscle overload, as recognized by McAardle, Katch & Katch in their book titled Essentials of Exercise Physiology (1991):

> "A specific exercise overload must be applied to enhance physiologic improvements effectively and to bring about a training change. By exercising at a level above normal, a variety of adaptations take place that enable the body to function more efficiently. The appropriate overload for each person can be achieved by manipulating combinations of training frequency, intensity, mode, and duration. This concept of individualized and progressive overload applies to the athlete, the sedentary person, the disabled, and even the cardiac patient" (p. 347).

> "In training for muscular strength, the overload principle is applied by the use of weights, (dumbbells or barbells), immovable bars, straps, pulleys, or springs, and water, air, and oil hydraulic devices. There is nothing unique in the use of a barbell or spring or any heavy object to improve muscular strength. In each case, the muscle responds to the intensity of the overload rather than to the actual form of overload" (p. 377).

As stated above, there is nothing unique about the type of object being used to improve muscular strength, although some objects or techniques will create an overload in a more efficient way. As an example, it is known that isokinetic exercise is the best way to improve skeletal muscle strength, but the machines needed to do this type of exercise are expensive. Weight lifting with free weights is beneficial, as well as convenient, cost effective, relatively safe to do, and will isolate specific muscle tissues. Being able to isolate a muscle is important, because it creates an intensive stimulus to a specific muscle area. Using isolation in combination with the proper amount of weight for a given exercise, optimal stress can be targeted to a specific skeletal muscle. This is what makes weight lifting superior to other forms of exercise (Bond, 1997).

To further understand why weight lifting is such an ideal exercise for skeletal muscle, it is helpful to examine how skeletal muscle tissue derives its energy in response to an overload. Skeletal muscle uses a phosphate called adenosine triphosphate (ATP) as an energy source to produce or sustain muscle contractions. It is known that muscle contractions producing high intensive movements need to be supplied with ATP through anaerobic metabolism. Anaerobic metabolism is used because aerobic metabolism, which utilizes oxygen to transport reactions into the cells mitochondria, is too slow to keep pace with high-level energy demands of contractions done at high tension or at a very fast rate. Skeletal muscle tissue stores a small supply of glucose, ATP, and another phosphate called creatine phosphate (CP), to use as energy when instant movements are needed without delay. However, these energy stores are quickly depleted (usually within 10 seconds) then additional energy must be produced and maintained by anaerobic glycolysis if activity is to continue. Glucose and CP will be depleted and will remain so until the intensity of the activity ceases or slows down, but ATP will remain relatively at the same level due to anaerobic glycolysis (McAardle et al., 1991).

If anaerobic exercise intensity is high and long enough, hydrogen ions will combine with pyruvate to form lactic acid. Although lactic acid can be used as an energy source, it accumulates quicker than the body can use it during high intensity activities. If lactic acid remains high or builds up to a high enough state, it will cause pH to decrease. When pH decreases it will cause a high acid environment to form within the blood and in the muscle tissue. This results in a break down of the enzymes needed to process ATP. When this occurs, fatigue of the muscle tissue sets in and activity will cease until the environment rights itself by converting lactic acid back to pyruvate (Tortora, 1994).

Due to its short, high intensity activity, weight lifting relies upon anaerobic sources for energy while also causing adaptations to take place within this system, especially the buffering system. Buffering allows for higher levels of lactic acid accumulation to occur before anaerobic energy systems fail and repeated bouts of training will cause an adaptation to the buffering system to occur (McDonach & Daviesm, 1984).

Neural adaptations also take place during the first 10 to 12 weeks of training. Motor nerves, which propagate the stimuli, which cause the skeletal muscles to contract, adapt better by synchronizing themselves and thus firing homogenously (Billeter & Hoppeler, 1992). This motor unit development occurs at a fast and steady rate and contributes to the overall muscle strength produced by a given muscle (Lash & Sherman, 1997). The increases in muscle strength through neural adaptation can be quite significant for the novice. However, after the 10^{th} to 12^{th} week, skeletal muscle strength develops more slowly until true hypertrophy occurs to produce more muscle tissue in response to the increased amounts of resistance (Edstrom, 1986).

Weight lifting creates the stimulus necessary to cause these physiological changes to occur but the speed at which these changes occur is dependent on the type of weight lifting program that is used. There are different types of weight lifting programs that employ the progressive resistance principle. Some programs use higher repetitions from set-to-set to create an overload stimulus, while other programs use more weight from set-to-set. Likewise, there are still other programs that employ a combination of both methods. Regardless of the type of program, every exerciser will arrive at a point where neural adaptation plateaus. If further gains in strength are to be realized, the exerciser must wait until muscle hypertrophy occurs (Howley & Franks, 1997). To stimulate hypertrophy and strength development, the training program will need to be adjusted so that more stress can be placed upon the muscle tissue. This is accomplished by either increasing the total amount of weight lifted or by adjusting the lift in a manner that produces some type of variation in the application of force for a given exercise. While observing body builders, it is easy to see how proper adjustments to an exercise program will produce the maximum gains in muscle hypertrophy. When body builders use a combination of high intensity lifting with multiple sets and repetitions, they are able to produce large gains in muscle hypertrophy. This type of training produces high degrees of muscle hypertrophy, yet only medium-high gains in overall strength due to the sets and repetitions are of a high number. Compare this to the power and strength athlete who lifts using fewer repetitions and a lower number of sets. This athlete will have a high level of strength gain with skeletal muscle tissue hypertrophy (Tesh, 1992). Training program modifications have to also be done properly and with care, because too much stress and too little rest will result in overtraining. Overtraining leads to damage of skeletal muscle and tendons and will prevent subsequent muscle hypertrophy from occurring (Garhammer & Takano, 1992).

It is known that several factors have to be present for progressive overload to be effective. These factors include, the number of sets, the number of repetitions, and the amount of weight used. These factors must be present in a combination that will cause an overload of the skeletal muscle tissue for adaptation to occur. Although it is not clear as to what the exact combination of repetitions, sets, and weights are needed to best accomplish this goal, it is assumed that the heaver the weight, the more stress will be placed upon muscle tissue. This will cause the greatest amount of strength adaptation to occur (Hooks, 1974). Typically this is seen by the sets and repetitions being dependent upon the amount of weight used: a heavier weight requires less repetitions, a lighter weight will need more.

Current Exercise Physiology Literature

Exercise physiologists have demonstrated that strength will increase quickly for the first 10 to 14 weeks, then plateaus until skeletal hypertrophy occurs. Skeletal muscle tissue is innervated by a combination of large and small motor nerves. These nerves originate from the spinal column and attach to skeletal muscle fibers by a motor plate at the end of the axon. These motor end plates attach to different areas of muscle fibers and can range from a few in a small muscle to hundreds in a large muscle. Muscle contractility is highly dependent upon how well the motor neurons stimulate the muscle tissue. If only a few motor nerves fire instead of all of the available nerves, a less forceful contraction occurs that cannot overcome a heavy load. If all of the nerves fire uniformly, there is a more forceful contraction, which can overcome a heavy load (Noth, 1992).

All skeletal muscle fiber sarcomeres that are stimulated by a motor nerve will react the same way, that is they contract completely. Therefore, there is no such thing as a partial contraction of skeletal muscle. This phenomenon is known as the all-or-none principle. When sufficiently stimulated, muscle fibers contract completely, otherwise no contraction occurs at all (McAardle et al., 1991). Graduations in the strength of a muscle's response are produced by the recruitment of varying numbers of motor units.

When the muscle fibers of a given motor unit contract, a twitch occurs. When sustained contractions occur, the result is fused tetanus of the muscle fibers (Noth, 1992). There are three different types of nerves that stimulate this twitch: fast-twitch fatigue sensitive (FF), fast-twitch fatigue resistant (FR), and slow-twitch (S), which is highly fatigue resistant (Noth, 1992). There are different types of skeletal muscle tissue that are classified by their rate of twitch, use of ATPase, how long it takes the fibers to contract, and how long the fibers can sustain movement. These classifications are: slow oxidative Type I (SO), a slow-twitch fiber that has low force and can sustain movements for a long period of time; fast oxidative glycolytic Type IIA (FOG), a fast-twitch fiber that can generate moderate amounts of force and is fatigue resistant; fast glycolytic Type IIB (FG), a fast-twitch fiber that can generate high force and fatigues quickly. These fiber types vary from individual to individual and are influenced by the amount of training that is incurred (Pipes, 1994). Untrained fibers are not able to generate and sustain as much force as trained fibers. However, after a short period of training the body will learn to respond to the specific type of training stimulus to which it is exposed (Lash & Sherman, 1997). This is the principle of specificity of training and applies to all skeletal muscle fiber tissues. Each muscle fiber type is influenced by the type of training received and will respond to that training within its specific ability (Zatsiorsky, 1995).

Weight lifting demands large amounts of energy in a short period of time. This demand causes specific types of changes to occur within the body. Intensive weight training results in a more proficient activation and production of some hormones involved with the growth process of skeletal muscle. Some of the hormones thought to be effected by weight lifting and are responsible for skeletal muscle growth due to training, are listed below (Kraemer, 1992).

Growth hormone (GH) is responsible for the availability and use of amino acids for tissue repair, the inhibition of glucose uptake, and the increased use of adipose tissue for energy. The amount and availability of GH increases with exercise and changes occur within several minutes of the start of exercise. GH secretion levels are influenced by the intensity of exercise and not by the duration of exercise (Kraemer, Marchitelli, McCurry, Mello, Dziados, Harman et al., 1990). Therefore, weight lifting near a maximum level will influence GH.

Testosterone, a testes gland hormone, increases in amount with exercise and its production are directly related to exercise intensity. This hormone controls muscle size, increases red blood cell count, decreases body fat, and promotes male sex characteristics (McAardle et al., 1991). Therefore, as with GH, weight lifting near a maximum load profoundly influences testosterone levels.

The pancreas naturally secretes insulin and its amount decreases with the onset of strenuous exercise, which in turn causes an increase in carbohydrate catabolism and a decreased blood glucose level. Insulin also promotes the utilization of fatty acids and the transport of amino acids into the cells. This activity has a nitrogen sparing effect wherein there is decreased catabolism of amino acids and the creation of an anabolic state. This anabolic state will only help to promote a better environment to be present after doing strenuous weight lifting so that GH and testosterone can work together to create skeletal muscle growth and increased strength (McAardle et al., 1991).

Thyrotropin, a thyroid-stimulating hormone (THS), is released by the anterior pituitary gland and increases in amount in response to increased levels of exercise. Its main purpose is to influence the release of two other important hormones, thyroxine (T4) and triiodothyroine (T3), by the thyroid gland. Together, T3 and T4 regulate the metabolic rate by increasing carbohydrates and lipid metabolism, which in turn affects the basal metabolic rate (BMR) of the entire body (Baechle, 1992). During weight lifting these hormones stimulate anaerobic glycolysis and help supply muscles with quick energy.

Catecholamines, epinephrine, and norepinephrine are adrenal medulla hormones that influence heart rate, size of blood vessels, fatty acid release, and glycogen catabolism. They serve to enhance rate and force of muscle contraction and are directly related to exercise intensity. As exercise intensity increases, so does the rate of the release of these hormones. It is interesting to note that the rate of secretion of these hormones is greater in males than females, and greater in older individuals who exercise at the same rate as younger individuals. Here again are hormones that are stimulated by a high-intensity weight lifting program and are directly involved with creating changes that affect muscle contraction (Kraemer, 1992).

The aforementioned hormones create these changes in the body and are though to be the ones that are most influenced by weight lifting exercises. When considering hormones, it should be noted that there are differences in the rates hormones respond to exercise. There are fast responses, responses of a modest rate, and responses with a long lag period. It is thought that there are two mechanisms involved for activating the endocrine system at the beginning of exercise: one is for rapid activation, while the other is for delayed activation, and the type of exercise determines which activation occurs (Viru, 1995). Rapid activation causes the release of catecholamines within six seconds of the onset of exercise. Testosterone and GH have a modest rate of activation and then maintain higher levels for extended periods of time after exercise has ended. Hormones that fall into the long lag category are insulin and glucagon, which need the longer activation period in order to replenish glucose after exercise (Viru, 1995).

It is apparent that activation speed is influenced by the intensity of the exercise activity. Exercises that are highly strenuous cause hormones such as epinephrine, to activate at a fast rate to meet immediate demands, while hormones such as insulin, GH and testosterone lag and keep working for extended periods of time. A rapid response time seems to be directly related to the anaerobic threshold of the individual, while slower responses seem to be related with varying levels of oxygen consumption and differing anaerobic thresholds. Hormone release is closely tied to enzyme activity and other factors such as body temperature, pH balance, hydration, circulation, blood pressure, and respiration (Thorstensson, Hulren, Doblen & Karlsson, 1992).

The Benefit Of A Near Maximum Lift

By performing two near maximum lifts in sets of three, strength gains and muscle hypertrophy should be equal to any other progressive lifting program trying to promote strength gains and hypertrophy. Using a weight that can only be lifted twice for three sets will create a constant level of stress to the skeletal muscle, and exercising twice a week with two days of rest in between the workouts, allows for proper adaptation and recovery to occur (Hooks, 1974).

A two-repetition weight lifting program has other potential benefits beyond promoting gains in strength and muscle hypertrophy. One is time management, especially for team sports such as football, basketball, wrestling, or any other sport that strength development is imperative. By using fewer repetitions to get the comparable strength gains, less time will be spent in the weight room. This frees up more time for other training activities. Additionally, using a near maximum weight should produce a shorter plateau effect. This occurs because the skeletal muscle is not able to rapidly adapt to the weight that is used. By only performing two near maximum lifts, skeletal muscle will remain fresher by comparison to a muscle that has been completely fatigued. This should allow heavier amounts of a weight to be lifted in a more controlled manner.

This type of training can have other additional benefits as well, especially for those who suffer from arthritis and the elderly. Being able to lift a given load briefly and still produce strength gains while alleviating overuse injuries, would be beneficial for those who cannot handle the multiple sets and repetitions of a standard weight lifting program (Rock, 1994). Utilizing a two-repetition program can help in training athletes who are working exclusively with developing speed and power. This program specifically targets type IIa & IIb muscle fibers, because completing just two near maximum repetitions, the duration is too short for type I muscle fibers to be properly activated.

Summary

Within the machine called the human body, there are hormones and energy systems which all work together to keep things running proficiently. All are ready to respond to the different stresses that are placed upon them by creating changes to meet stress demands that are chronic. Weight lifting can be seen as a chronic stress exercise that is used to cause desired changes to skeletal muscles. Using a two-repetition program, exercisers can hope to create changes in the shortest period of time, while doing less work overall. Using proven theories of the past, mixed with ideas and unproven theories of the future, the idea of a two-repetition program is born.

CHAPTER THREE

METHODOLOGY

Subject Selection

Twenty-two male and female subjects between the ages of 19 and 25 were selected based on their freedom from injuries, drug use, supplementation, and availability for testing. Each subject selected was assigned to one of two groups in equal amounts, called, Exercise Group One (two-repetition group) and Exercise Group Two (eight-repetition group). Subject population was selected by using volunteers who were currently enrolled at the university. Recruitment posters were placed at the wellness center and at the weight rooms. Students enrolled in weight lifting classes were also solicited and received bonus points for participating.

Each test subject was categorized as having either experience in weight lifting (seven males, one female), or not having experience (nine males, one female). To be considered experienced, subjects had to be exercising for the past four months, at least two times per week, with weight lifting exercises. To be considered inexperienced, subjects had to be free from any weight lifting programs for the past six months, despite any prior weight lifting experience before this time. This criterion was based on past studies that showed the rate of strength reduction after discontinuing exercise through bed rest, limb immobilization, or voluntary discontinuance of exercise. Although motor nerve memory maintains some ability to produce at a higher rate than pre-exercise, there is still a loss in the motor nerve being able to transfer needed calcium for reactions that would be considered at the level of an experienced weight lifter (MacDougal, 1986).

There were no injuries caused by this study, but four people did drop out after spring break, which brought the total number of subjects to 18. One subject dropped out due to an injury sustained while playing varsity football, while the other three dropped out due to lack of participation. An interesting point to note is that the three people who dropped out where all from the eight repetition group. Although this could simply be due to odds, it was noted that when the eight repetition subjects were questioned about their progress, each complained about the length of the workout and the difficulty of the third set in the program. Most eight-repetition subjects averaged 30 more minutes to complete their workout than those in the two-repetition program. Compare this to the two-repetition group who always complained that it felt like they were not doing enough work and enjoyed being able to complete the workout during the one hour class period.

Methodology

Subjects were administered a 1RM strength test to check for absolute strength in performing a series of weight lifting exercises. This test was based on American College of Sports Medicine protocols that require no more than five trials to be used in any exercise test with a minimum of a two minute rest between each trial (Franklin, Whaley & Howley, 2000). Subjects were tested with the 1RM during the fourth and seventh week, and pre and post testing. The exercises used were a bench press, seated latissimus dorsi cable pull-down, seated shoulder press, standing arm curl, standing triceps cable push down, seated leg press, seated leg extension, and a prone leg curl. Data was also collected at these times for each subject for body weight, percentage of body fat, and overall girth size in the upper biceps, pectorals major circumference, abdominal circumference, thighs (overall circumference measured around middle thigh), and calves (gastrocnemius, soleus and tibialis anterior circumference) (Balado, Stead, Magargle & Sheir, 1995).

The equipment used for the exercise tests listed above were as follows:

- **Bench Press**: Standard flat weight bench with high capacity load ability.
- **Free Weights**: Olympic style large collar end bars and weight plates.
- **Seated Leg Press**: Floor unit with 45-degree sliding foot sled.
- **Seated Leg Extension**: Floor unit with free weight leg extension.
- **Prone Leg Curls**: Floor unit with free weight leg curl capability.
- **Body Weight**: Standard floor scale with beam and moveable balance weights.
- **Percentage of Fat**: Large skinfold calipers with 0 to 67 degrees of range. Manufactured by Cambridge Scientific Industries, Inc.
- **Girth Measurements**: Gulick II measuring tape with spring tension gauge. Manufactured by Country Technology, Inc.

Methods for Data Collection:

Subjects were administered a one repetition maximum (1RM) lift test for each of the exercises listed above. Once a true 1RM was determined, this data was used to make comparisons of pre-experiment strength and post-experiment strength that occurred during the course of the experiment. Subjects also had to perform a 1RM strength test at two other separate times, during week four and week seven of the study, so that adjustments could be made to the amount of weight being lifted for each exercise. This was to ensure that each subject remained within the criteria of percentage of weight being lifted for each exercise group. While performing the 1RM test, subjects had to maintain the proper form and movement for each weight lifting exercise before it would be counted and tabulated. The proper form for each exercise is listed as follows:

Bench Press: Subjects laid on the bench with both feet flat on the floor while keeping their back flat on bench. The weight was held extended at arms length above their mid-chest area, then lowered to approximately one inch above their chest. Immediately the subjects pushed the weight back to the starting position to fulfill one repetition for the bench press.

Prone Leg Curls: Subjects started laying face down on the leg curl machine while placing their heels under the pad on the movement bar of the machine. Subjects then lifted both legs upward towards their buttocks until their legs were at least 90 percent in relationship to the body's torso. Subjects then returned their legs in a controlled manner to the starting position. This counted as one repetition.

Seated latissimus dorsi cable pull-down: Seated subjects started with both feet on the floor, then grasped the hanging bar at approximately shoulder-width with palms facing away from them. The subjects then pulled the bar down in front of their face to the level of their chin without leaning back. Once accomplished, subjects then returned the bar up to its starting position. This was counted as one repetition.

Seated leg extension: Seated subjects started with both feet under the leg extension pad resting on the dorsal area of the foot. Legs were in the down or flexed position. Subjects raised their legs until they were fully extended, then lowered their legs to the starting position. This constituted one repetition for the leg extension.

Seated leg press: Subjects were seated in the leg press machine with both feet on the sliding footplate with legs bent at least 90 degrees. Subjects then pushed both feet upward until both of their legs were fully extended. Subjects did not hyper-extend their knees, or come up onto their toes. After a brief pause, the weight was brought back to the starting position under control to constitute one repetition.

Seated shoulder press: Subjects placed both hands approximately shoulder-width apart on the weight bar and then were assisted with the weight until it was held above their heads at arms length. The weight bar was then lowered without assistance to the front of their face to chin height. After a brief pause, they pushed the weight back up to the starting position with arms fully extended. This constituted one repetition. Subjects were not allowed to hyperextend their elbows or arch their back during this exercise.

Standing arm curl: Subjects stood upright holding a weighted bar with arms hanging down along their body with palms facing forward. Subjects brought their arms upward until the arms came up to a full contraction without making the elbows move forward. Subjects then returned the weight to the starting position to count as one repetition.

Standing triceps cable push down: Subjects stood upright, arms next to their body, and elbows bent at 90 degrees with palms facing downward. Subjects pushed the weight down until their arms came to a full extension, then returned the weight to the starting position. This counted as one repetition.

Subjects had to maintain proper form when completing each of these exercises. The lift did not count when subjects took their feet off the floor, arched their backs, or became unbalanced in an attempt to gain more leverage. Proper form was maintained so that uniformity and safety could be established throughout the testing period.

Guidelines For Testing

The following tests were conducted on each subject of this study. Subjects were scheduled individually and in groups to meet with the author at specific times at the campus weight room to have the 1RM test administered to them. All male subjects were measured for body weight, body girth, and percent body fat at the beginning of these tests by the author in the men's locker room. All female test subjects were measured for body weight, body girth, and percent body fat by a trained female graduate student in the exercise lab prior to being tested by the author. This testing was completed before any subject was allowed to begin 1RM testing. Next, subjects had to perform a warm up lift consisting of 15 repetitions done at approximately 40 percent of their maximum one minute before they were allowed to make a 1RM attempt for any exercise. Based on the difficulty and success of the attempt, additional lifts were conducted after a two-minute rest period. Subjects continued until they could not complete a lift in the proper form, or until five attempts were fulfilled, which ever came first. The 1RM exercise tests were done in the following order: bench press, latissimus dorsi cable pull down, seated shoulder press, standing arm curl, standing triceps cable push down, seated leg press, seated leg extension, and seated leg curl.

Listed below is a more detailed account of how each test was administered for each test subject.

- Body weight was taken while subjects stood on a swinging arm counter balance scale wearing gym clothes and no shoes.
- Girth measurements were taken at the following locations, biceps (at the middle), pectoral major muscle (at the nipple level), shoulders (at the widest point around with both arms held down to sides), waist (at the umbilical level), hips (at the widest point), thighs (at the widest point), and calves (at the widest point).
- Skin fold measurements were obtained from the following anatomical land sites: chest (half-way between nipple and anterior axillary line for males, and one-third from anterior axillary line and nipple for females); triceps (back of arms, midway); subscapular (upper right quadrant of back on shoulder blade); abdomen (adjacent right of belly button); thigh (halfway between knee and inguinal fold, mid line); suprailiac (along hipbone right side); and axillia (axilliery junction under the armpit at the level of the xiphoid process on the breastbone).
- The author gave subjects instructions regarding how to complete each exercise as described in methods for data collection above.
- Subjects were assigned to one of two groups, Exercise Group One or Exercise Group Two. Exercise Group One exercised with three sets of two repetitions at 90 percent of a 1RM maximum lift. Exercise Group Two exercised with three sets of eight repetitions at 65 percent, 70 percent, and 75 percent of a 1RM maximum.

Data Analysis

Data was tabulated using SPSS statistical program and Excel for Windows. Exercise Group One and Exercise Group Two were compared using pre-experimental maximum strength and post-experimental maximum strength for the following exercises: bench press, seated lat. pull-down, seated leg press, seated leg extension, prone leg curl, standing triceps cable push down and standing arm curl. A similar analysis was conducted for girth size. Alpha for all statistical tests was set at .05.

Maximum strength was tested at four different stages: before the study, after the fourth week, during the seventh week and post study for the 12-week program using a 1RM test for the exercises mentioned above. This resulted in four separate strength scores for each individual and four mean scores for each group. Pre- and post-test means were tabulated to discover any increases that may have occurred. The mean from each group was compared using a one-way ANOVA and a Newman-Keuls Multiple Range post hoc test to gauge any significance over time regardless of the group. Girth measurements and body fat percentages were analyzed for significance from Test One to Test Four.

CHAPTER FOUR

FINDINGS

Introduction

The purpose of this study was to compare two methods of weight training using two separate groups of subjects. Group One (n = 9) used three sets of two-repetitions at 90 percent of a 1RM maximum, while Group Two (n = 9) used three sets of eight-repetitions done at 65 percent, 70 percent, and 75 percent of a 1RM maximum. Eighteen test subjects consisting of 16 males (ages 19-25) and two females (ages 20-21) participated in the study. Experienced subjects ranged from having four months to two years of experience, while the inexperienced subjects ranged from not working out for the past eight months, to never having lifted weights before. There were seven males and one female in the experienced subjects and nine males and one female for the inexperienced.

Results

All subjects completed a single maximum range of motion (1RM) lifting exercise to determine their individual maximum muscle strength in eight different weight lifting exercises. The 1RM test was administered at the pre-test, after week four, during week seven, and post-testing using the following exercises: flat bench press, lat-pull-down, seated shoulder press, standing arm curl, standing triceps push-down, seated leg press, seated leg extension, and seated leg curl. Subjects also had their weight, individual body girths and body fat measured during these times. Table I and Table II reflects body girth and percent fat changes for both groups over the course of the study.

Table I

Body girth changes for the two-repetition group.

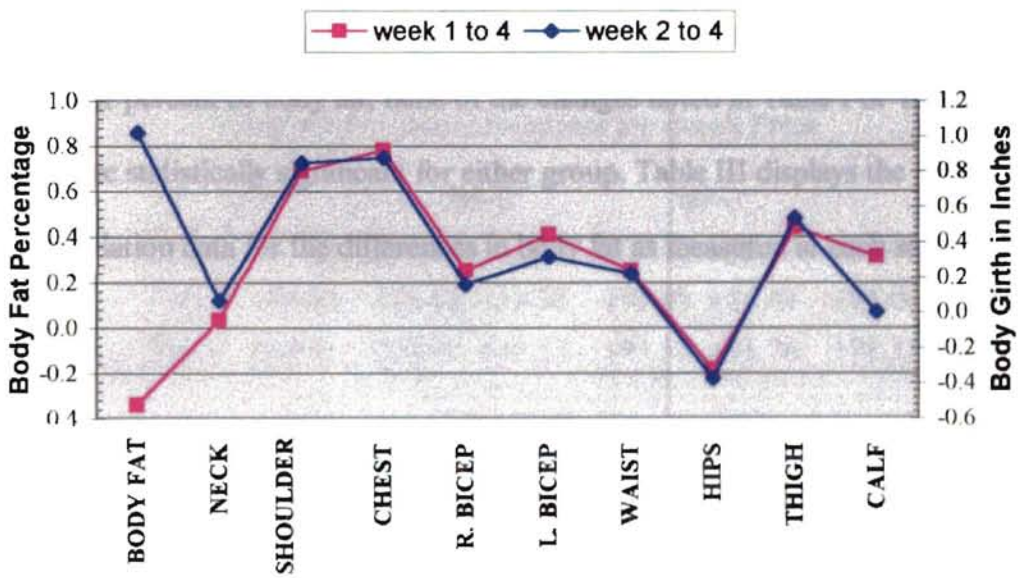
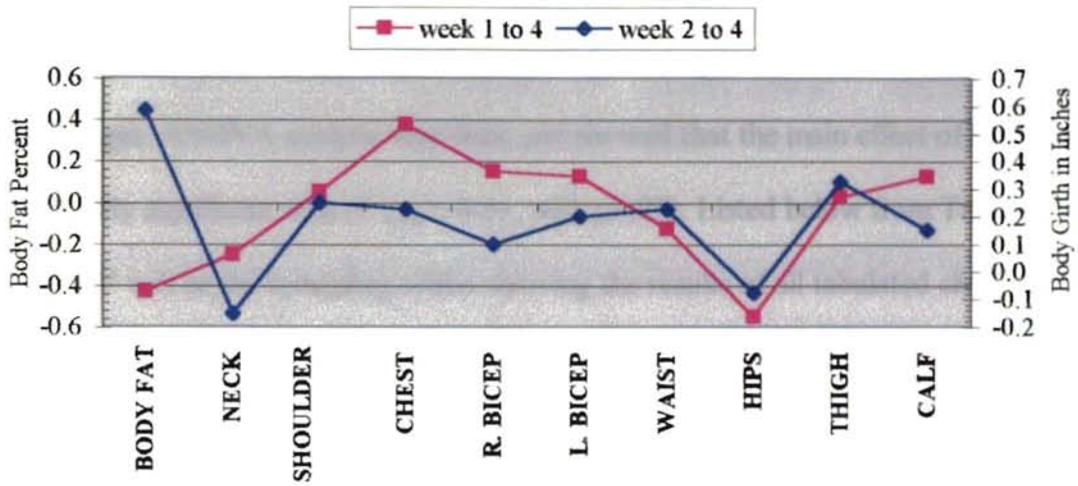


Table II

Body girth changes for the eight-repetition group.



Except for percent of body fat, none of the changes noted in Table I or Table II for body girth are statistically significant for either group. Table III displays the means and standard deviation data for the differences in body fat as measured at each separate test time.

Table III

Means ± Standard Deviations for Body fat at Four Measurement Points

	BF-1	BF-2	BF-3	BF-4
2 rep	19.61 ±6.89	18.60 ±7.04	18.34 ±7.36	19.18 ±7.66
8 rep	19.20 ±6.16	17.90 ±5.83	17.91 ±5.68	18.90 ±5.58
Marginal	19.43 ±6.39	19.04 ±22.67	18.26 ±6.36	18.15 ±6.48

Table III shows that percent body fat went down for both groups from the first test to the last test at the end of the study. Post hoc analysis via the Newman-Keuls Multiple Range Test revealed differences between Test One and Test Four and between Test Two and Test Four. There was no statistical difference between Test Two and Test Three or between Test Three and Test Four for percent body fat. Table III shows that the majority of the weight loss occurred during the beginning stages of the study, then after this period the body maintained the new body fat percentage or began to return to prior fat percentages. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 6.51$, with $p<.05$). Listed below from Table IV to Table XV will be the remaining tables showing the results of all tabulated changes for each of the different exercises measured during the four separate single range of motion maximum tests (1RM) from Test One to Test Four.

Table IV

Means ± Standard Deviations for Bench Press

	BP-1	BP-2	BP-3	BP-4
2 rep	181.50 ±53.08	196.50 ±52.50	206.50 ±50.17	215.00 ±52.33
8 rep	174.37 ±48.66	183.13 ±53.38	191.88 ±50.85	195.00 ±47.06
Marginal	206.11 ±49.66	200.00 ±49.53	190.56 ±51.76	178.33 ±49.79

Table IV shows that the average mean for both groups increased from Test One to Test Four, and from Test Two to Test Four. No statistical difference from Test Three to Test Four was seen. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,42} = 24.06$, with $p<.05$). A closer examination revealed that the eight-repetition group had a statistically measurable difference for the experienced subjects but not for the Inexperienced subjects. The two-repetition group showed a statistically measurable difference for the Inexperienced subjects but not for the experienced subjects. Both groups showed an overall statistical difference over time in increasing strength for the bench press regardless of experience.

Table V

Means ± Standard Deviations for Lat-Pulldown

	PD-1	PD-2	PD-3	PD-4
2 rep	198.00 ±33.60	224.00 ±55.22	247.00 ±68.77	259.00 ±64.50
8 rep	196.88 ±33.91	213.75 ±48.39	240.63 ±59.61	250.00 ±62.34
Marginal	255.00 ±61.84	244.17 ±63.07	219.44 ±51.05	197.50 ±32.73

Table V shows that the average mean for both groups increased from Test One to Test Four and from Test Two to Test Four. There was no statistical difference from Test Three to Test Four. Strength increased overall for both groups whether experienced or inexperienced. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 32.60$, with $p<.05$).

Table VI

Means ± Standard Deviations for Shoulder Press

	SP-1	SP-2	SP-3	SP-4
2 rep	133.00 ±33.52	138.50 ±36.67	148.00 ±34.98	156.00 ±35.81
8 rep	124.38 ±30.05	136.88 ±34.74	140.63 ±27.31	148.13 ±27.31
Marginal	152.50 ±32.37	144.72 ±31.13	137.78 ±34.78	129.17 ±31.40

Table VI showed that the average mean for both groups increased from Test One to Test Four and from Test Two to Test Four. There was a statistical difference from each test. Strength increased in all phases of the study, no plateau effect was encountered. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 25.52$, with $p<.05$).

Table VII

Means ± Standard Deviations for Standing Curls

	CUR-1	CUR-2	CUR-3	CUR-4
2 rep	96.00 ±24.47	103.00 ±24.52	109.00 ±26.65	109.50 ±23.62
8 rep	93.13 ±19.63	100.63 ±18.98	101.25 ±19.59	103.75 ±20.66
Marginal	106.94 ±21.91	105.56 ±23.45	101.94 ±21.64	94.72 ±21.86

Table VII showed that the average mean for both groups increased from Test One to Test Four and from Test Two to Test Four. There was no statistical difference from Test Two to Test Three and from Test Three to Test Four. What is seen here is that strength increased from the beginning of the study to the end. Strength gains were slow over the course of the study, causing little gains at midpoints, but they were great enough to create significant gains in strength overall. ANOVA analysis was done and showed the main effect of time was statistically significant with ($F_{3,48} = 21.99$, with $p<.05$).

Table VIII

Means ± Standard Deviations for Standing Triceps Pushdown

	TRI-1	TRI-2	TRI-3	TRI-4
2 rep	100.00 ±18.26	108.00 ±16.19	112.00 ±20.44	114.00 ±18.38
8 rep	95.00 ±10.69	101.25 ±13.56	107.50 ±11.65	108.75 ±8.35
Marginal	111.67 ±14.65	110.00 ±16.80	105.00 ±15.05	97.78 ±15.17

Table VIII showed that the average mean for both groups increased from Test One to Test Four. There was no statistical difference from Test Two to Test Four and from Test Three to Test Four. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 12.38$, with $p<.05$).

Table IX

Means ± Standard Deviations for Seated Leg Press

	LP-1	LP-2	LP-3	LP-4
2 rep	566.50 ±207.15	620.00 ±220.91	624.00 ±325.31	798.50 ±329.75
8 rep	534.38 ±110.31	626.88 ±120.38	668.13 ±109.22	718.13 ±124.96
Marginal	762.78 ±256.29	643.61 ±247.88	623.10 ±178.37	552.22 ±167.33

Table IX showed that the average mean of both groups increased from Test One to Test Four. There was no statistical difference from Test One to Test Two and from Test Two to Test Three. All subjects increased in strength from the beginning to the end of the study. Strength continued to increase up to the end of the study, as seen by a significance of mean measured from Test Three to Test Four. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 8.14$, with $p<.05$).

Table X

Means ± Standard Deviations for Seated Leg Extension

	LEX-1	LEX-2	LEX-3	LEX-4
2 rep	252.00 ±68.77	281.00 ±88.00	291.50 ±50.66	309.00 ±94.16
8 rep	251.25 ±56.58	266.25 ±47.79	285.00 ±50.43	303.13 ±56.88
Marginal	306.39 ±77.68	288.61 ±67.10	274.44 ±71.39	251.67 ±61.86

Table X showed the average mean for both groups increased from Test One to Test Four and from Test Two to Test Four. The mean also increased statistically from each test to the next. Leg strength increased significantly throughout the study, no plateaus were encountered by any test subject. ANOVA analysis was done and showed that the main effect of time was statistically significant with ($F_{3,48} = 40.52$, with $p<.05$).

Table XI

Means ± Standard Deviations for Prone Leg Curl

	LCUR-1	LCUR-2	LCUR-3	LCUR-4
2 rep	173.00 ±45.72	195.00 ±51.48	215.00 ±41.77	239.00 ±42.26
8 rep	182.50 ±27.12	193.13 ±44.15	222.50 ±38.91	240.63 ±44.36
Marginal	240.00 ±41.90	218.00 ±39.52	194.17 ±46.98	177.22 ±37.86

Table XI showed the average mean for both groups increased from Test One to Test Four and from Test Two to Test Four. A statistical difference in mean occurred between each test. Leg strength increased steadily over the entire test period and no plateau occurred. This increase occurred for both groups. ANOVA analysis showed that the main effect of time was statistically significant with ($F_{3,48} = 39.95$, with $p<.05$).

Discussion

There was a statistically measurable difference from Test One to Test Four, and from Test Two to Test Four, in all exercises for both groups. There was no statistical significance between the two-repetition group and the eight-repetition group over time and there was no statistical significance between the experienced and inexperienced subjects, except in the bench press exercise.

In the bench press exercise for the eight-repetition group, higher gains in strength were achieved for the experienced compared to the inexperienced subjects. With the two-repetition group, the inexperienced subjects had higher gains in strength than did the experienced subjects, but both groups increased in strength overall. It could be argued that other factors caused these differences since it did not occur in any other exercises.

A statistically significant and measurable difference occurred for all groups, showing that both exercise programs promoted gains in muscle strength.

When comparing both programs it was noted that the two-repetition program took less time to complete. Listed in Table XII is an example of how much time is saved using the two-repetition program compared to an eight-repetition program. Extrapolate time saved from twelve different exercises -- adding rest periods in-between sets and each individual exercise and it is easy to see how serious time can be saved.

Table XII

Time difference between repetition groups

# Reps	Seconds Per lift	# sets	Total sec
8	3	3	72
2	3	3	18

Using a time saving program that produces strength results equal to a lengthy program can be beneficial. When specific athletic skills are what makes the difference between winning and losing a game, having an exercise program that spends less time in the gym can free up more practice time. This extra time on the field may be the key to what makes a team successful. A time efficient strength program is also beneficial for novices. By reducing an exercise program by 15 to 20 minutes, a novice exerciser can fit a two-repetition program into a lunch period, where the eight-repetition program would not fit.

Being able to fit a strength program into two workouts a week other benefits may be seen. Possible benefits of this program could help in the fight against adult obesity, adult onset osteoporosis, and age-related muscle atrophy. It is known that a large contributor to obesity, osteoporosis, and age-related atrophy is the lack of strenuous exercise. Weight lifting can provide a means to combat these problems by helping to develop strong bones and lean tissue for a healthy life in the adult years (Conroy, Kraemer, Maresh & Dalsky, 1992).

Safety is another area that should be addressed. By decreasing the number of repetitions and sets needed to develop strength, less overall work is completed which should help to reduce the potential for overtraining injuries. By reducing the potential for overuse injuries the sport of weight lifting in general becomes safer.

What makes this program unique is that it is only done two times per week and the sets are only three per exercise with two repetitions. Although, lifting a weight near a maximum 1RM can be highly taxing for the muscles, the amount of work is brief enough to keep muscle fatigue low, which leaves the muscle fresher to handle the stress.

End of study questionnaires were used to get an idea of how strenuous the workouts were perceived using the Borg RPE scale of one to 10 for each test subject. Based on this RPE scale of one to 10, the eight-repetition group repeatedly reported the third set to be a lot more taxing than the prior two sets. Usually they reported a difficulty of seven and eight on the RPE scale for the third set, compared to a five or six on prior sets. Compare this to the two-repetition group who usually kept their RPE scale at a seven or eight across all three sets. This type of difficulty should be expected for a group who is lifting at 90 percent of a 1RM, but there is concern for the eight-repetition group when they have to continue to work at this level over twelve different exercises.

Another interesting result from the study was that the two-repetition group continued to ask if they would be able to raise the weight they were lifting. Some reported that they could do more than the two repetitions, while others stated that it felt like they were not working hard enough, which made them think they were not doing a good workout. This was especially apparent in the experienced lifters, who were use to doing a workout that pushed the muscles to a more fatigued state. Compare this to how the eight-repetition group felt and there's a big contrast, especially when two subjects who had to lower the workout weight in the third set for the first week until they could handle the workload.

It was suspected at the beginning of this study that the two-repetition program would not be capable of producing strength gains equal to the eight-repetition program, because it did not create as much work over a given period of time. The ideal behind this was that the two-repetition program would not be able to create enough muscle tissue stress to create a load ratio that would cause significant strength gains, or fatigability. Table XIII gives a better understanding of this. Comparing two people of different body weight, each having a unique maximum 1RM, it is shown how the ratio of the amount of work completed over a period of time will affect the total amount of work generated. In turn, this effects the total amount of stress produced for muscle fatigue.

Table XIII

Ratio of weight lifted per second and total weight lifted.

Body weight	175 lbs			Body weight	120 lbs		
1RM lifted	200 lbs			1RM lifted	110 lbs		
Using 8 rep program		Total weight lifted	Weight lifted second	Using 8 rep program		Total weight lifted	Weight lifted second
65% 1RM	130	1040	43	65% 1RM	72	576	24
70% 1RM	140	1120	46.6	70% 1RM	77	616	25.6
75% 1RM	150	1200	50	75% 1RM	83	664	27.8
Total lifted	3 sets	3360		Total lifted	3 sets	1856	
Using 2 rep program		Total weight lifted	Weight lifted second	Using 2 rep program		Total weight lifted	Weight lifted second
90% 1RM	180	360	60	90% 1RM	99	198	33
Total lifted	3 sets	1080		Total lifted	3 sets	594	
Difference	2 to 8	2280		Difference	2 to 8	1262	

The four different weights lifted in Table XIII are based on the different percentages used in this study: 65 percent, 70 percent, 75 percent, and 90 percent of a 1RM maximum. When looking at the total amount of pounds lifted for each program, it can be seen that there was a huge difference in the total amount of weight lifted between the two groups. The eight-repetition group lifted a total weight that was almost three times as much as the two-repetition group. These total weights were based on estimates that it took three seconds per repetition, then multiplied by the total number of repetitions and sets per exercise group. It is interesting to note that although the eight-repetition group lifted the most weight overall, the two-repetition group lifted more weight per second. Reviewing this chart, it could be asked how can a program that is doing three times less work overall be able to create equal amounts of strength gain.

Skeletal muscle adapts when enough stress is created and maintained to cause an overload to the muscle (Robergs & Roberts, 1997). Obviously lifting a weight at 90 percent of a 1RM will create a high degree of stress. What is not certain is how only two repetitions are enough of a continued stimulus to create a change over time. The two-repetition program worked because there obviously was enough stimulus being created to trigger a muscle overload. This stress may also be enough of a stimulus to cause changes to the nervous system, the hormonal system, and the energy system as well. High stress when applied to skeletal muscle is also thought to create minor micro-tears within the skeletal muscle cells. Allowing a minimum of two days rest between each exercise day, ample time would be available for most cellular damage to be repaired, which could help to explain why further gains in strength and muscle hypertrophy were accomplished with the two-repetition program.

Listed in tables XIV and XV are the overall average percentage of strength gained for each test group. The increases are based on the average percentage gained in all subjects for each group. Both groups made gains that were similar over time for this study, but it can be seen that the two-repetition group made gains in strength that on average were higher than those made by the eight-repetition group, although not statistically significant.

Table XIV

Percentage of average strength increases all two-repetition subjects.

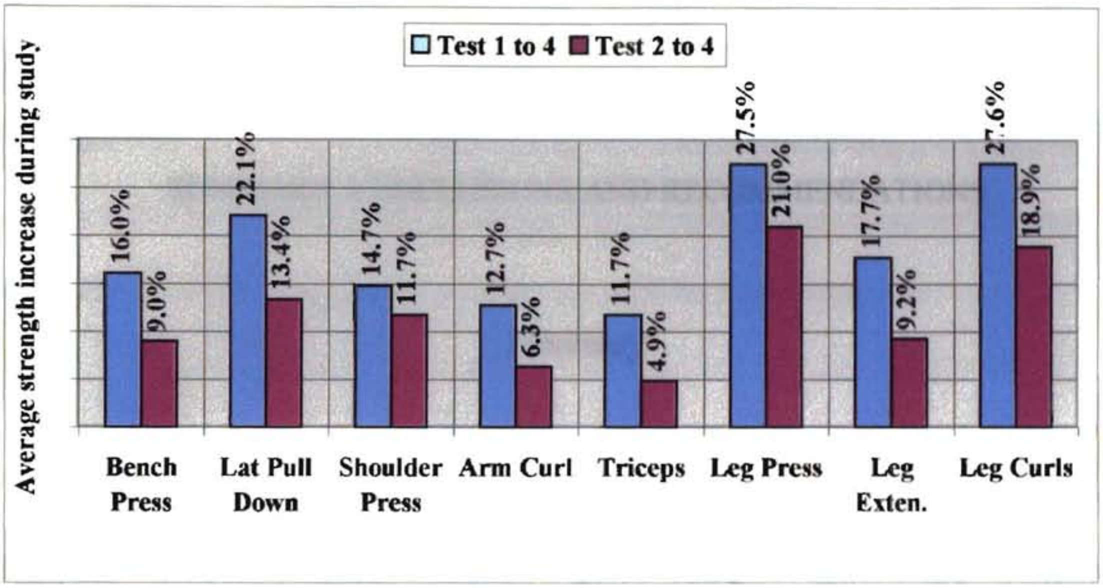
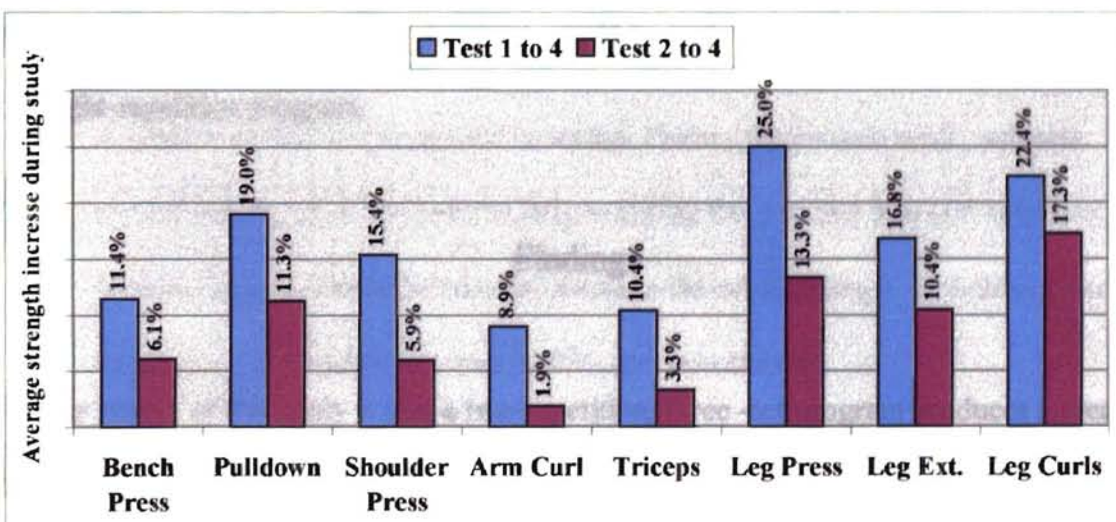


Table XV

Percentages of average strength increase all eight-repetition subjects.



CHAPER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The data showed that to develop skeletal muscle strength it did not matter if a three set two-repetition program or a three set eight-repetition program were used, both were equal in achieving this goal. Both programs, when done twice a week, showed a measurable difference in strength development over a period of time. Both programs were successful in reducing overall body fat percentage based on skin-fold caliper measurements. It was estimated that the two-repetition program would be two-thirds less time consuming than the eight-repetition program.

Findings

The impact of this study is that a two-repetition, three -set program produces increases in strength similar to an eight-repetition program using three sets. Both programs successfully reduced body fat percentages. It was estimated that the eight-repetition program would take approximately three times longer to complete.

Conclusions

The two-repetition program will produce strength gains and fat loss that are equal to an eight-repetition program while being approximately two-thirds less time consuming to complete. The two-repetition program creates less overall muscle fatigue and leaves exercisers feeling less tired than a eight-repetition program based on surveys conducted after testing, which could lead to less drop out rates for future exercisers.

Recommendations

If future studies are conducted, it is recommended that one or more of the following considerations be applied:

- All test subjects should have more than two years of experience. This would allow the two-repetition program to be compared to lifting programs being done by advanced lifters.
- A wrist/forearm exercise should be added. During the seventh week, subjects were complaining about forearm fatigue during the standing arm curl exercises.
- Muscle biopsies should be taken to measure the actual changes in skeletal muscle tissue, such as epinephrine, insulin, GH, and testosterone.
- Measurements of joint range of motion (ROM) should be taken to see if any marked differences occur after testing which could lead to future injuries.
- Percentage of fat should be done by at least two separate testers to compare values and range. This is to eliminate possible errors.

- Do not perform the research during a period where time will be missed. All subjects missed one week of training due to spring break.
- Subjects should take a protein supplement with branch chain amino acids (BCAA's) and/or creatine. This would be more realistic since most experienced weight lifters use some form of a supplement.
- The two-repetition program could be used with an aerobic program to compare increases in both strength and VO_2 maximum simultaneously. Although this area has been researched extensively, the two-repetition program will give the muscles more rest. This could create better results when compared with other programs that are done three or more days a week.

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APPENDIXES

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	January 21, 2000	IRB #: ED-00-198
Proposal Title:	"THE EFFECT OF TWO NEAR MAXIMUM DYNAMIC LIFTS COMPARED TO EIGHT AND TEN DYNAMIC LIFTS IN RELATION TO STRENGTH AND HYPERTROPHY DEVELOPMENT IN SKELETAL MUSCLE"	
Principal Investigator(s):	Steve Edwards Patrick Conway	
Reviewed and Processed as:	Expedited	

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

January 21, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

Questionnaire Form

Looking through the questions below pick each answer that reflects the most accurate answer to describe how you felt during your work out.

1. How would you rate the beginning program that allowed only 60% and 65% of your maximum 1 RM in regards towards difficulty?

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

2. In the program above how easy or difficult was it to manage time?

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

3. Rate your level of physical discomfort while practicing in this beginning workout program.

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

4. How would you rate the eight-repetition [ ] or two-repetition program [ ] in regards to difficulty. (please check the one you participated in)

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

5. In the test program above, how easy or difficult was it to manage time.

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

6. Rate your level of physical discomfort while participating in the test program.

Easy [ ] low medium [ ] medium [ ] high medium [ ] high [ ] very high [ ]

7. Were there any exercises that caused any extra discomfort or extra soreness during the study?

Yes [ ] No [ ]

8 If yes, circle the exercises that were found to create more soreness or discomfort.

Bench press incline bench press Lat. pull-down bent over rows
Shoulder press arm curls triceps push down triceps pull-down
Shoulder extension (front) shoulder extension (back) leg Press
Leg extension Leg Curls Sit-ups Back raise.

9. Was this the first time you ever done a single maximum 1RM lift to find maximum strength?

Yes [ ]   No [ ]

10. Do you feel that the maximum 1 RM lift test got easier, harder or stayed the same each time?

Easier [ ]   Harder [ ]   Same [ ]

11. What was the hardest exercise for you to do?

Bench press   Incline bench press   Lat. pull-down   bent over rows
Shoulder press   arm curls   triceps push-down   triceps pull-down
Shoulder extension (front)   shoulder extension (back)   leg Press
Leg extension   leg Curls   Sit-ups   back raise.

12. What was the easiest exercise for you to do?

Bench press   incline bench press   Lat. pull-down   bent over rows
Shoulder press   arm curls   triceps push-down   triceps pull-down
Shoulder extension (front)   shoulder extension (back)   leg press
Leg extension   leg curls   sit-ups   back raise.

13. Which exercise did you consider to be your favorite to do?

Bench press   incline bench press   Lat. pull-down   bent over rows
Shoulder press   arm curls   triceps push-down   triceps pull-down
Shoulder extension (front)   shoulder extension (back)   leg press
Leg extension   leg curls   sit-ups   back raise.

14. Which exercise did you like the least to do?

Bench press   incline bench press   Lat. pull-down   bent over rows
Shoulder press   arm curls   triceps push-down   triceps pull-down
Shoulder extension (front)   shoulder extension (back)   leg press
Leg extension   leg Curls   sit-ups   back raise.

15. If you had to skip an exercise, which one, or ones, did you skip?

Bench press   incline bench press   Lat. pull-down   bent over rows
Shoulder press   arm curls   triceps push down   triceps pull-down
Shoulder extension (front)   shoulder extension (back)   leg press
Leg extension   leg curls   sit-ups   back raise.

16. If you skipped an exercise did you make it up later?
Yes [ ]   No [ ]

17. Were you able to exercise the prescribed amount of days per week as assigned?

Yes [ ]   No [ ]

18. If you answered No, to question 17 above, how many days did you miss during the first 4 weeks of the study period while working out 3 days per week?

1 2 3 4 5 6 7 8 9

19. If you answered No to question 14, how many days did you miss during the 7 weeks of the study period lifting 2 days per week?

1 2 3 4 5 6 7 8

20. Were any of these days during spring break?

Yes [ ]   No [ ]

21. Did you miss any days due to illness?

Yes [ ]   No [ ]

22. If yes, do you feel that the workout program contributed to the illness?

Yes [ ]   No [ ]

23. If you got sick, then returned to working out, what happen to your strength?

Stayed Same [ ]   Reduced [ ]   Increased [ ]

24. Did your overall strength increase during the study?

Yes [ ]   No [ ]

25. Did you see strength gains from work out to work out?

Yes [ ]   No [ ]

26. Could you see your strength increasing when you did the maximum 1RM tests?

Yes [ ]   No [ ]

27. Did all exercise areas increase the same?

Yes [ ] No [ ]

28. If you answered No to # 27 above, which exercise areas increased the most?

Bench press incline bench press Lat. pull-down bent over rows
Shoulder press arm curls triceps push-down triceps pull-down
Shoulder extension (front) shoulder extension (back) leg press
Leg extension leg curls sit-ups back raise.

29. If you answered No to # 27, which exercise areas increased the least?

Bench press incline bench press Lat. pull-down bent over rows
Shoulder press arm curls triceps push-down triceps pull-down
Shoulder extension (front) shoulder extension (back) leg press
Leg extension leg curls sit-ups back raise.

30. Did you follow the program as it was prescribed to you, or did you modify it?

I did the exercises as prescribed [ ] I modified the exercises [ ]

31. If you modified the workout, please check below the things you modified.

Decreased weight [ ] Decreased repetitions [ ] Decreased sets [ ]
Increased weight [ ] Increased repetitions [ ] Increased sets [ ]
Eliminated exercises [ ] Added exercises [ ]

32. If you checked items above, please write below how long you modified your program, what was modified, and why did you modify it.

33. Did your body weight increase, decrease or stay the same from start to finish of this study?

Increase [ ] Decrease [ ] Same [ ]

34. Did your body fat go up, down or stay the same during the study?

Up [ ] Down [ ] Same [ ]

35. Did you follow the suggested diet during the study?

Yes [ ] No [ ]

36. Did you follow any type of diet during the study?

Yes [ ] No [ ]

37. If yes, did you count total grams of protein per day?

Yes [ ] No [ ]

38. Did you count calories, and if so, were you trying to maintain weight or loose it?

count calories [ ] loose weight [ ] No calories [ ] No loose weight [ ]

39. Did you participate in any other sports or exercise activities during the study?

Yes [ ] No [ ]

40. If yes, did you see any improvements in these activities that you believe could be attributed to the workout program?

Yes [ ] No [ ]

41. If yes to question 39, did you see any reductions to these activities that you believe could be attributed to the workout program?

Yes [ ] No [ ]

42. Please list below the things that were improved or reduced in your other activities.

43. Would you recommend your workout program to someone else trying to build strength?

Yes [ ] No [ ]

44. Will you continue to use this program after this study is complete?

Yes [ ] No [ ]

45. Did you feel that this program demanded enough physical work, not enough physical work or too much physical work overall?

Enough [ ] Not Enough [ ] Too Much [ ]

VITA

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Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF TWO NEAR MAXIMUM DYNAMIC LIFTS COMPARED TO EIGHT DYNAMIC LIFTS IN RELATION TO STRENGTH DEVELOPMENT

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Personal Data: Born in Granite City, Illinois, December 23, 1958,

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