ABSTRACT

GREGOR, T. J. Effects of parallel squat training and 45 degree angle leg press training on absolute strength and relative power acquisition. M.S. in Physical Education-Human Performance, 1988. 80 p. (A. W. Freeman).

This study compared the effects of parallel squat (PS) training and 45 degree angle leg press (LP) training on the acquisition of absolute strength (AS) and relative power (RP). Thirty male subjects (19-24 yr.) volunteered with 20 completing the ten week program. The subjects from three basic weight training classes were assigned to two groups (N = 10 PS, N = 10 LP). Subjects trained two times per week for ten weeks. All subjects performed each strength and power pre- and post-test. The pre-test was performed before the onset of training; the post-test was administered the week following the conclusion of each respective training program. Test battery consisted of the vertical jump (VJ), Margaria-Kalamen (MK) power test, one-repetition-maximum (1RM) PS, and 1RM LP. Comparisons were made using a two factor Analysis of Variance ANOVA with repeated measures on one factor. When significance was found a Scheffe' post hoc test was performed. Statistical analysis revealed significant ($p < .05$) differences for AS as measured by 1RM tests for PS and LP training. Significance ($p < .05$) occurred for RP as measured by MK test for PS training. Neither group showed significant difference in RP as measured by the VJ. It was concluded that the training programs used produced significant improvement in AS for both experimental (PS & LP) groups, but only PS training produced significant improvement in RP as measured by the MK test.

Effects of Parallel Squat Training and 45 Degree Angle Leg Press Training on Absolute Strength and Relative Power Acquisition

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A Thesis Presented

to

The Graduate Faculty

University of Wisconsin-La Crosse

In Partial Fulfillment

of the Requirements for the

Master of Science Degree

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by

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December 1988

UNIVERSITY OF WISCONSIN-LA CROSSE
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We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science Physical Education - Human Performance

The candidate has completed his oral report.

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This thesis is approved for the College of Health, Physical Education and Recreation.

Dean, College of Health, Physical Education and Recreation — Date: 11/28/88

Dean of Graduate Studies — Date: 12-13-88

ACKNOWLEDGEMENTS

I would like to thank my committee members. The memories of the time spent with them will never be forgotten. Their gracious help and assistance strengthened my persistence throughout this project and made this thesis a reality.

I thank Dr. Freeman for all of the precious time and effort he put forth as my thesis chairperson. His attention to detail added much to the outcome of this thesis. Dr. Freeman was a constant source of encouragement and reassurance. I was truly honored to have Dr. Freeman as my chairperson.

I thank Dr. French for his knowledge and expertise in the areas of exercise and biomechanics. Dr. French provided many helpful suggestions which greatly enhanced the presentation of the material.

I thank Dr. Castek for his knowledgeable assistance with the statistical analysis. The effort he put forth was indispensable.

I thank the subjects who participated in this study. I commend them for their time and effort. Their performance was admirable.

I thank Liz Johnson for all her help in formatting this document for the laser printer.

My acknowledgements would be incomplete without recognizing the immense contributions of my wife Gloria. Her editorial assistance, typing, proofreading, and belief in this project deserve special recognition. Although this project prompted many inconveniences, the countless hours we shared while working together will always be treasured.

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CHAPTER I

INTRODUCTION

In 1982 Berger wrote, "The significant relationship between absolute strength and relative power emphasizes the importance of strength in athletic ability and fitness." (p. 29). The ability to generate maximum power and strength is a prime factor in athletic performance.

The past decade has seen some extraordinary performances in athletics; athletes are jumping farther and higher, runners are lowering their times with regularity, and the shot and discus are being projected remarkable distances (Clutch, Wilton, McGown, & Bryce, 1983). It is the contention of many coaches and athletes that improvements in weight training techniques and methods have been the major contributors to modern athletic accomplishments (O'Shea, 1976). Athletes are incorporating weight training programs into their training regimens to promote maximum athletic performance.

Leg and hip strength and power are generally considered major factors in the performance of most athletic events (Stone, O'Bryant, & Garhammer, 1981). Coaches and athletes are constantly seeking training methods that improve leg and hip strength. Two widely used leg and hip weight training exercises are the parallel squat and the 45 degree angle leg press (Watkins, 1983).

Need for the Study

In the past 25 years research has demonstrated the effectiveness of parallel squat training in improving absolute strength and relative power (Berger, 1963b; McLaughlin, Lardner, & Dillman, 1978; O'Shea, 1966; Stone et al., 1981). The increasingly widespread use of the parallel squat in weight lifting and general weight training suggests that further research would be valuable to both physical education practitioners and athletes (McLaughlin et al., 1978).

The effects of parallel squat training on absolute strength and relative power have been scientifically studied; however, few attempts have been made to determine if the parallel squat is more effective than the 45 degree angle leg press. Because absolute strength and relative power contribute to optimal athletic performance, it would be beneficial to investigate the effects of parallel squat training and the effects of 45 degree angle leg press training on these strength and power parameters. This data would be most helpful to physical therapists, physical educators, coaches, and athletes in the development of programs that promote absolute strength and relative power acquisition. Since resistance training appeals to such a diverse group of people, more research is merited.

Purpose of the Study

The purpose of the study was to determine which method increased more absolute strength and relative power in the hip and thigh muscles, parallel squat training or 45 degree angle leg press training in college males after a 10 week training program.

Null Hypotheses

The following null hypotheses were investigated:

1. There will be no significant difference in absolute strength as a result of 10 weeks of parallel squat training.

2. There will be no significant difference in absolute strength as a result of 10 weeks of 45 degree angle leg press training.

3. There will be no significant difference in absolute strength as a result of 10 weeks of training between the parallel squat and the 45 degree angle leg press groups.

4. There will be no significant difference in relative power as measured by the vertical jump as a result of 10 weeks of parallel squat training.

5. There will be no significant difference in relative power as measured by the vertical jump as a result of 10 weeks of 45 degree angle leg press training.

6. There will be no significant difference in relative power as measured by the vertical jump as a result of 10 weeks of training between the parallel squat and 45 degree angle leg press groups.

7. There will be no significant difference in relative power as measured by the Margaria-Kalamen power test as a result of 10 weeks of parallel squat training.

8. There will be no significant difference in relative power as measured by the Margaria-Kalamen power test as a result of 10 weeks of

45 degree angle leg press training.

9. There will be no significant difference in relative power as measured by the Margaria-Kalamen power test as a result of 10 weeks of training between the parallel squat and 45 degree angle leg press groups.

Assumptions

The following were the assumptions of this study:

1. All subjects performed to the best of their ability during the testing and training sessions.

2. All subjects followed the directions of this study and were not involved in other strength training programs outside of class which could influence the results of this study.

Delimitations

The following delimitations were made for this study:

1. The subjects were University of Wisconsin-La Crosse undergraduate students enrolled in physical education weight training classes during the 1988 spring semester.

2. The subjects were volunteers, and they consented to participate in this study.

3. The subjects were not members of an athletic team during this study.

4. The subjects agreed to only do the prescribed leg exercises presented during this study.

Limitations

The following limitations occurred in this study:

1. The subjects were instructed to maintain their normal diet habits for the duration of the study; however, the investigator had no way of knowing whether or not this instruction was followed.

2. This investigator had no control over vacations scheduled during the course of this investigation.

3. This investigator had no control over the training frequency of the classes per week. The schedule was determined by the university.

4. Subjects who missed a training or testing session due to physical injury, illness, or absence were permitted to make up the session at a specified time during the week. Subjects unable to make up sessions or those who failed to train for two consecutive or a total of four sessions were eliminated from this study.

Definition of Terms

Absolute Strength - strength in moving a heavy object other than body weight or applying force to an immovable object was measured in this study as the amount of weight squatted or leg pressed one time (Berger, 1982).

Anaerobic Power - the maximal rate at which energy can be produced or work can be performed without a significant contribution of aerobic energy production (Lamb, 1984).

Diurnal - showing a periodic alteration of condition with day and night. In this study the training and testing sessions were performed at the same time of the day.

Isotonic - a resistance training exercise where the external resistance or weight does not vary (Fleck & Kraemer, 1987).

Leg Press / 45 degree angle - a leg and hip exercise performed on a machine from a reclined position. The carriage was pressed at a 45 degree angle.

Lewis Nomogram - a formula used to determine power from jump-reach score and body weight (see Appendix A). Power was determined in foot pounds per second (Fox & Mathews, 1981).

Margaria-Kalamen Power Test - a measure of power output that required each subject to run up a flight of stairs at maximum speed, three steps at a time (Kalamen, 1968).

One-Repetition-Maximum (1RM) - refers to the maximum amount of weight parallel squatted or leg pressed one time (McArdle, Katch, & Katch, 1986).

Parallel Squat - a leg and hip exercise performed with a bar held across the back of the shoulders. Each subject descended until the upper thigh was parallel with the floor, then returned to an upright position (McLaughlin, Dunn, Kroll, O'Shea, & Wathen, 1984).

Power - work done per unit of time. The formula $P = W \times D/t$ was used to convert to foot pounds per second of power.

Relative Power - strength or force in moving body weight quickly and explosively per unit of time (Berger, 1982). In this study relative power was determined with the vertical jump and the Margaria-Kalamen power test.

Strength - the maximal force a muscle or muscle group can exert against a resistance at a specific velocity (Knuttgen & Kraemer, 1987).

Vertical Jump - a test of relative power involving a subject jumping vertically from a crouched position and reaching as high as possible with maximal effort. The conversion of foot pounds of power produced was done using the Lewis Nomogram method (Stone et al., 1981).

CHAPTER II

REVIEW OF LITERATURE

Introduction

A topic of great interest is the constant improvement of championship times, distances, and records (Golding, 1987). For many years running the four minute mile seemed physiologically impossible. Yet, once an individual achieved this goal, others quickly followed. Likewise, the men's gold medal winners of past Olympic swimming events would have a difficult time competing against the current gold medal winners in the women's division. Weight lifters are also getting bigger and better developed. At one time a 1,000 pound competition parallel squat was only a dream. Recently this feat has become a reality. How do coaches and athletes account for these performances, which were in many cases deemed physiologically impossible?

A substantial degree of athletic ability depends on inherited characteristics; yet many of these elements of athletic performance can be improved substantially with training despite the genetic influence (Sharkey, 1986). In strength training, athletes now have new sophisticated equipment to isolate and exercise the muscle maximally (Golding, 1987). Perhaps the more sophisticated training programs or an increased knowledge of physiology has improved strength acquisition and sport performance.

Since strength and power are intricate components of many conditioning programs, these components must be tested and trained with meticulous care. To determine precise measurements of strength and power, refined assessment tools must be utilized. Performance tests are carefully studied and performed in many sports science laboratories. Strength and power tests were examined in the following review of literature.

Vertical Jump

It is commonly known that the vertical jump has been consistently included in many general motor ability batteries; therefore, this test has an extensive history. Historically, many versions of the vertical jump have been used to assess power (Gray, Start, & Glencross, 1962; McCoy, 1932; Sargent, D., 1921; Sargent, L., 1924; Van Dalen, 1940). The assessment and significance of anaerobic power was of great interest to these investigators. Consequently, they devoted considerable effort to its measurement and relevance.

In A Test of Physical Man, D. Sargent presented a measure of leg power output. D. Sargent pioneered one of the most widely used tests in physical education (Martin & Stull, 1969). Sargent (1921) had the subject swing both arms downward and backward. The body was bent forward while the subject assumed a crouched position under a piece of cardboard which was suspended above the head. The subject paused in this position, then jumped as high as possible swinging the arms upward and forward to a vertical position. Just before the highest point of the jump was reached, the arms were swung forward and downward. The distance between standing height and the height of the cardboard where the head had touched was called the jump height.

L. Sargent (1924) and McCoy (1932) analyzed the original Sargent Jump test and concluded that it was a measure of power. However, L. Sargent (1924) cautioned that subsequent research might reveal a relationship between size of dip, height, and weight on vertical jump performance. Considine (1971) reported that he felt the original intent of the Sargent Jump was to measure the physical efficiency of human effort. He felt that the Sargent test of physical man had quickly gained notoriety; however, its original purpose had become obscured.

Various vertical jump protocols have been derived from the original Sargent Jump. More recently, the recording of the height has become less complex. Few researchers continue to use the top of the head to determine jump height. The jump and reach test technique is now frequently used as a common test of power because of its ease of administration (Glencross, 1966).

Van Dalen (1940) compared the Sargent Jump and seven other vertical jump techniques with four athletic events. Van Dalen's results indicated that arm swing was the primary factor that contributed to optimum vertical jump performance.

Gray et al. (1962) contended that vertical jump may indicate general muscular power. However, it cannot be deemed a test of pure leg power because the upward thrust of the arms and the extension of the trunk assists the performer in the completion of the jump. Gray et al. devised a power test which utilized the physical science definition of power. Power was measured as the rate of doing work.

Martin and Stull (1969) investigated the effects various knee angle and foot spacing combinations had on vertical jump performance. A knee angle of 115 degrees with feet spread 5 to 10 inches laterally and around 5 inches anterior-posteriorly was reported to be the most effective stance.

More recently, researchers have utilized a force platform to measure instantaneous power produced during a vertical jump (Davies, 1971; Davies & Rennie, 1968; Offenbacher, 1970). A force platform is an electronic device which records the amount of force that is exerted on the platform. Peak and average power during the thrust can be calculated using the force platform.

In recent years, several researchers have used the vertical jump to evaluate explosive leg and hip power. Wathen and Shutes (1982) conducted a study comparing commonly used modes of isotonic and isokinetic training with respect to vertical jump improvements. Silvester, Stiggins, McGown, and Bryce (1982) used the vertical jump to determine if greater strength gains can be achieved with variable resistance machines than with more conventional training equipment. Stowers et al. (1983) assessed the effects of three short-term weight training programs on body weight, upper body strength, leg and hip strength, and leg and hip power using the vertical jump and the Lewis Nomogram to convert the vertical jump to a power measure.

O'Bryant (1984) reported that the vertical jump is not a sound indicator of power unless mass and time are taken into consideration. Likewise, Fox and Mathews (1981) stated that the Sargent Jump is a poor test of power because of the exclusion of body weight and speed. However, they also stated that the vertical jump test is valid when the vertical jump is converted to units of power using the Lewis Nomogram.

The Lewis Nomogram is a formula used to determine power from a jump-reach score and body weight.

Margaria-Kalamen Power Test

Investigators of human performance have had a long and continued interest in maximum, short-term power output (Margaria, Aghemo, & Rovelli, 1966; McCartney, Heigenhauser, & Jones, 1983). As a result an anaerobic power test was devised with a protocol of repeated exercise bouts, separated with short rest intervals. A test developed by Margaria et al. (1966) calculated power output during stair climbing at maximal speed. Margaria and associates felt the step test accurately measured leg power because of the inclusion of time in power output calculations. Power was measured as the result of body weight acting through a given vertical distance in a minimum amount of time (Fox & Mathews, 1981). McArdle et al. (1986) cautioned that this test may be best suited for testing performers of similar body weight, or the same individuals before or after a specific training program designed to develop rapid anaerobic leg power.

A study by Ayalon, Inbar, and Bar-Or (1974) indicated that the Margaria step test is a feasible and reliable determiner of explosive power. They reported test-retest correlation coefficients between 0.85 and 0.90.

The anaerobic power test devised by Margaria et al. (1966) was altered by Kalamen in 1968. Costill, Miller, Myers, Kehoe, and Hoffman (1968) reported that the modifications of the original procedure have demonstrated the reliability of the test as a tool for identifying persons capable of exceptional power production. Mayhew, Schwegler, and Piper (1986) supported this statement. They reported that the Margaria-Kalamen test is a widely accepted anaerobic power test.

As outlined by Fox and Mathews (1981), the Margaria-Kalamen power test consists of sprinting up a flight of stairs from a six meter running start negotiating three steps at a time. The performer is timed from the instant contact is made with the third step until contact with the ninth step. Power output is computed using the formula: $P = \frac{W \times D}{t}$.

One-Repetition-Maximum Test

In 1983 Weil wrote, "I feel very strongly that strength testing is the cornerstone of a good strength program; without testing the program is at best based on intangibles." (p. 16). Strength is defined as the maximal force a muscle or a group of muscles can exert against a resistance at a specific velocity (Knuttgen & Kraemer, 1987). If improvements in leg strength can be achieved by training, then accurate testing instruments are needed to determine strength gains. When measuring strength, the force of a muscle is measured indirectly through the leverage system of the skeleton (Berger, 1982). Berger contended that changes in muscle force as a result of training can be measured by testing strength before and after training. Berger concluded, since the leverage system of the skeleton does not change, any differences represent an increased force capacity of the muscle.

Muscular strength is often evaluated by one of four methods: tensiometry, dynamometry, one-repetition-maximum, and the computer-assisted force and work output method (McArdle et al., 1986). McArdle and associates contended that the one-repetition-maximum test is a dynamic measure of muscular strength. The one-repetition-maximum testing method refers to the maximum amount of weight lifted one time during an execution of a standard weight lifting exercise. It does not require elaborate equipment, and it is easy to administer. This testing method has recently been used in training studies as an instrument to determine strength performance.

Hickson (1980) conducted a study to determine how individuals adapt to a combination of strength and endurance training as compared to the adaptations produced by either strength or endurance training separately. Leg strength was measured by determining the maximum amount of weight that could be lifted for one repetition in a parallel squat. The criterion for determining strength was the inability to continue to perform a single repetition against increasing resistance.

Clutch et al. (1983) utilized the one-repetition-maximum testing procedure to determine the effects of depth jumps and weight training on leg strength and vertical jump. Leg strength was evaluated by determining the weight with which a subject could do a one-repetition-maximum squat and by measuring the force of a maximum isometric knee extension performed at an angle of 125 degrees.

Isotonic Training

The past ten years have witnessed a popularity explosion in the use and acceptance of resistance training (Fleck & Kraemer, 1987). Isotonic training exercises are designed to strengthen specific muscles by causing them to overcome a fixed resistance, usually in the form of a barbell, dumbbell, or weight machine. It is widely-accepted that the best way to increase the strength of a muscle is to subject it to near-maximum loads and to increase these loads progressively as the strength of the muscle increases (Hay, Andrews, Vaughan, & Ueya, 1985). Isotonic strength training refers to a resistance training exercise where the external resistance or weight does not vary (Fleck & Kraemer, 1987).

An examination of available literature has revealed investigations done to determine significant factors that contribute to successful isotonic training programs. Researchers have attempted to document optimum numbers of repetitions, interactions of sets and repetitions, and load resistance pertaining to isotonic strength training.

Looking back in time to the beginning of progressive resistance training, it can be seen that its founders made significant contributions in this field. While working in a rehabilitation facility following World War II, DeLorme (1945) marked the beginning of research which elaborated on the principles of progressive resistance. DeLorme was preeminent in the clinical application of the principles of progressive resistance. He developed weight training techniques that increased the strength capacity of previously atrophied or injured limbs. DeLorme's work implied that low repetitions and high resistance produced significant gains in strength. After DeLorme determined the maximal load an individual could lift for 10 repetitions, each individual completed 30 repetitions per session. The first 10 at one-half the 10 repetition maximum, a second set of 10 at three-forths the 10 repetition maximum, and a third set of 10 at the 10 repetition maximum. The subject would try to increase the number of repetitions from day to day. The weight load was increased at weekly intervals. With a few refinements, Delorme's basic principles of progressive resistance are still used today.

Researchers continued to investigate progressive resistance training. Chui (1950) and Berger (1962b) in separate studies reported optimum gains in vertical jumping ability following isotonic training. This indicated favorable power changes from isotonics.

Stull and Clarke (1970) investigated the effects of high-resistance, low-repetition training on the development of muscular strength and endurance. Significant gains were obtained in initial strength, final strength, and total work. The researchers concluded that the principle effects caused by high-resistance, low-repetition progressive weight training resulted in increased levels of muscular strength and absolute endurance. Relative muscular endurance was unchanged.

Wathen (1980) investigated differences between isotonic and isokinetic programs with respect to vertical jump improvements in college athletes. The isotonic group displayed significance beyond the .01 level. A follow-up study done by Wathen and Shutes (1982) reported that vertical jump improvement was positively affected by the isotonic program. Again, the isotonic group displayed significance beyond the .01 level.

Silvester et al. (1982) compared two variable resistance leg press exercises with the traditional free-weight squat exercise. The findings indicated that exercises performed with variable resistance machines and free-weights were equally effective in developing strength.

Stone, Johnson, and Carter (1979) investigated and compared the effects of short term Nautilus training with free weight training on the performance variables of leg strength and power. The subjects were trained identically for four weeks using both free weights and Nautilus. Following the training, leg strength variables were measured with the one-repetition-maximum parallel squat and the one-repetition-maximum Nautilus leg press. Power was determined using the vertical jump and the Lewis Nomogram. After the initial training period, the subjects were assigned to a Nautilus or free weight training group. Strength and power increases were measured after five weeks. The results favored the free weight group. Free weight training was found to be superior in producing significant changes in the one-repetition-maximum parallel squat and the vertical jump.

Training Protocol

Number of sets, number of repetitions, and training frequency were factors deemed important in the review of literature; however, a consensus was not found. Consequently, much confusion and controversy lies in the development of effective strength and conditioning programs. A great deal of this is due to the wide variety of training variables. Future research may reveal more effective exercise prescription strategies.

O'Shea (1966) determined that beginning lifters excel most when they train with three sets. O'Shea also reported that five to six repetitions were best for individuals in introductory strength programs. Berger (1962a) reported that strength from isotonics was best gained by working in the multiple sets of two to five and by working with repetitions as close as possible to maximal strength values. Hoeger, Barette, Hale, and Hopkins (1987) conducted a study with subjects with no previous strength training experience. The results indicated that a given number of repetitions is not always associated with similar percentages of the one-repetition-maximum when performing various weight training exercises. Simply stated, the findings of this study indicated that if 10 or fewer maximum repetitions are used to stimulate strength development, a minimum of 80 percent of the one-repetition-maximum may be needed in most lifts to obtain strength gains.

Various progressive resistance exercise regimes have been shown to increase strength. To increase strength, most research stated that the optimal number of repetitions lies between three and ten. This conclusion demonstrates that there may be various combinations of sets and repetitions that cause optimal gains in strength (Fleck & Kraemer, 1987).

Three studies pertaining to frequency of workouts agreed that three workout days per week were superior to two (Berger, 1963a; Hunter, 1985; O'Shea, 1966). Hay et al. (1983) reported that training four or five days a week may be less effective for increasing strength than training three times per week. Hay and associates also reported that more frequent strength training may prevent sufficient recuperation between training sessions. Conversely, Gilliam (1981) reported greater strength gains using a five day program than exercise schedules of one, two, three, or four days per week. Groups training between three and five days per week recorded greater strength increases than those who trained one day per week. Collectively, the results implied that the more frequent the stress the greater the adaptation (Gilliam, 1981).

It appears that definitive studies which isolate the influence of frequency from that of repetitions, sets, and load resistance have not yet been completed. The optimal method is yet to be formulated. While there is little agreement regarding details in a training program, there is one agreement in principle. If you want to develop strength, use progressive resistance exercise in the overload zone (Fox & Mathews, 1981).

Summary

In summary, it is worthwhile to repeat certain statements presented earlier regarding the concepts of strength and power. The literature cited supports the vertical jump and the Margaria-Kalamen power test as valid measures of power. Power is the rate of doing work, and time is an essential factor to consider when measuring power. Strength, however, is a force a muscle or a group of murcles can exert against a resistance in one maximal effort. The one-repetition-maximum is considered one of the primary instruments used to measure strength. This test is capable of rapid and efficient administration to large groups without expensive or complicated apparatus.

The search for training programs that promote optimal strength and power has been historically an ongoing process that continues to this day. As the field of applied physiology becomes more highly developed and scientifically based, one of the challeging tasks facing researchers is to become more effective in exercise prescription. The review of literature has demonstrated a need for further study concerning the effects of parallel squat and leg press training on the acquisition of strength and power. Research in this area may well increase our understanding of athletic performances.

CHAPTER III

METHODS

Introduction

It was the intent of this study to compare the effects of parallel squat training and the effects of 45 degree angle leg press training on absolute strength and relative power acquisition. The vertical jump and the Margaria-Kalamen power test were used to assess power gains. Absolute strength was determined using the one-repetition-maximum testing procedure. These tests were administered to all subjects before the onset of training and also at the conclusion of this study. Included in this chapter are: subject selection; testing procedures; training procedures; and statistics.

Subject Selection

The training subjects consisted of 30 undergraduate male volunteers enrolled in basic weight training classes held during the 1988 spring semester at the University of Wisconsin-La Crosse. Group A consisted of 14 subjects obtained from one Tuesday-Thursday weight training class. The subjects in group A were assigned the parallel squat training program. Sixteen subjects selected from two Monday-Wednesday weight training classes participated in group B. Group B performed the prescribed 45 degree angle leg press weight training program.

Both training groups attended their respective training session. They participated in each strength and power pre-test to determine baseline performance. Each subject performed the strength and power post-tests to determine if strength and power parameters had changed as a result of the training program.

Subjects who missed a training or testing session due to physical injury, illness, or absence were permitted to make up the training session at a specified time during the week. Subjects unable to make up the training sessions or those who failed to perform for two consecutive or a total of four exercise sessions were eliminated from this study. Permission for participation was obtained prior to the onset of the study. Each subject consented to perform the prescribed strength and power tasks used in the study. The subjects signed a statement of agreement not to participate in any other forms of weight training (see Appendix B). Subjects who violated this agreement were eliminated from the study.

Each subject attended an orientation program. They were briefed on testing procedures for the vertical jump, the Margaria-Kalamen power test, and the one-repetition-maximum testing method. Demonstrations of the warm-up exercises, the parallel squat, and the 45 degree angle leg press were given. To reduce the learning effect, the subjects were given four practice sessions to learn proper technique and to become familiar with the equipment before a baseline strength or power assessment was given. During these sessions the subjects were given parallel squat and 45 degree angle leg press trials to determine the amount of weight needed for the initial testing trial.

Testing Procedures

The testing order for the subjects and the testing order for the tests were randomly determined prior to testing. The subjects were instructed to do specific stretching exercises as outlined by Anderson (1980) prior to each testing session (see Appendix C). Each subject was allowed 5-10 minutes to complete these warm-ups. Upon the completion of each test, the investigator recorded the results on an accumulative profile sheet (see Appendix D).

Vertical Jump

Each subject was required to wear the same clothing and shoes for each vertical jump test. Prior to testing, each subject was weighed on a medical scale to the nearest quarter pound. The Vertex vertical measurement and training apparatus (Sports Imports, Columbus, Ohio 43221) was used for taking the standing reach measurement (see Appendix E). Keeping the feet flat on the floor, each subject stood beneath the apparatus and extended his preferred arm as high as possible (see Figure 1). The standing reach was recorded (see Appendix F). Each subject was required to use the same arm for all subsequent tests.

Vertical jump performance was determined using the Vertec vertical measurement and training apparatus. The Vertec apparatus consisted of 49 movable vanes. The vanes were spaced vertically at one-half inch intervals and suspended above an unobstructed floor area. It provided a total range of 6 to 12 feet.

Following the warm-ups, each subject initiated the vertical jump by crouching beneath the Vertec apparatus with feet parallel and slightly apart (see Figure 2). Each subject was instructed to take off from and land on the same point on the floor. The depth of the crouch was not controlled. Each subject explosively jumped and reached pushing the highest vane with the preferred hand (see Figure 3).

Figure 1. Standing reach.

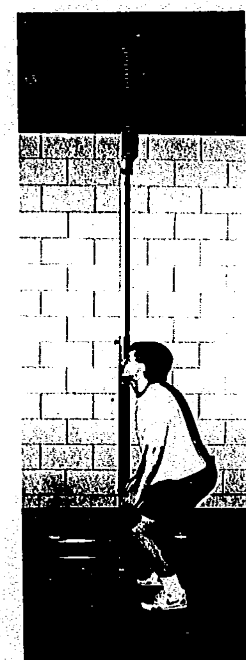

Figure 2. Crouch.

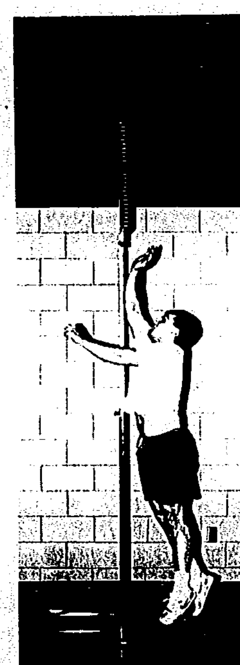

Figure 3. Jump reach.

The trials were performed with a minimum of 30 seconds rest between each jump. Due to diurnal variation in strength, all testing was carried out at the same time each day for all groups (Withers, 1970). Each test consisted of three practice trials followed by three test trials. The three test trials were recorded in inches. The highest value was used to measure vertical jump performance. The vertical distance jumped was determined by subtracting the standing reach from the maximum jump height. The vertical distance jumped and the subject's body weight were applied to the Lewis Nomogram formula to determine power output (Fox & Mathews, 1981). The Lewis Nomogram formula is P = (4 x weight) x the square root of the jump reach score (see Appendix A).

Margaria-Kalamen Power Test

Following the prescribed stretching exercises, each subject was weighed on a medical scale to the nearest quarter pound. Each subject was weighed wearing the same clothing and shoes that would be worn during the test. Anaerobic power was measured using the Margaria-Kalamen power test as outlined by Fox and Mathews (1981). Each subject stood two meters in front of a staircase (see Figure 4). When ready, each subject ran up the stairs as rapidly as possible, taking three steps at a time. A switchmat was placed on the third and ninth step (see Figure 5). A Dekan timer was activated when the subject stepped on the first switchmat and deactivated when he stepped on the second switchmat (see Figure 6).

Each subject was encouraged to rehearse this task as many times as necessary to acquire the skills needed to perform the task. When each subject felt proficient, three trials were given. A minimum of 30 seconds was allowed between trials. If a subject's time continued to decrease, the trials were increased until the time equalized. This was done to reduce the initial learning effect found with practice. After the test trials, the scores were recorded (see Appendix G). The lowest time was used to determine power output. Power output was calculated using the formula P = W x D / t, in which:

P = *power in foot pounds per second*
W = weight of subject (pounds)
D = vertical height between the third and ninth steps (3.6 feet)
t = time from initial contact of the foot on the third step until it again contacted on the ninth step.

This formula determined power in foot pounds per second (Fox & Mathews, 1981).

Figure 4. Start.

Figure 5. Power test.

Figure 6. Dekan timer.

One-Repetition-Maximum Strength Tests

The one-repetition-maximum test was used to determine absolute strength. Each subject was tested prior to and also following the training program. The one-repetition-maximum test was used with both the parallel squat and the 45 degree angle leg press. Prior to testing, each subject was instructed to do specific stretching exercises.

During previous practice sessions, each subject was permitted to adjust to the parallel squat exercise to reduce the influence of learning upon initial strength measures. Based on the practice trials, the investigator determined the amount of weight to be lifted during the initial parallel squat trial. The investigator encouraged each subject to perform to maximal ability during the testing situations.

After completing the specified warm-up exercises, each subject faced the upright squat racks and grasped the bar with an even grip. The grip was required to stay inside the collars on the bar. Each subject stepped beneath the bar and centered the bar across the back of the shoulders. The bar was not allowed to be more than three centimeters below the top of the rear deltoid. Each subject looked up, the shoulders were kept back, and the chest pushed out. Each subject stood up with the weight, stepped two steps away from the uprights, and placed the feet flat on the floor shoulder width apart (see Figure 7). After inhaling deeply, each subject commenced to squat down slowly in a controlled manner until the upper thigh was parallel with the floor. (see Figure 8). Each subject maintained control during the descent phase and was not allowed to bounce out of the parallel position. When parallel depth was reached, each subject was told to press the weight back to the standing position. Spotters were used for safety purposes, and the squats were performed in a power or tier rack.

Figure 7. Erect start.

Figure 8. Parallel depth.

The one-repetition-maximum was determined by increasing the weight load after each successful lift until the parallel squat could not be performed with proper form. Strength was evaluated to the nearest five pounds. All tests were administered and recorded by this investigator (see Appendix H). A minimum of two minutes rest was given between trials. This rest was given to insure that each trial was performed maximally without undue fatigue (Westcott, 1983).

The procedures used to administer the 45 degree angle leg press tests were the same as those used for the parallel squat. Following the prescribed warm-up exercises, each subject was permitted to adjust to the 45 degree angle leg press exercise to reduce the influence of learning upon initial strength measures. Again, the investigator determined the amount of weight to be lifted on the initial trial. This was based on the subject's previous practice trials. This investigator encouraged each subject to perform to maximal ability during the testing sessions.

The 45 degree angle leg press was performed on the OEI leg press machine (Owatonna Engineering Inc., Medford, Minnesota). Following the completion of the prescribed stretching exercises, each subject reclined on the base pad with shoulders against the shoulder yoke (see Appendix I). The feet were placed shoulder width apart on the foot plate. Each subject then raised the carriage by straightening the legs. When the legs were straight, each subject moved the brake lever to the outside. The carriage was then ready to be lowered (see Figure 9). Each subject lowered the carriage slowly until it reached the bumper pads (see Figure 10). A bounce was not allowed during the descent phase. The carriage was returned to the top position with an explosive extension of the legs. Each subject was instructed not to lock the knees during the extension phase of the leg press. The base of the machine was adjusted so that the subject's thighs were perpendicular before leg extension.

The one-repetition-maximum for the 45 degree angle leg press was determined by increasing the weight load after each successful lift until the weight could not be pressed with proper form. Strength was evaluated to the nearest five pounds. All leg press tests were given and recorded by the investigator (see Appendix J). A minimum of two minutes rest was given between leg press trials.

Lifting belts were allowed to be worn during the parallel squat and 45 degree angle leg press testing and training sessions; however, knee wraps and power suits were not worn. All the plates, collars, and bars used were the same to insure accurate measures of weight.

Training Procedures

The training procedures began the session following the strength and power pre-tests. The treatment groups trained for a period of 10 weeks. Each group trained two days per week. The parallel squat group trained on Tuesdays and Thursdays. The 45 degree angle leg press group trained on Mondays and Wednesdays. Each session lasted 50 minutes. Prior to each workout, each subject followed a specific warm-up routine which lasted for 5-10 minutes.

Berger (1962c) reported that the ideal number of sets and repetitions for the parallel squat was three and six, respectively. Each subject handled maximum weight loads for three sets of six repetitions. Group A trained the parallel squat exercise using three sets and six repetitions per set. Group B trained the 45 degree angle leg press exercise using three sets and six repetitions per set. Each subject was instructed to press the weights with optimum velocity and control. In this study a six repetition maximum was the maximum amount of resistance lifted for six repetitions. At a six repetition maximum the resistance was such that only six repetitions could be completed and the seventh repetition was not possible (Fleck & Kraemer, 1987). The initial training weight load for the study was set at 80% of the subject's one-repetition-maximum. The weight was increased when the subject felt he could achieve a seventh repetition during the final set. Each individual attempted to increase at least five pounds per week. Each subject was allowed to rest at least two minutes between the first and second set. A maximum of five minutes rest was given between the second and third set. Each subject recorded his lifts on a data sheet (see Appendix K). Each subject was closely supervised to ensure that correct lifting techniques and procedures were followed. The data sheets were collected and reviewed by the investigator at the end of each training session. The parallel squat and the 45 degree angle leg press lifting techniques were the same as those described in the section on the one-repetition-maximum tests.

Statistics

Comparisons were made using a two factor Analysis of Variance (ANOVA) with repeated measures on one factor. Subjects were analyzed across four variables. The two by two design used Factor A (groups) at two levels, parallel squat and 45 degree angle leg press training groups and Factor B (tests) at two levels, pre- and post-tests. There was also potential factor interaction (A x B). If significant main effects were found, they were examined with the Scheffe' post hoc analysis.

The statistics package used for computing the F ratios was the Statistical Package for the Social Sciences (SPSSx). The computations were performed on the VAX-11-780 computer system at the University of Wisconsin-La Crosse. The statistical significance level was set at $p < .05$.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the results and discussion of absolute strength and relative power changes as shown in a population of college males aged 19-24 after participation in a ten-week parallel squat and 45 degree angle leg press training program. A description of the subjects is reviewed, followed by tables which summarize absolute strength and relative power pre- and post-test data. A general discussion of the results concludes the chapter.

The data were statistically treated using a repeated measures analysis of variance to determine if differences existed between and among the groups. In the present study the level of significance was set at $p < .05$. This level of significance was the critical statistical value utilized for the acceptance or rejection of the null hypotheses. The F ratio necessary to denote statistical significance at the $p < .05$ level with 1 and 18 degrees of freedom was 4.41 (Winer, 1971).

Subjects

Initially, the total number of subjects was 30. This was reduced to 20 by the end of the training period. Missing four training sessions, or two in succession, made a subject ineligible. Eight dropouts occurred as a result of noncompliance. The final two were the result of injury and sickness. The physical problems were a result of occurrences unrelated to the study. If an individual failed to meet training session requirements, his results were completely removed from the study. Twenty subjects, ten per group, were involved in the study from pre-test to post-test.

Data Summary

Table 1 contains the vertical jump pre- and post-test mean and standard deviation measures. The vertical jump values were expressed in foot pounds per second (as determined by the Lewis Nomogram method). As shown in Table 1, the parallel squat values increased and the leg press values decreased.

Table 1

Vertical Jump (ft-lbs/sec)

Group	n	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.	Diff
Squat	10	951.35	156.95	961.78	155.79	+10.43
Leg Press	10	953.92	165.21	936.92	149.40	-17.00
Combined	20	952.63	156.84	949.35	149.10	-3.28

An analysis of variance for the vertical jump is presented in Table 2. Groups by trial interaction was not significant. The ANOVA revealed no statistically significant differences. A detailed record of the vertical jump pre- and post-test data for each group is presented in Appendix F.

Table 2

Analysis of Variance of Difference Measures of Vertical Jump

Source of Variation	SS	df	MS	F
Between Subjects				
Group	1242.56	1	1242.56	.03
Within cells	870001.78	18	48333.43	
Within Subjects				
Trial	107.58	1	107.58	.12
Group by Trial	1881.06	1	1881.06	2.03
Within cells	16667.66	18	925.98	

* Significant F < .05 = 4.41

A summary of the pre and post Margaria-Kalamen mean and standard deviation scores is presented in Table 3. The power values were recorded in foot pounds per second. Both groups demonstrated an increase in relative power.

Table 3

Mean Values for the Margaria-Kalamen Power Test

Group	n	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.	Diff
Squat	10	1050.82	117.58	1110.18	147.67	+59.36
Leg Press	10	1010.04	178.86	1045.30	123.14	+35.26
Combined	20	1030.43	148.80	1077.74	136.45	+47.31

A summary of an analysis of variance for the Margaria-Kalamen power test is presented in Table 4. Groups by trial interaction was not significant. A significant F for trials was shown in Table 4; therefore, a Scheffe' post hoc test was performed to determine which group caused the significant F to occur. The post hoc critical value needed for significance was ±45.23. The parallel squat group had a significant mean difference score of 59.36; however, the 45 degree angle leg press group's mean difference score of +35.26 was not significant. A detailed record of the Margaria-Kalamen pre- and post-test data for each group is presented in Appendix G.

Table 4

Analysis of Variance Difference of the Margaria-Kalamen Test

Source of Variation	SS	df	MS	F
Between Subjects				
Groups	27907.98	1	27907.98	.71
Within cells	703324.51	18	39073.58	
Within Subjects				
Trial	22381.41	1	22381.41	*9.65
Group by Trial	1451.30	1	1451.30	.63
Within cells	41752.59	18	2319.59	

* Significant F < .05 = 4.41

The mean and standard deviation scores recorded for the one-repetition-maximum parallel squat are summarized in Table 5. The value differences obtained from the pre- and post-test scores revealed that both groups demonstrated significant gains in absolute strength. The standard deviation values show that there were differences within groups for the parallel squat.

Table 5

Mean Values for the One-Repetition-Maximum Parallel Squat Test

Group	n	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.	Diff
Squat	10	273	56.28	318.00	60.70	+45.00
Leg Press	10	253	75.47	279.00	85.66	+26.00
Combined	20	263	65.58	298.50	74.98	+35.50

Table 6 summarizes the analysis of variance for the one-repetition-maximum parallel squat test. Group by trial interaction was not significant. Since a significant F for trials was shown, a Scheffe' post hoc was performed. The Scheffe' post hoc revealed that significant differences occurred in both groups The critical value needed for significance was ± 16.81. The parallel squat group had a mean difference of +45, and the 45 degree angle leg press group had a mean difference of +26. This shows that both groups significantly improved between the pre- and post-test trials. A detailed record of the one-repetition-maximum parallel squat pre- and post-test data for each group is presented in Appendix H.

Table 6

Analysis of Variance of Difference Measures of the Parallel Squat

Source of Variation	SS	df	MS	F
Between Subjects				
Groups	8702.50	1	8702.50	.90
Within cells	173150.00	18	9619.44	
Within Subjects				
Trial	12602.50	1	12602.50	* 39.31
Group by Trial	902.50	1	902.50	2.82
Within cells	5770.00	18	320.56	

* Significant F < .05 = 4.41

The mean and standard deviation pre- and post-test values for the one-repetition-maximum 45 degree angle leg press are presented in Table 7. The values are expressed in pounds. The data indicate that both groups achieved almost identical gains in absolute strength.

Table 7

Mean Values for the 45 Degree Angle Leg Press

		Pre-Test		Post-Test		Diff
Groups	n	Mean	S.D.	Mean	S.D.	
Squat	10	502	92.11	577.00	114.02	+75.00
Leg Press	10	481	99.47	557.50	98.47	+76.50
Combined	20	491	93.92	567.25	104.17	+76.25

A summary of the analysis of variance data for absolute strength as measured by the one-repetition-maximum 45 degree angle leg press is presented in Table 8. Groups by trial interaction was not significant. This table shows a significant F for trials. A Scheffe' post hoc test of individual comparisons did not reveal significant differences between the groups; both groups showed significant change. The critical value required for significance was ± 24.90. The parallel squat group had a value of +75 and the 45 degree angle leg press group showed a value of +76.5. Both groups significantly improved between the pre- and post-test trials. A detailed record of the one-repetition-maximum 45 degree angle leg press pre- and post-test data for each group is presented in Appendix J.

Table 8

Analysis of Variance Difference of the 45 Degree Angle Leg Press

Source of Variation	SS	df	MS	F
Between Subjects				
Groups	4100.62	1	4100.62	.21
Within cells	357021.25	18	19834.51	
Within Subjects				
Trials	57380.63	1	57380.63	*81.64
Group by Trial	5.63	1	5.63	.01
Within cells	12651.25	18	702.85	

* Significant F < .05 = 4.41

Discussion

The primary purpose of this study was to compare the effects of parallel squat and 45 degree angle leg press training on absolute strength and relative power acquisition. The discussion which follows will examine the significance of the results and factors that may have been of influence.

Relative Power

After a 10 week program of two training sessions per week, both the parallel squat group and the 45 degree angle leg press group failed to demonstrate an increase in relative power as determined by vertical jump performance and the Lewis Nomogram method. As presented in Table 2, the interaction between groups for the vertical jump was $F = 2.03$. This indicated some interaction; however, it was not statistically significant. The mean relative power gain for the parallel squat group was +10.43 foot pounds per second. In contrast, the leg press group demonstrated a mean relative power decrease of -17 foot pounds per second. The inconsistencies revealed in the vertical jump performance merits further explanation.

Perhaps the primary explanation for the lack of improvement displayed in relative power performance may be the small group size. Only 20 subjects participated in this study, with a N of 10 per group. The small N of the training groups may have influenced the results. A larger group may have yielded a higher level of significant improvement.

Secondly, bodyweight and jump reach score may account for the moderate between group difference in vertical jump performance. It is interesting to note that bodyweight and jump reach score increased in the parallel squat group, however; both decreased in the leg press group. The parallel squat group obtained a mean bodyweight gain of .53 pounds and a jump reach gain of .38 inches. These results differed from the bodyweight and jump reach scores observed for the leg press group. The leg press group showed a mean bodyweight loss of 1.65 pounds and a jump reach loss of .4 inches. From this data it may be concluded that a loss in bodyweight may result in a loss in relative power output because bodyweight was a factor used in the formula to determined power.

One final explanation for the moderate between group difference is that the parallel squat movement is biomechanically specific to the vertical jump (Wathen, 1980). If the parallel squat is indeed biomechanically specific, then the parallel squat's motor pattern may have increased the jump reach score. Simply stated, the vertical jump improvement may have resulted from the similar motor pattern. This conclusion is verified by Schultz (1967). Schultz reported that strength training patterns should be closely related to performance patterns to be of significant benefit.

The mean power gains, as measured by the Margaria-Kalamen power test, were significantly greater than those obtained with the vertical jump. Following a 10 week program of two training sessions per week, the parallel squat demonstrated statistically significant relative power gains as measured by the Margaria-Kalamen power test. The mean gain results from the Scheffe' post hoc test indicated a significant gain for the parallel squat group but not for the 45 degree angle leg press group. However, the F ratio for interaction of .63 indicated that very little interaction existed between the groups and the tests.

Absolute Strength

Both the parallel squat and the 45 degree angle leg press training groups were measured for absolute strength gains using the one-repetition-maximum parallel squat testing method. Both groups improved significantly at the $p < .05$ level. Forty-five degree angle leg press training was found to be as effective as parallel squat training in producing gains in absolute strength. The strength gains attained in the present study are in agreement with similar research done by Silvester et al. (1982). Silvester et al. reported that similar strength gains can be achieved using either free weights or machines if comparable set and repetition programs are performed.

Previous studies using a similar parallel squat training group reported that absolute strength can be increased significantly by training three days per week for a duration of six weeks (Berger, 1965; O'Shea, 1966; Stone et al., 1981). In these investigations the range of absolute strength gain as measured by the one-repetition-maximum parallel squat varied from 35 to 55 pounds. The previous studies as well as the present study used approximately the same number of training sessions, 18 and 20 respectively. It is noteworthy to state that the parallel squat group in the present study revealed an absolute strength mean gain of 45 pounds which is similar to the gains reported in the studies cited.

Significant differences in absolute strength gains were not observed between training groups. In comparing the mean absolute strength increase of the groups, the parallel squat group recorded a 45 pound gain while the leg press group recorded a 26 pound gain. As shown in Table 6, the interaction between groups was F = 2.82. The F ratio indicated that there was no significant difference between the groups. The moderate difference exhibited between the groups may be attributed to a concept regarding specificity of exercise. The concept of specificity of exercise suggests that individuals who train on a given device may test better on that device (Astrand, & Rodahl, 1986). This concept may apply to the parallel squat since many muscles are required to balance and coordinate free weights (Stone, 1982). In contrast, the leg press machine does not require a high degree of balance. Specificity of exercise may have, in part, influenced the leg press group performance when absolute strength was determined by the one-repetition-maximum parallel squat testing method. The 45 degree angle leg press test results seem to support this conclusion.

The results of the one-repetition-maximum 45 degree angle leg press testing method clearly indicated that both types of training modes resulted in equal absolute strength gains. The parallel squat group attained a mean gain of 75 pounds; the 45 degree angle leg press group obtained a mean gain of 76.5 pounds. No significant between group differences were obtained. The parallel squat exercise seemed to generalize to the leg press. Again, balance, agility, and coordination may have been factors which influenced the results. Hay et al. (1985) reported that lifting well on a leg press machine is due partially to the greater confidence the subjects have in their ability to balance and control the weight while performing the lift. Hay et al. implied that this greater confidence resulted in greater weights lifted. This, in turn, may result in greater absolute strength gains.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to compare the effects of parallel squat and 45 degree angle leg press training on the acquisition of absolute strength and relative power. Twenty male subjects from three basic weight training classes were assigned to two training groups. One group trained using the parallel squat resistance exercise, and the other using the 45 degree angle leg press resistance exercise. The subjects in the study trained two times per week for 10 weeks. Prior to training, they attended an orientation program in which they were briefed on testing and training procedures.

All subjects performed each strength and power pre- and post-test to determine if these parameters had changed as a result of the training program. Absolute strength was determined using the one-repetition-maximum testing procedure for both the parallel squat and the 45 degree angle leg press. Relative power was measured using the vertical jump and the Margaria-Kalamen power test. The pre-test was performed the week immediately following the orientation period. The post-test was administered the week following the conclusion of each respective training program. The performance measures for each test were collected and organized for analysis.

The data were statistically treated using a repeated measures analysis of variance to determine if any significant differences existed in absolute strength. Data yielding significant F ratios were then examined using the Scheffe' post hoc test. Statistically significant differences for absolute strength occurred within each training group but not between groups. Neither group was found to be significantly different from the other in absolute strength gain measurements.

The data were statistically treated using a repeated measures analysis of variance to determine if any significant differences existed in relative power as measured by the Margaria-Kalamen power test and the vertical jump. Data producing significant F ratios were then further analyzed using the Scheffe' post hoc test. The Scheffe' post hoc test revealed that the parallel squat group was significantly different than the 45 degree angle leg press group on main effect.

Findings

Based on the hypotheses tested, the following results were obtained for absolute strength and relative power:

1. The null hypothesis which stated there would be no significant difference in absolute strength as a result of 10 weeks of parallel squat training was rejected.

2. The null hypothesis which stated there would be no significant difference in absolute strength as a result of 10 weeks of 45 degree angle leg press training was rejected.

3. The null hypothesis which stated there would be no significant difference in absolute strength as a result of 10 weeks of parallel squat or 45 degree angle leg press training was accepted.

4. The null hypothesis which stated there would be no significant

difference in relative power as measured by the vertical jump as a result of 10 weeks of parallel squat training was accepted.

5. The null hypothesis which stated there would be no significant difference in relative power as measured by the vertical jump as a result of 10 weeks of 45 degree angle leg press training was accepted.

6. The null hypothesis which stated there would be no significant difference in relative power as measured by the vertical jump as a result of 10 weeks of parallel squat or 45 degree angle leg press training was accepted.

7. The null hypothesis which stated there would be no significant difference in power as measured by the Margaria-Kalamen power test as a result of 10 weeks of parallel squat training was rejected.

8. The null hypothesis which stated that there would be no significant difference in power as measured by the Margaria-Kalamen power test as a result of 10 weeks of 45 degree angle leg press training was accepted.

9. The null hypothesis which stated there would be no significant difference in relative power as measured by the Margaria-Kalamen power test as a result of 10 weeks of parallel squat or 45 degree angle leg press training was rejected.

Conclusions

Within the limitations of this study the following conclusions were formulated:

1. Forty-five degree angle leg press training is as effective as parallel squat training in producing absolute strength gains as

determined by either the one-repetition-maximum parallel squat test or the one-repetition-maximum 45 degree angle leg press test.

2. The balance factor which is required when squatting with free weights seemed to affect the amount of weight lifted when compared to the 45 degree angle leg press machine which balanced the weight for the lifter. This may be due in part to performers having greater confidence in their ability to maintain balance and to control the load when using the 45 degree angle leg press machine.

Recommendations

The following recommendations are made for future study:

1. Further study in which the number of subjects is considerably larger is needed to determine if a larger number of subjects will yield a higher level of significant improvement between groups.

2. A similar study could be conducted with trained lifters rather than novice lifters.

3. This study could be expanded to 16 weeks with repeated testing every four weeks to determine when the effects of training occur.

4. A similar study could be conducted in which the subjects are grouped according to their weight or age index.

5. Cinematography could be utilized to determine biomechanical differences between the parallel squat and the 45 degree angle leg press.

6. Further investigations could be performed which study the relationship between strength and power gains when using a large number of subjects and a control group.

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APPENDIX A

Lewis Nomogram

THE LEWIS NOMOGRAM FOR DETERMINING ANAEROBIC POWER FROM JUMP-REACH SCORE AND BODY WEIGHT

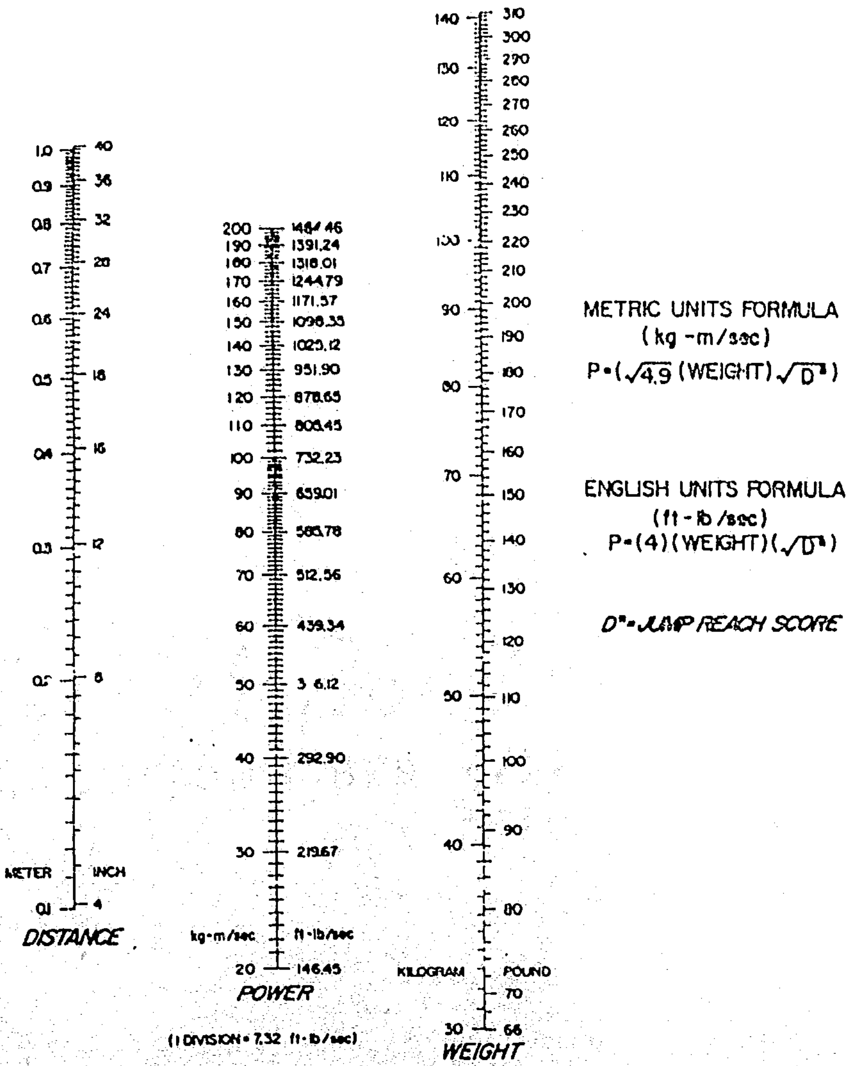


Figure G-1. The Lewis Nomogram. A person's power output can be determined by knowing the score on the jump reach and the body weight. See text for example.

APPENDIX B

Informed Consent Form

INFORMED CONSENT FORM

Project Title: Comparing the Effects of Parallel Squat Training and the Effects of 45 Degree Angle Leg Press Training on Absolute Strength and Relative Power Acquisition.

Principal Investigator: Thomas J. Gregor

I agree to participate in this study to determine the effects of the parallel squat and the effects of the 45 degree angle leg press of the acquisition of absolute strength and relative power. I understand that this study will involve training two times per week for 10 weeks.

I agree to participate in each testing and training session. I will participate in the following tests: vertical jump; Margaria-Kalamen power test; and the one-repetition-maximum strength tests. I agree to only participate in this study's stipulated forms of training and will not be involved in any other form of leg and hip strength training for the duration of the study.

I understand that in testing and training situations certain risks are involved. I have been fully advised of the procedures and the possible risk and complications.

I,________________________, being of sound mind and ______ years of age, do hereby consent to, authorize and request the person named above, Thomas J. Gregor, to undertake and perform on me the proposed procedure, treatment, research or investigation (herein called "procedure").

I have read the above document, and I have been fully advised of the nature of the procedure and the possible risks and complications involved in it, all of which risks and complications I hereby assume voluntarily.

I hereby acknowledge that no representations, warranties, guarantees or assurances of any kind pertaining to the procedure have been made to me by the University of Wisconsin-La Crosse, the officers, administration, employees or by anyone acting on the behalf of them.

I understand that I may withdraw from this study at any time. Signed at_____________________________ this _________ day of___________, 19___, in the presence of the witnesses whose signatures appear below opposite my signature.

____________________________ ____________________________
(SUBJECT)

____
(WITNESSED BY)

APPENDIX C

Warm-up Protocol

Warm-up Protocol

Prior to all testing and training sessions, perform the following stretching exercises in the prescribed manner. Do not bounce during the stretch. Relax the muscle, then ease into the stretch position and hold. When you reach the point where you feel a mild tension, relax as you hold the stretch. Do not go beyond a degree of tension that is not comfortable. A demonstration of each exercise will be given.

Calf Stretch: Stand about three feet away from the wall. With feet flat and pointed straight ahead, lean forward and touch the wall with the heel of the hand. The forward lean should be increased as the calf muscle stretches. Do this exercise slowly.

Seated Groin Stretch: Sit in a Buddah position with the soles of the feet together, knees out, elbows placed on the knees, and hands on the ankles. While keeping the back flat, lean forward slowly and put a downward pressure on the knees with the elbows. Hold the stretch position for 10-30 seconds.

Seated Hamstring Stretch: Sit with the right leg extended and straight. Bend the left leg with the sole of the foot touching the inside of the upper right leg. Bend forward at the hip until a stretch is felt in the hamstring area. Hold this position for 30 seconds. Repeat the same procedure with the left leg.

Elongation Stretch: While lying on your back with arms overhead and legs straight, extend the fingers and point the toes as far as possible. Hold for five seconds.

Hip and Buttocks Stretch: While lying on your back and having both legs straight, bend one leg grasping the bent leg on the knee with both hands. Pull the leg to the chest. Hold for 10-30 seconds. Repeat the same procedure with the other leg.

Mountain Climber Stretch: Assume a deep lunge position. With front knee directly above your ankle, shift your weight to the toes and ball of your back foot. Hold the stretch with the back leg fairly straight for 20 seconds. Repeat this procedure with the other leg.

Quadricep Stretch: Assume a deep lunge position. Reach behind with the hand opposite of the leg which is back. Bend this leg and grasp the foot with the hand. Pull the foot to the buttocks. Hold an easy stretch for 20 seconds. Repeat the same procedure with the other leg.

Shoulder Overhead Stretch: With arms extended overhead and palms together, stretch arms upward and slightly backwards. Inhale as you stretch upward. Hold the stretch for 20 seconds.

Shoulder Stretch: Gently pull your elbow across your chest toward your opposite shoulder. Hold the stretch for 10 seconds. Repeat this procedure using the other arm.

Tricep and Upper Shoulder Stretch: With arms overhead, hold the elbow of one arm with the hand of the other arm. Gently pull the elbow behind your head. Hold this stretch for 15 seconds. Repeat this procedure using the other arm.

Arm Circles: With both arms extended at the sides and at shoulder height, form small circles with both hands by rotating the arms at the shoulders. Slowly make larger circles until a full range of motion is achieved.

APPENDIX D

Accumulative Profile

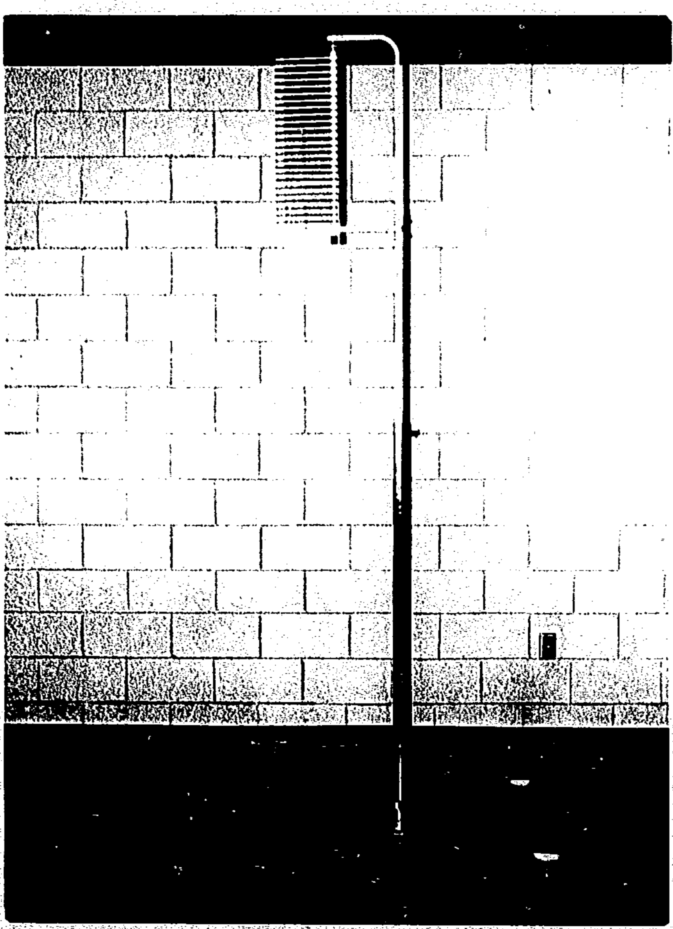
Accumulative Profile

Name:__________________________ Group:_____ Age:________

PRE-TEST	POST-TEST
Bodyweight:_____________	Bodyweight:_____________
Standing Reach:_______in	Standing Reach:________in
Jump Reach:___________in	Jump Reach:____________in
Lewis Index:____________ (ft-lbs/sec) Lewis Formula:	Lewis Index:_____________ (ft-lbs/sec) Lewis Formula:
(4) (Bdywt lbs) $x\sqrt{\text{J.R. in ft}}$ 4 x _________ x _______ =	(4) (Bdywt lbs) $x\sqrt{\text{J.R. in ft}}$ 4 x ________x ________ =
_______________ft-lbs/sec	______________ft-lbs/sec
Margaria-Kalamen Power:	Margaria-Kalamen Power:
$\frac{\text{Bdywt lbs x 3.6 ft}}{\text{Time (sec)}}$	$\frac{\text{Bdywt lbs x 3.6 ft}}{\text{Time (sec)}}$
$\frac{\text{\_\_\_\_\_\_\_\_ x 3.6 ft}}{\text{\_\_\_\_\_\_\_\_ sec}}$ =	$\frac{\text{\_\_\_\_\_\_\_\_ x 3.6 ft}}{\text{\_\_\_\_\_\_\_\_ sec}}$ =
_____________ft-lbs/sec	______________ft-lbs/sec
Parallel Squat (1RM):	Parallel Squat (1RM):
_______________lbs	_______________lbs
45 Degree Leg Press (1RM):	45 Degree Leg Press (1RM):
_______________lbs	_______________lbs

APPENDIX E

Vertec Apparatus



APPENDIX F

Vertical Jump Trials

VERTICAL JUMP TRIALS

GROUP: SQUAT PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	STANDING REACH (in)	JUMP REACH TRIAL 1 (in)	TRIAL 2 (in)	TRIAL 3 (in)	FT LBS/SEC (best trial)	
01	171.25	R-95	20	20*	19.5	883.65	Pre
	176.50	R-95	21.5*	21	20.5	946.04	Post
02	163.50	R-88	19.5	19.5	19.5*	833.85	Pre
	157.00	R-88	18.0	19.5*	19.0	800.70	Post
03	181.75	R-90.5	19*	18.5	18.5	914.57	Pre
	181.75	R-90.5	20	20.5*	20.0	950.19	Post
04	177.00	R-88.5	24.5	25*	24	1001.11	Pre
	177.75	R-88.5	23.0	23.5*	22.5	994.69	Post
05	259.00	R-105	20*	19	19.5	1336.44	Pre
	253.75	R-105	21*	19.5	19.5	1339.80	Post
06	163.00	R-96	17.5*	16	16	786.96	Pre
	171.00	R-96	18.25*	17.5	18	843.37	Post
07	191.50	L-96	20.5*	20	19	1001.16	Pre
	199.50	L-96	20.0*	20	19	1029.42	Post
08	143.25	R-86	24*	21.5	23.5	810.22	Pre
	137.50	R-86	25*	23.5	23.0	792.00	Post
09	190.00	R-98	19.5	20	20.5*	993.32	Pre
	187.25	R-98	19	20*	20	942.24	Post
10	172.50	R-93	23*	21.5	21.5	952.20	Pre
	175.00	R-93	23.5*	23.5	23.0	979.30	Post

R - Denotes right arm used for the vertical jump
L - Denotes left arm used for the vertical jump
* - Denotes highest test trial value

VERTICAL JUMP TRIALS

GROUP: LEG PRESS PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	STANDING REACH (in)	JUMP REACH TRIAL 1 (in)	TRIAL 2 (in)	TRIAL 3 (in)	FT LBS/SEC (best trial)	
11	178.00	R-95	15.5	15.5	16*	822.36	Pre
	179.50	R-95	16.5*	16.5	16.5	840.06	Post
12	195.00	R-98.5	22	22	22.5*	1068.60	Pre
	195.75	R-98.5	21	20	23.0*	1080.54	Post
13	202.00	R-92	15.5	20.5	21*	1066.56	Pre
	201.75	R-92	19.0	18.5	19.5*	1028.92	Post
14	168.00	R-89	24	26*	25	987.84	Pre
	168.00	R-89	23	24.5*	24.5	960.96	Post
15	131.25	R-88	19.5	22	22*	708.75	Pre
	133.25	R-88	22.5	23*	23	734.16	Post
16	187.00	R-93	25	24.5	26*	1099.56	Pre
	190.00	R-93	25	26.5*	26.5	1130.12	Post
17	169.50	R-88.5	22.5	23.5	24.5*	969.54	Pre
	169.00	R-88.5	24	25*	25	973.44	Post
18	249.25	L-93.5	17.5	18	18*	1217.56	Pre
	235.50	L-93.5	16.0*	15.5	14	1088.01	Post
19	159.50	R-95	19.5	20	20.5*	833.87	Pre
	155.75	R-95	19	19	19.5*	790.50	Post
20	138.50	L-92	20	21.5	23*	764.52	Pre
	137.50	L-92	22.5*	21.5	22	742.50	Post

R - Denotes right arm used for the vertical jump
L - Denotes left arm used for the vertical jump
* - Denotes highest test trial value

APPENDIX G

Margaria-Kalamen Power Test Trials

MARGARIA-KALAMEN POWER TEST

GROUP: SQUAT PRE-TEST AND POST-TEST TRIALS

SUB	SUB WEIGHT (lbs)	TRIAL 1 (sec)	TRIAL 2 (sec)	TRIAL 3 (sec)	FT LBS/SEC (best trial)	
01	171.25	.68*	.72	.69	902.62	Pre
	176.50	.67	.62*	.65	1024.84	Post
02	163.50	.71	.62*	.65	949.35	Pre
	157.00	.64	.67	.63*	897.14	Post
03	181.75	.63*	.69	.66	1038.57	Pre
	181.75	.72	.62*	.64	1055.32	Post
04	177.00	.61*	.62	.64	1044.59	Pre
	177.75	.55*	.60	.61	1163.45	Post
05	259.00	.79	.77*	.80	1210.90	Pre
	253.75	.72	.71*	.71	1286.62	Post
06	163.00	.64	.61*	.64	961.97	Pre
	171.00	.63	.59	.58*	1061.38	Post
07	191.50	.61	.58*	.61	1188.62	Pre
	199.50	.58*	.65	.61	1238.28	Post
08	143.25	.55*	.57	.57	937.64	Pre
	137.50	.57	.56	.55*	900.00	Post
09	190.00	.75	.65*	.73	1052.30	Pre
	187.25	.58*	.63	.64	1162.24	Post
10	172.50	.54	.53	.51*	1217.65	Pre
	175.00	.52	.48*	.48	1312.50	Post

* Highest test trial value

MARGARIA-KALAMEN POWER TEST

GROUP: LEG PRESS PRE-TEST AND POST-TEST TRIALS

SUB	SUB WEIGHT (lbs)	TRIAL 1 (sec)	TRIAL 2 (sec)	TRIAL 3 (sec)	ft lbs/sec (best trial)	
11	178.00	.66	.62*	.65	1033.55	Pre
	179.50	.69	.65*	.67	994.15	Post
12	195.00	.67	.65*	.67	1080.00	Pre
	195.75	.63	.61*	.61	1155.25	Post
13	202.00	.70	.70	.64*	1136.25	Pre
	201.75	.67	.66	.65*	1117.38	Post
14	168.00	.66*	.69	.68	916.36	Pre
	168.00	.62	.60*	.64	1008.00	Post
15	131.25	.63*	.64	.66	750.00	Pre
	133.00	.60	.57	.55*	870.55	Post
16	187.00	.72	.59*	.61	1141.02	Pre
	190.00	.63	.60*	.60	1140.00	Post
17	169.50	.69	.61	.59*	1034.23	Pre
	169.00	.62	.56*	.62	1086.43	Post
18	249.50	.74	.67*	.70	1340.60	Pre
	235.50	.71	.71	.68*	1246.76	Post
19	159.50	.73	.71	.71*	808.73	Pre
	155.75	.62	.65	.60*	934.50	Post
20	138.50	.62	.58*	.61	859.66	Pre
	137.50	.58	.57	.55*	900.00	Post

* Highest test value

APPENDIX H

One-Repetition-Maximum Parallel Squat Trials

PARALLEL SQUAT ONE-REPETITION-MAXIMUM

GROUP: SQUAT PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	TRIAL 1 (lbs)	TRIAL 2 (lbs)	TRIAL 3 (lbs)	TRIAL 4 (lbs)	
01	171.25	165	____			Pre
	176.50	190	215	____		Post
02	163.50	235	245	____		Pre
	157.00	225	265	300	____	Post
03	181.75	215	230	240	____	Pre
	181.75	250	265	____		Post
04	177.00	350	375	____		Pre
	177.75	350	375	415	____	Post
05	259.00	275	305	315	335	Pre
	253.75	335	365	385	____	Post
06	163.00	225	235	____		Pre
	171.00	250	270	285	____	Post
07	191.50	285	300			Pre
	199.50	315	355	____		Post
08	143.25	235	255	265	____	Pre
	137.50	265	275	285	295	Post
09	190.00	255	275	305	____	Pre
	187.25	275	300	____		Post
10	172.50	235	255	275	____	Pre
	175.00	315	345	365		Post

____ Denotes a missed attempt

PARALLEL SQUAT ONE-REPETITION-MAXIMUM

GROUP: LEG PRESS PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	TRIAL 1 (lbs)	TRIAL 2 (lbs)	TRIAL 3 (lbs)	TRIAL 4 (lbs)	
11	178.00	175	195	____		Pre
	179.50	200	215	____		Post
12	195.00	305	315	____		Pre
	195.75	315	____			Post
13	202.00	215	245	275	____	Pre
	201.75	265	275	____		Post
14	168.00	235	____			Pre
	168.00	240	250	255		Post
15	131.25	165	175	____		Pre
	133.25	185	195	____		Post
16	187.00	255	275	300	____	Pre
	190.00	305	325	345	375	Post
17	169.50	275	305	325	335	Pre
	169.00	305	325	345	375	Post
18	249.25	285	325	345	365	Pre
	235.50	325	345	375	415	Post
19	159.50	125	140	150	____	Pre
	155.75	155	185	____		Post
20	138.50	150	175			Pre
	137.50	175	195	____		Post

____ Denotes a missed attempt

APPENDIX I

OEI Leg Press Apparatus

APPENDIX J

One-Repetition-Maximum Leg Press

<u>45 DEGREE ANGLE LEG PRESS ONE-REPETITION-MAXIMUM</u>

GROUP: <u>SQUAT</u> PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	TRIAL 1 (lbs)	TRIAL 2 (lbs)	TRIAL 3 (lbs)	TRIAL 4 (lbs)	
01	171.25	400	430	______		Pre
	176.50	450	470	______		Post
02	163.50	400	430	______		Pre
	157.00	450	480	500		Post
03	181.75	400	430	______		Pre
	181.75	420	460	500	______	Post
04	177.00	600	650	700	______	Pre
	177.75	750	800	850	______	Post
05	259.00	470	490	500	______	Pre
	253.75	580	______			Post
06	163.00	380	400	420	______	Pre
	171.00	470	500	520	540	Post
07	191.50	540	560	580	______	Pre
	199.50	580	600	______		Post
08	143.25	430	450	______		Pre
	137.50	450	470	500		Post
09	190.00	450	480	______		Pre
	187.25	500	525	550		Post
10	172.50	520	540	560	580	Pre
	175.00	620	640	660	680	Post

______ Denotes a missed attempts

45 DEGREE ANGLE LEG PRESS ONE-REPETITION-MAXIMUM

GROUP: LEG PRESS PRE-TEST AND POST-TEST TRIALS

SUB	SUBJECT WEIGHT (lbs)	TRIAL 1 (lbs)	TRIAL 2 (lbs)	TRIAL 3 (lbs)	TRIAL 4 (lbs)	
11	178.00	380	390	410	______	Pre
	179.50	450	500	525	______	Post
12	195.00	400	450	495	______	Pre
	195.75	520	560	______		Post
13	202.00	450	______			Pre
	201.75	520	550	______		Post
14	168.00	500	550	575	595	Pre
	168.00	560	610	______		Post
15	131.25	360	370	______		Pre
	133.25	400	425	450	______	Post
16	187.00	520	540	560		Pre
	190.00	610	640	660	690	Post
17	169.50	450	500	520		Pre
	169.00	575	610	620	______	Post
18	249.25	600	620	650		Pre
	235.50	650	690	700	______	Post
19	159.50	360	385	400		Pre
	155.75	400	420	440		Post
20	138.50	340	360	______		Pre
	137.50	400	420	430	______	Post

______ Denotes a missed attempt

APPENDIX K

Training Schedule Sheet

Weight-Training Daily Exercise Chart

Student: ____________

Group: Squat or Leg Press

Note: 20-kg bar = 44 lb.
45-lb. bar = 20.5 kg

Instructor: Mr. Gregor

Time: ____________

Exercises	Date: Tuesday Body weight: ____ Load / Repetitions					Date: Thursday Body weight: ____ Load / Repetitions				
	set #1	set #2	set #3	set #4	set #5	set #1	set #2	set #3	set #4	set #5
Squat or Leg Press	/ 6	/ 6	/ 6	/	/	/ 6	/ 6	/ 6	/	/
Leg Extension	/ 10	/ 10	/ 10	/	/	/ 10	/ 10	/ 10	/	/
Leg Curl	/ 10	/ 10	/ 10	/	/	/ 10	/ 10	/ 10	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
Comments										

Exercises	Date: ____ Body weight: ____ Load / Repetitions					Date: ____ Body weight: ____ Load / Repetitions				
	set #1	set #2	set #3	set #4	set #5	set #1	set #2	set #3	set #4	set #5
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
	/	/	/	/	/	/	/	/	/	/
Comments										