

THE EFFECT OF TWO TYPES OF ISOTONIC
STRENGTH TRAINING ON
VERTICAL JUMP

BY

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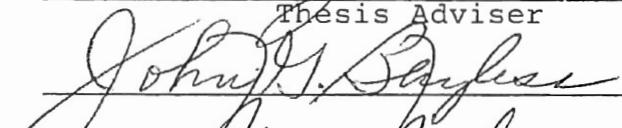
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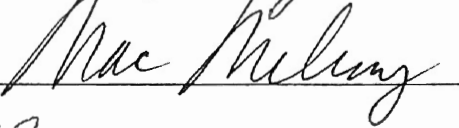
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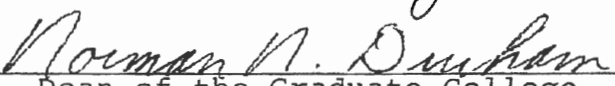
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CHAPTER I

INTRODUCTION

Coaches and physical educators are constantly researching methods to enhance their participants performance in the athletic arena or recreational activities. To improve the student-athletic performance coaches must design training programs that will ultimately result in optimal levels of performance.

Prior to developing training programs coaches must evaluate their student-athletes level of conditioning, (ie...strength, power, body composition, flexibility, etc...). One level of conditioning that many level of performances are based on is power. Technically, power combines strength and speed, or force X distance ÷ time (1). One method of measuring power is the seargents vertical jump. The vertical is a means of measuring power of the hip and leg regions of the body, (38). Although vertical jump is not the sole indicator of athletic prowess, it is a major component in activities involving explosive leg and hip power (Ie...basketball, volleyball, track and field, football, soccer, etc...).

The question that many coaches and physical educators ask is what training regimens must be employed to increase the athletes power potential? One method is progressive resistance

which utilizes free weights or machine weights to consistently overload the muscles, thereby stimulating the muscular system beyond its normal intensity (21). Systematic resistance training induces muscle overload enabling muscles to increase in strength and/or size (11).

Empirical evidence concludes that progressively strengthening the muscles of the jumping chain (ie...gluteals, hamstrings, quadriceps, gastrocnemius, soleus, deltoids, and trapezius) in conjunction with jumping drills, will enhance the athletes jump potential (42).

However, in spite of current research and studies, historically a number of coaches and physical educators have mistakenly felt that resistance training may inhibit an athletes performance by reducing speed, flexibility, and agility. However, research has disproven these myths by noting that weight training may actually improve movement time, flexibility, vertical jump, along with strength (4,14,18,24,40,41,42). Presently, the majority of division one collegiate athletic programs and professional teams employ full time strength and conditioning coaches to train their athletes. When all other variables in a performance is equal, greater strength will result in better performance (20), thus, making the strength coaches role more significant in an athletic program.

Although weight training is recommended for the majority of competitive athletes, strength is a necessity for all individuals in order to function efficiently and to meet daily emergencies (1). In addition, investigators have demonstrated significant

correlation between training, increased oxygen uptake, decreased percent body fat, and increased muscular endurance (2,11).

Generally, weight training techniques are similar for both the athlete and the non-athlete; however, because the athlete places greater physical demands on the body during competition, greater intensity must be incorporated into the training sessions. The athlete must also place greater emphasis on training those muscle groups specific to his/her performance.

The purpose of this investigation was to compare the effect of two isotonic progressive resistance exercises on vertical jump heights. More specifically, training by a powerlift known as the parallel squat, was compared to the training effects of the hip sled. The hip sled is similar to a leg press in that the athletes back is isolated while the trainee is lying in a supine position with the hip joint flexed at a 60 degree angle (refer to figure 1 and 2, chapter 3).

The two independent training variables, which are the effects of parallel squat and hip sled, was utilized to compare the effect on the subjects vertical jump height. A pre- and post-test vertical jump for the squat group, hip sled group, and a control group was conducted prior to and concluding an eight week training session.

The significance of this study is to determine training effects of a free weight exercise (parallel squat) versus a machine resistant exercise (hip sled) and how they can be incorporated within an athletic/physical education program for increased performance.

Hypothesis

The following hypothesis stems from the stated problem.

1. Training effects of the parallel squat did not significantly affect vertical jump height.
2. Training effects of the hip sled did not significantly affect vertical jump height.
3. Vertical jump height of the control group did not improve significantly.
4. There was no significant difference between the parallel squat group versus hip sled group in improvement in vertical jump.
5. There was no significant difference between parallel squat group versus control group in improvement in vertical jump height.
6. There was no significant difference between hip sled versus control group in improvement of vertical jump height.

Limitations

1. Subjects rest and diet was not prescribed.

Delimitations

1. Study consisted of thirty male caucasian students of Oklahoma State University between the ages of 18-23.
2. Training sessions consisted of fifty minute workout sessions, three days per week, continuous for eight weeks.
3. No subjects were involved in any additional progressive resistance training outside of the study.

4. Subjects did not engage in any varsity or intramural sport.

5. Subjects in control group were restricted to training upper body only.

Assumptions

1. All subjects exerted maximal force during both pre- and post-tests.

2. All subjects exerted maximal effort in all training sessions.

3. All subjects attended training sessions three days per week.

4. Subjects body composition was effected by training and may have had an affect on vertical jump.

Definition of Terms

Supine position is lying on back and/or facing upward.

Bio-mechanics is the external and internal forces on the human body and the effect produced by those forces (17).

Contraction occurs when the muscle responds to a stimulus, thus leading to tension within the muscle which causes shortening, lengthening, or static tension.

Isokinetic contractions are elicited by an apparatus which controls the speed of muscular contraction, thus allowing full muscular force throughout the range of motion (35).

Isometric contraction allows no movement within the joint while muscles exert maximal tension.

Isotonic contraction occurs during shortening and lengthening

of the muscle groups as a result of applied resistance.

Concentric contraction involves the shortening of the muscle as it overcomes resistance.

Eccentric contraction involves the lengthening of the muscle while it develops tension.

Muscle Overload involves progressively applying resistance to the muscle until it reaches a point of exhaustion.

Strength is the amount of maximal force exerted within a movement by a single muscle or groups of muscles.

Repetitions are the sequence of movements from beginning to end.

Set is the specific number of repetitions executed within a given time (3).

One Maximum Repetition (1,MR) is the maximal amount of weight a subject can perform in one given sequence.

Power is the product of strength times speed (velocity), or force time distance/time.

Spotting is the technique of utilizing partner assistance during the lifting movement of the bar. Spotters are necessary when attempting a heavy amount of resistance or maximal number of repetitions. The responsibility of the spotter is to assist the lifter through a range of motion if he/she reaches a sticking point and needs assistance to keep the bar moving and reduce the possibility of injury.

Flexion is the movement of the body part that causes a decrease in joint angle.

Extension is the movement of the body part that causes an

increase in the joint angle.

Skeletal Muscles are composed of fibers of varying lengths and are the basic structure of fibers which are long, thin elements termed myofibrils.

Fiber Types

Type I, Slow twitch, slow fatiguing (oxidative).

Type IIA, Fast twitch, intermediate (oxidative-glycolytic).

Type IIB, Fast twitch, fast fatiguing (glycolytic) (35).

CHAPTER II

REVIEW OF LITERATURE

The components of power is force, distance, and time. Strength training will increase the force (strength) of muscle over a given distance within an equal period of time (21). Yesis (47) states that "power is strength combined with speed, and that power increases after strength increases" (pg. 1). Considerable studies have been conducted to determine the relationship between the vertical jump and leg strength in various types of resistance training programs (4,24,28,30,35,37). The general consensus of the researchers was that isotonic weight training was associated with definite increases in leg strength and vertical jump height. Currently there is no current research devoted to the training effects of the hip sled on strength and/or power.

For convenience, the review of literature will be divided into four categories:

1. literature dealing with developing strength,
2. literature dealing with developing power,
3. literature dealing with vertical jump, and
4. literature dealing with parallel squat and hip sled.

Strength

Strength is the "absolute maximum amount of force that can be generated in an isolated movement of a single muscle or groups of muscles" (33) (pg. 48). According to Jensen and Schultz (20) strength is dependent on three factors:

1. contractile forces within the muscles that cause the movement,
2. coordination of agonists and antagonists synchronistically and,
- 3, bone arrangements (levels) around the joints (29).

This study will deal primarily with first and second factors noted by Jensen and Schultz.

In order to develop strength, the muscles must be stressed beyond their normal workload, which involves incorporating the overload principle (21). Three methods of overloading the muscle involves muscular contraction; these methods are isotonic, isometric, and isokinetic contractions (refer to Definition of Terms, Chapter I).

Physiologically certain changes occur within the muscle as a result of overload:

1. muscle fiber size increases,
2. increase of type II muscle fibers,
3. protein content (myosin) within muscle increases,
4. fluid content of muscle increases,
5. number of capillaries increase within muscles,
6. increase of connective strength, and
7. less inhibition of muscle control (20).

Training the muscles to become stronger involves intense, frequent workouts (3days/week), training with specificity, and variation within workouts (13). According to several investigators (16,37,40,41,42), training programs must be developed with a progression from low intensity to high intensity, training emphasizing specific muscle groups, while avoiding overtraining. This concept is termed periodization of training, which is utilized in several athletic and conditioning programs.

Georgeoski and Little (46) emphasize the development of explosive strength in training high jumpers. The periodization model is designed in four phases.

Basic Strength Phase

Following an initial conditioning period, this phase emphasizes strengthening the legs and torso. This phase emphasizes rear maximal or maximal loading while working on the strength domain rather than the speed domain.

Related Power Phase

Following the basic strength phase, the components of velocity is introduced within the program (depth jumps, hopping, bounding, explosive lifting, etc.). This phase is designed to facilitate the development of the neuromuscular pathways used in high jumping.

Imitative Power Phase

During this phase, resistance loads are considerably decreased and the athlete simulates actions used in jumping.

Specific Skill Phase

This phase consists of actually performing the type of jump the athlete will compete in.

Several studies have been conducted to determine the optimum number of sets and repetitions for strength development. The consensus of research suggests training with three sets of 4 to 9 repetitions to ellicit significant strength gains (6,7, 11,30).

Powers (35) investigated the effects of a holistic strength training and its affects on horizontal and vertical jumps. Subjects consisted of 50 eighth-grade students divided into experimental and control groups. The experimental group strength trained both upper and lower body, while the control group did no weight training. After eight weeks, results indicated the experimental groups improved 72% and 80% in the horizontal and vertical jumps respectively, while the control group improved only 8% in both horizontal and vertical jump.

Power

Power is a product of force and distance over time. According to Thomas (43), all physical movements require force, "if force is great enough to overcome any resistance which is present, then movement will occur" (pg. 51), and stronger muscles exert a greater force. O'Shea (28) states, "to improve athletic power, one option is to increase the force muscles can generate around the joints". As stated in the previous section, force is equivalent to strength.

Strength is increased by a progressive overload of the muscle. Studies have concluded that weightlifters were significantly faster than non-weightlifters in muscle contractions involving rotary arm movements (34). It is concluded that since weightlifters were stronger, their muscles generated more force, thus, increased speed of movements (34).

Vertical Jumps

Dynamics is the science of producing motion (10). In power related sports one must possess the explosive dynamic in order to compete. Dynamic power of the hips, knees, and ankles is essential in almost every athletic event. The Seargeants vertical jump is one means of measuring the power of the lower body region (38). Recognizing certain biomechanic factors involved in jumping, Hay (17) states that "the maximum height to which his center of gravity can be lifted and the distance to which he can reach beyond his height" (pg. 72). According to Smith (38), the amount of force exerted, divided by the mass of the individual, determines the height of the jump.

Semenick and O'Adams (37) state that the goal in training to improve the vertical jump is to maximize the bodys' vertical movement at the point of takeoff. In order to achieve this the athlete must maximize force produced on the ground per unit of time and/or spend less amount of time on the ground which subsequently produces more force prior to takeoff. Seminick and O'Adams divide the vertical jump into three phases.

Preparatory Phase

This is the crouched position of the body. It is the action of gravity as opposed to the pull of the muscles that causes the lowering of the body.

Movement Phase

The forceful extension of the hips, knees, and plantar flexion of the ankles causes upward movement of the body. The most efficient jump for height must be in a linear (straight upward) motion of the body's center of gravity produced by a series of "uncoilings" from the hips, knees, and ankles. In addition, if coordinated properly, the forward and upward swing of the arms will aid in the momentum in the jump.

Landing Phase

The body in the movement phase has achieved a fully extended position and must return to the ground in a crouched position similar to the preparatory phase.

Several studies exist regarding the effects of various foot spacings and knee joint angles upon vertical jump (3,22,46,18). Results indicated that subjects with foot spacings of 12 inches in width and 5-10 inches in the anterior/posterior plane demonstrated significant increases in vertical jump. In addition, this study indicated that subjects with knee joint angles of ninety degrees to one hundred degrees prior to takeoff demonstrated improvement in vertical jump height. In 1962 Bangerter

(3) investigated the effects of weight training on specific muscle groups used in vertical jump. The study was conducted with 112 college students divided into 5 groups. Four groups trained a specific muscle group:

- Group I - trained plantar flexors,
- Group II - trained knee extensors,
- Group III - trained hip extensors,
- Group IV - trained all the above, and
- Group v - Control group.

Each group trained for a total of eight weeks. Findings revealed that the knee extensor group, hip extensor group, and the combination group had a significant improvement in vertical jump. The group training the plantar flexors did not significantly improve their vertical jump height.

In a similar study investigating the effects of various weight training programs on vertical jump height, McKetban and Mahew (30) compared the effect of isotonic and isometric training on vertical jump. Subjects were divided into 4 groups consisting of:

- Isometric group (N=7)
- Isotonic group (N=5)
- Combined Isotonic/Isometric (N=6)
- Control group (N=4)

The isotonic group used a training of 3 sets of their 6 RM (repetition maximum) with a weighted boot in knee extensions, whereas the isometric group trained with maximal six second leg extensions with each leg. The combined isometric/isotonic group

trained using an Exer-Genie, which provided a period of isometric contractions followed by an immediate isotonic movement.

All subjects in the treatment groups trained 2 days/week for a total of 9 weeks. The control group participated only in the initial and final testing period.

The study revealed that subjects who trained isototonically had a significant increase in strength but not in vertical jump, in addition, the combined isometric/isotonic group did not significantly increase in vertical jump but did have notable increases in leg strength among those with low pre-test scores.

In another study investigating the effects of weight training Berger (4) conducted a study comparing the effects of dynamic and static training on vertical jump. The subjects were divided into four groups:

Group I (N=29) Barbell Squats 10RM

Group II (N=20) Jump Squats, 50-60% of the 10RM, 10 repetitions

Group III (N=21) Trained statically (isometrically)

Group IV (N=19) Trained with vertical jumps only.

Group I trained with parallel barbell squats with a load of 10 RM for 10 repetitions. If the subjects performed more than 10 repetitions the weight was increased to acquire a new 10 RM. Group II trained with jump squats from a deep knee bend position using 50-60 percent of the 10 RM for 10 repetitions for each training session. Group III trained statically at knee angles of 90 degrees and 135 degrees. A barbell was placed behind the

neck in a normal squat position, however, the subject squated to pre-determined knee flexion angles and held with a maximum muscle contraction of 7 to 8 seconds. Group IV trained with vertical jumps each session (10 repetitions), using maximum effort. Training sessions were held 3 days/week during the course of the investigation.

Results revealed that groups that trained dynamically improved significantly more in vertical jump than groups that trained statically or by vertical jumping alone.

In 1980, Wathen (44) compared the training effects of an isokinetic Mini-Gym leaper versus barbell squats. The experimental groups consisted of 52 athletes with 26 subjects in each group. The squat group trained with 1 set of 8, 7, 5, and 3 repetitions respectively, whereas, the isokinetic group trained with 5 sets of 20 repetitions. Results indicated that subjects who trained with barbell squats demonstrated significant increases in the vertical jump, conversely, subjects who trained with the Mini-Gym leaper did not demonstrate any significant increase in vertical jump.

Squat

Purpose

Parallel squat training is beneficial in the development of the gluteus maximus, quadriceps, hamstrings, and gastrocnemius, and consequently is a very efficient method of maximizing power of the leg and hip region (23). According to O'Shea (32), power initiates from the central region of the body, mainly the ab-

dominals, lower back, hip extensors, and leg extensors.

These muscles must be trained as a unit and through proper ranges of motion in order to optimize strength. O'Shea also notes that unless the athlete achieves a technical skill level in his/her sport, strength and power is not utilized properly.

O'Shea, in a roundtable discussion (28), states that squat training stimulates growth for the athlete. There is an increase in bone density, strengthening of tendons and ligaments, and greater neuromuscular efficiency.

Mechanics

Squat training involves flexion of the hip joint and extension of the hip joint with the trunk area flexed at an approximate 60 degree angle. Hip flexion occurs by eccentric contraction during descent, and hip extension occurs by concentric contraction during ascent (20).

During the eccentric phase, the muscles of the hip and knee joint contract while shortening (23). The coach or instructor should be aware of certain steps when teaching the squat to his/her participants (23,32);

1. The squatter uses a slow downward velocity to a half squat with the top of his/her thighs parallel.
2. The trunk is flexed with an approximate 60 degree angle.
3. During the ascent phase, his/her hips are forcefully extended.

Hip Sled

Hip sled training is beneficial in development of the

muscles of the lower body region, more specifically, the quadriceps, hamstrings, and gastrocnemius (14). One advantage of the hip sled versus the squat is that it reduces stress on the lower back region (9).

CHAPTER III

METHODS AND PROCEDURES

Selection of Subjects

Subjects were 33 male caucasian volunteers ranging in age 18 to 23 years from Oklahoma State University. Volunteers consisted of students from fitness classes who were willing to abide by the conditions of the eight week study. The conditions of the study were as follows;

1. Subjects remained in the study for the full eight weeks.
2. Frequency of training was three days/week.
3. Subjects did not participate in weight training sessions outside of designated study.
4. Subjects executed proper body mechanics while training.
5. All subjects were encouraged to exert maximal effort in all sessions.

Eleven male caucasian volunteers served as the control group. These volunteers ranged in ages 18 to 23 years. Members of the control group were students in fitness classes and were not allowed to train the lower body during the eight week study, however, they were allowed to train the upper torso area.

Measuring Devices

Vertical Jump

Vertical jump was measured by the Seargents vertical jump test. Subjects were directed to stretch and warm up by jogging around an indoor track prior to the testing session. According to Astrand(2), proper stretching and warm-up is essential in increasing core temperature which leads to more efficient nerve transmissions during high intensity activities.

Subjects were directed to place chalk on their preferred hand and stand facing a chalkboard mounted on the wall. The subject then placed his preferred hand on the chalkboard with his arm completely extended above his head and feet flat on the floor. The fingers were completely extended in order to mark the highest point of the hand. This pre-jump chalk mark on the board was used as the base-line in measuring the ensuing jumps.

The subject was then directed to turn his body parallel with the wall with his dominant side closest to the wall. The subjects feet were to be displaced anteriorally/posteriorally approximately five to six inches in distance. In addition, the subjects were instructed to swing their arms to gather momentum prior to jumping. The subjects were instructed to touch the chalkboard at the summit of the jump with hands and fingers completely extended. Each subject was given three trial jumps. Each jump was recorded by measuring the base-line mark to the highest mark of each jump.

Hip Sled

The hip sled (figure 1 and 2) is designed to increase strength and power of the hip and leg regions of the body (14) without undue stress on the lower back.

Subjects began with head and shoulders on the hip sled with the feet placed approximately shoulder width apart (figure 1). The hips and legs were extended, moving the carriage upward at a 45 degree angle and then lowered slowly without using momentum (figure 2).

Squat

The squat, a primary developer of the quadriceps, gluteals, and lower back extensors is a free weight exercise using a barbell. a barbell was placed upon the back of the shoulders on trapezius and deltoid muscles. The lifter was constantly facing upward throughout the exercise with a slight bend of the trunk area (60 degrees). The feet were spaced 4-6 inches wider than shoulder width and pointed slightly outward.

The body was then lowered with trunk area remaining slightly flexed and the top of the thighs parallel with the floor (figure 3). During the upward movement, the trunk angle remained constant while the hips and knees extended upward (14,39) (figure 4).

Testing Prodecures

All subjects within the treatment groups were given a brief orientation prior to the beginning of the experiment. During

the orientation, the subjects trained with a low resistance/high volume routine to learn the technique. All subjects performed a one maximum repetition (1 MR) on the initial day of the study.

All subjects trained with 85 percent of their 1 MR and performed three sets of five to seven repetitions. The resistance was increased 5 percent for the next training session. Muscle failure was to occur between five and seven repetitions for proper exertion of the exercise.

The squat training group was required to have a minimum of 2 spotters on each of the bars prior to execution of the lift. Subjects training in the hip group were instructed to align themselves with the hip joint flexed at 60 degrees prior to movement of carriage. Subjects performing the hip sled were required to have a spotter, and in order to eliminate momentum, were informed not to slam the weight on the downward of the lift.

Statistical Analysis

Analysis of Variance (one-way ANOVA) procedures were used to determine if there were any significant differences between the groups in pre- and post-test data. Where the significant differences were noted, the Tukey studentized (Post-Hoc) range test was performed to compare the group means.

Each hypothesis was tested in the following manner;

1. The first hypothesis was tested by a one-way ANOVA comparing pre- and post-test results of vertical jump mean within the parallel squat (refer to table 3).

2. The second hypothesis was tested by a one-way ANOVA comparing pre- and post-test results of vertical jump mean within the hip sled group (refer to table 3).

3. The third hypothesis was tested by a one-way ANOVA comparing pre- and post-test results of vertical jump mean within the control group (refer to table 3).

4. The fourth hypothesis was tested by a one-way ANOVA comparing a change in the means of vertical jump height between hip sled and squat groups (refer to table 3).

5. The fifth hypothesis was tested by a one-way ANOVA comparing a change in the means of the vertical jump height between control and squat groups (refer to table 3).

6. The sixth hypothesis was tested by a one-way ANOVA comparing change in the means of the vertical jump height between control group and hip sled group (refer to table 3).

All analysis were conducted using the .05 level of significance.

HIP SLED



Figure 2. Hip Sled



Figure 1. Hip Sled

SQUAT

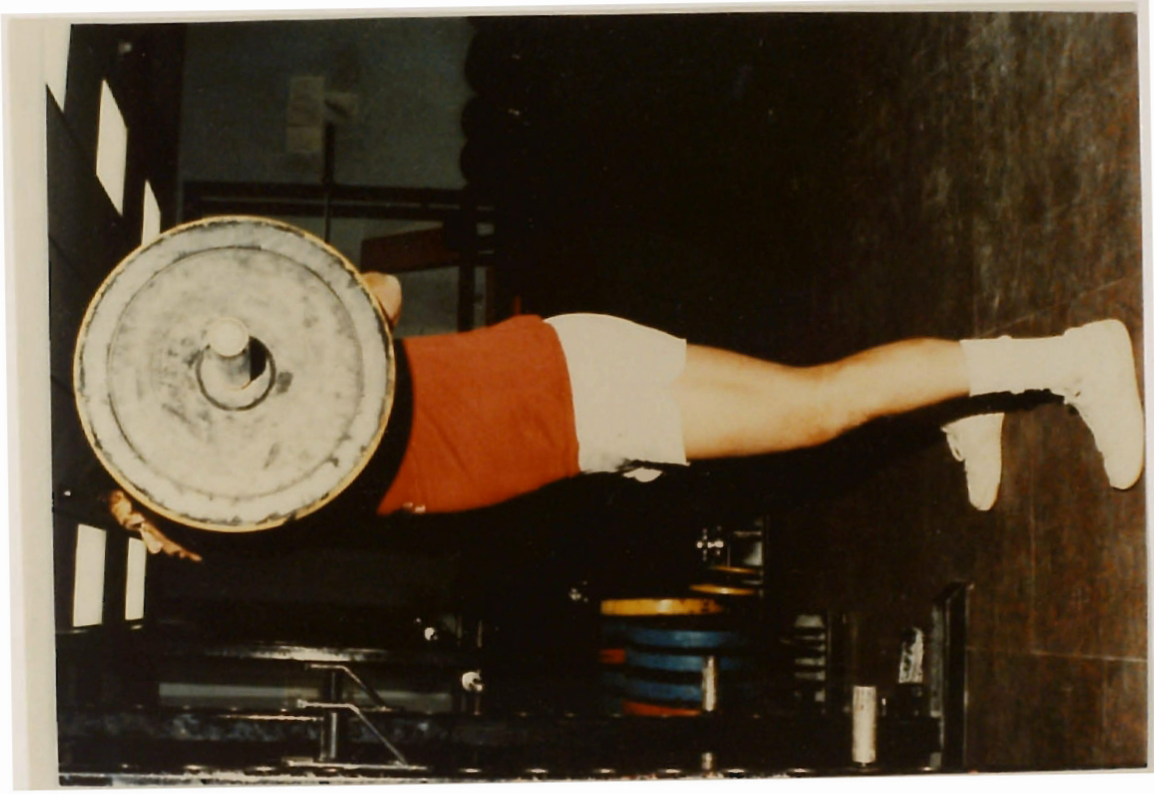


Figure 4. Squat

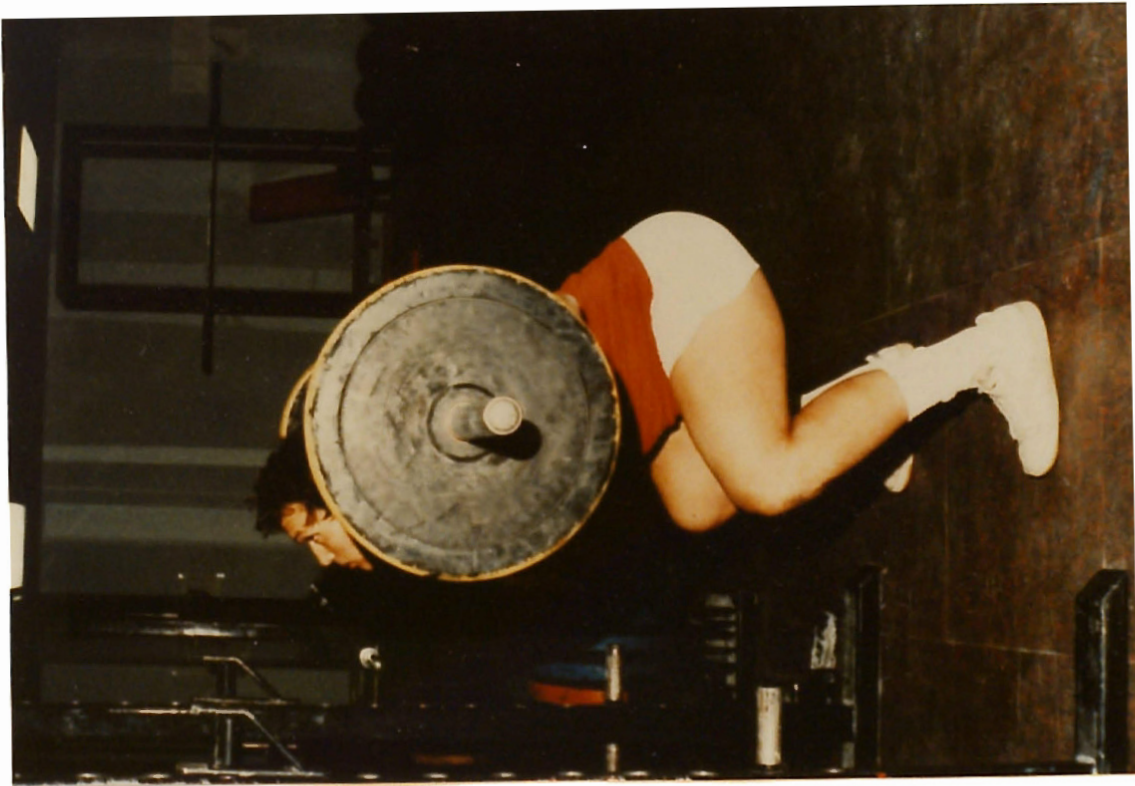


Figure 3. Squat

CHAPTER IV

RESULTS AND DISCUSSION

Results

It was the purpose of this investigation to compare two progressive resistance exercises (parallel squat vs. hip sled) and their effects on vertical jump height. The treatment effects of the parallel squat and hip sled were independently utilized to measure the vertical jump heights of male subjects from Oklahoma State University.

The dependent variable was the height measured on the vertical jump (inches) in both pre- and post- evaluations. The study included a one-week orientation to acquaint the subjects with the correct form and concepts of weight training. The length of the study was exactly 8 weeks. Testing procedures included a pre- and post-test evaluation of each subject (refer to table 1). A one-way ANOVA was used to state analysis of the three variables involving pre- and post- data (table 3). A Tukey post-hoc test was used to locate specific significant differences within the data.

Presentation of the Data

The data in this section will present the pre-experimental

condition first followed by the post experimental condition (Table 2). The mean scores for the parallel squat group were 20.18 inches and 21.7991 inches, for the hip sled group means were 20.59 inches and 22.04 inches, while the control group mean scores were 18.73 inches and 19.349 inches. The standard deviations were 2.308 inches and 2.371 inches for the squat group, while the hip sled standard deviations were 2.061 inches and 2.173 inches with the control group scoring 2.457 inches and 2.584 inches respectively.

Analysis of variance procedures revealed between the 3 experimental groups at pre-test showed that there was no significant difference (Table 3). However, the F-value within the the analysis revealed significant differences between the three experimental groups at post-test (Table 3). A tukey post-hoc test was conducted for specific locations of the differences. The Tukey test revealed significant differences between the hip sled versus control group.

Both treatment groups demonstrated significant increases in vertical jump in response to training, however, the control group did not increase significantly in vertical jump. In addition, there was no significant difference between the squat group versus control group, however, there was a significant difference between the hip sled versus control groups. The results would indicate that the null hypothesis was accepted in that there was no significant difference between the 2 treatment groups, however, it was rejected in that there was significant difference between the hip sled versus control group.

The following hypothesis was statistically treated with an Analysis of Variance Testing Procedure at the .05 level of Significance:

Hypothesis I

Was rejected in that the squat group demonstrated a significant difference in the change of the mean scores from pre- to post-test, with an increase of 1.691 inches.

Hypothesis II

Was rejected in that the hip sled group demonstrated a significant difference in the change of mean scores from pre- to post-test with an increase of 1.4409 inches.

Hypothesis III

Was accepted in that the control group increased .6118 inches from pre- to post-test which is not statistically significant.

Hypothesis IV

Was accepted in that there was no significant statistical difference between the squat group and hip sled group. The difference between the groups was .241 inches.

Hypothesis V

Was accepted in that there was no significant statistical

difference between the squat group and control group. The difference between the groups was 2.45 inches.

Hypothesis VI

Was rejected in that there was a significant difference between the hip sled and control group. The difference between the groups was 2.691 inches.

Implications

Results of this investigation suggests that progressive resistance training can increase the power component of jumping. Scores indicated that all subjects in both treatment groups improved from pre to post evaluations. There was no significant differences between the treatment groups, which would imply that strength training with the parallel squat or hip sled are equally effective in development of strength and power.

Discussion

This investigation revealed there was no significant difference between the training effects of the squat and hip sled on vertical jump. This would lead one to believe that both are equally effective in increasing power output. However, several authorities (28,37) recommend the use of squats or free weights as opposed to machine weights in that there are several advantages involved;

1. improved balance,
2. improved timing,

3. enhances coordination,
4. activation of large muscle groups,
5. excellent transfer of biomechanical motions from ground based sports,
6. greater neuromuscular efficiency,
7. stimulation of growth, bone, and connective tissue.

The afore mentioned advantages are certainly significant in effective athletic performances, in addition, would be beneficial in a physical education and/or recreational program.

During the course of the study the investigator noticed gains in upper strength which may have contributed to small gains in vertical jump. Increased upper torso strength could aid in transference of momentum during a vertical jump (37) along with proper coordinative movement of the arms during takeoff.

TABLE I
 RAW SCORES FOR VERTICAL
 JUMP HEIGHTS
 (IN INCHES)

GROUP I
 (SQUAT)

SUBJECT	T ₁	T ₂	CHANGE IN MEAN SCORE
1	17.12	19.5	2.38
2	16.375	17.250	.88
3	20.625	21.0	.38
4	18.37	20.7	2.33
5	22.12	24.25	2.13
6	22.50	23.50	1.0
7	20.75	21.62	.87
8	22.75	23.87	1.12
9	22.75	25.50	2.75
10	20.25	22.0	1.75
11	18.37	20.6	2.23
	$\Sigma = 222$	$\Sigma = 239.88$	$\Sigma = 17.82$

GROUP II
 (HIP SLED)

SUBJECT	T ₁	T ₂	CHANGE IN MEAN SCORE
1	18.62	20.2	1.58
2	18.37	22.0	3.63
3	22.37	23	.63
4	20.75	21.25	.50
5	20.25	21.25	1.0
6	21.25	22.87	1.62
7	20.62	21.75	1.13
8	16.75	18.12	1.37
9	21.87	23	1.13
10	21.62	22	.38
11	24.12	27	2.88
	$\Sigma = 260.37$	$\Sigma = 244$	$\Sigma = 15.85$

TABLE I (CONT'D)

 GROUP III
 (CONTROL GROUP)

SUBJECT	T ₁	T ₂	CHANGE IN MEAN SCORE
1	19.75	20.50	.75
2	20.25	21.62	1.37
3	23.75	24.75	1.0
4	15.25	16.75	1.50
5	18.12	19.87	1.75
6	17.12	16.62	-.50
7	18.50	17.37	-1.13
8	18.75	18.12	-.63
9	15.50	17.0	1.50
10	18	18.62	.62
11	21.12	21.62	.50
	$\Sigma = 206$	$\Sigma = 212.88$	$\Sigma = 6.73$

TABLE II
MEANS AND STANDARD DEVIATIONS

GROUP	PRE	POST
I		
MEAN	20.180	21.7991
SD	2.308	2.371
N	11	11
II		
MEAN	20.5991	22.0400
SD	2.061	2.173
N	11	11
III		
MEAN	18.7373	19.3491
SD	2.457	2.584
N	11	11

TABLE III
ANALYSIS OF VARIANCE
(ONE WAY ANOVA)

Pre Test Means:

SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR F	R-SQUARE
20.986	10.4930	2.02	0.1507	.118512
156.09415	5.2031			
177.0802				

Alpha = .05

DF = 30

Post Test Means:

SUM OF SQUARES	MEAN SQUARE	F-VALUE	PR F	R-SQUARE
48.7722	24.3801	4.30	.228	.222729
170.2037	5.673			
218.9760				

Alpha = .05

DF = 30

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

One of the hypothesis of this study investigation stated that training effects of the parallel squat and hip sled would not significantly affect vertical jump heights of 22 male subjects. This hypothesis was not supported by this study in that the training effects of the squat and hip sled significantly increased vertical jump heights for both treatment groups; however, the significant difference between the hip sled versus the control group in vertical jump was not evident in the squat and control comparison. In addition, the investigation revealed a notable difference within the hip sled group (.823 inches), however, it is not a statistical difference at the .05 level of significance.

Conclusions

Results of this investigation suggest that progressive resistance training can increase the power component of jumping. Pre- and post-test scores indicated that all subjects improved in both treatment groups in post-test evaluation.

There was no significant differences between the treatment groups, which would imply that strength training with the parallel or hip sled are equally affective in development of strength and power of the lower body region.

Recommendations

1. Future investigations may consider including a control group that is totally restricted from strength training any body area.

2. There is a need for future investigation into the training effects of plyometrics, which is a means of training the bodys neuromuscular system to react more efficiently (8), furthermore, plyometrics is the application of special jumping drills in which the muscle is pre-stretched, causing a rebound action known as a stretch reflex (26).

3. Measuring force in the horizontal dimension can be accomplished by designing a study measuring training effects on standing long jump (35).

4. Finally, studies could be conducted in which both the parallel squat and hip sled may be included to measure the affects on a power oriented movement (ie...jumping, sprinting, throwing, etc...).

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