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The Effects of the Front Squat and Back Squat on Vertical Jump and Lower Body Power Index of Division 1 Male Volleyball Players

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THE EFFECTS OF THE FRONT SQUAT AND BACK SQUAT ON VERTICAL JUMP AND LOWER BODY POWER INDEX OF DIVISION 1 MALE VOLLEYBALL PLAYERS

by

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GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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ABSTRACT

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The purpose of this study was to compare effects of the front squat and back squat on vertical jump and lower body power index of division 1 male volleyball players. Eighteen NCAA Division 1 male volleyball players volunteered for this study and were assigned either to a back squat or a front squat training program group. Subjects followed the training program for 8 weeks. Counter-movement vertical jump (CMVJ) height and lower body power index were measured at 0, 4 and 8 weeks of the study. A 2x3 factorial ANOVA revealed no significant difference in CMVJ height and power index between the training groups ($p = 0.921$). In addition, changes in power index over 8 weeks were not significant ($p = 0.931$). There was significant improvement for both groups in CMVJ height from 0 to 4 weeks ($p = .001$) and from 0 to 8 weeks ($p = .000$), but not from 4 to 8 weeks ($p = .080$). Both front squat and back squat strength training programs were both equally effective at enhancing CMVJ performance.

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Table of Contents

List of Tables

The Effects of the Front Squat and Back Squat on Vertical Jump and Lower Body Power Index of Division 1 Male Volleyball Players

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ABSTRACT

The purpose of this study was to compare effects of the front squat and back squat on vertical jump and lower body power index of division 1 male volleyball players. Eighteen NCAA Division 1 male volleyball players volunteered for this study and were assigned either to a back squat or a front squat training program group. Subjects followed the training program for 8 weeks. Counter-movement vertical jump (CMVJ) height and lower body power index were measured at 0, 4 and 8 weeks of the study. A 2x3 factorial ANOVA revealed no significant difference in CMVJ height and power index between the training groups (p = 0.921). In addition, changes in power index over 8 weeks were not significant (p = 0.931). There was significant improvement for both groups in CMVJ height from 0 to 4 weeks (p = .001) and from 0 to 8 weeks (p = .000), but not from 4 to 8 weeks (p =.080). Both front squat and back squat strength training programs were both equally effective at enhancing CMVJ performance.

Key Words: counter-movement, strength, training

INTRODUCTION

In many cases, successful athletic performance depends on the athlete's ability to generate power from their lower body to perform tasks and skills specific to their sport. Volleyball players need to jump high to perform effective blocks and spikes. This lower body power is generated in what is termed the power zone, made up of the musculature of the hips, thighs, and lower back (5, 12), and in the musculature of the posterior lower leg (6).

Strength training has been shown to increase muscular strength in the power zone (7). Squats and cleans have been shown to affect vertical jump more than any other comparable exercises (1, 7). Strength training programs that did not include Olympic lifts were compared to determine which had a greater effect on vertical jump height (1, 2, 16). The programs that included squats caused a greater improvement in vertical jumping ability than the programs that did not include squats (2, 16).

Two commonly utilized variations of the squat are the back squat and the front squat. The differences in these variations are in the placement of the bar. In the back squat, the bar is positioned across the back of the shoulders. This causes the lifter to increase hip flexion which puts more stress on the hip musculature and spinal column. This stress can cause bending (both flexion and extension), rotation, and compression of the lumbar spine, which can lead to discomfort, pain, and injury (15, 20). As hip flexion increases, so do the hip extensor moment arms (5). The front squat has the bar positioned across the front of the shoulders. As a normal response to this anterior bar position and anterior shift of the line of gravity, lifters adjust their squatting technique by decreasing hip flexion and increasing knee flexion to maintain balance (15). The bar position of the front squat allows the lifter to release and push the bar away when difficulty is encountered during the lift.

The counter-movement vertical jump (CMVJ) is a commonly used field test to evaluate an athlete’s lower body power output, because it is easy to administer and closely resembles sport specific activity (18). The counter-movement of the CMVJ allows energy to be stored in the tendinous structures of the lower limbs in anticipation of the upward phase of the jump. During the upward phase of the CMVJ this stored elastic energy is released at a higher rate than when it was initially stored allowing for greater peak power to be produced (9). In volleyball the counter-movement is integral to the preparatory phase of the jump set and spike (14, 17). Once the approach has occurred there is a rapid ankle dorsi flexion and flexion of the knee, hip and trunk immediately prior to take off (14, 17).

Lower body power index is a multiple jump method of evaluating leg power (13). Multiple jump testing variations have been shown to have a high correlation with a modified Wingate test ($r = .87$) and 60m sprint (.84) (3). Bosco et al observed higher power outputs with a multiple jump test than with a Wingate test and concluded that this may be due to the fact that the leg extensors for both legs are working simultaneously and not alternating as in the Wingate test (3).

The purpose of this study was to compare the effects of a strength training program including the front squat and a strength training program including the back squat on vertical jump and lower body power index of Division 1 male volleyball players.

METHODS

Experimental Design

A repeated measures experimental design was used to compare the effects of two different strength training programs on CMVJ height and lower body power index.

Subjects

Twenty-four NCAA Division 1 male volleyball players volunteered to participate in the study. At the completion of the study only 18 subjects remained due to drop out. All subjects read and signed the informed consent approved by the Institutional Review Board of Brigham Young University prior to participation.

Procedures

Probotics, Inc.'s Just Jump or Run (Huntsville, AL) was used to measure flight time for CMVJ height calculation. Each subject had 15 minutes of familiarization with the testing techniques and equipment 30 minutes prior to being tested. CMVJ height was measured for each subject, at week 0, using the Just Jump or Run mat (13). Each subject performed three maximal CMVJs with a ten second rest interval between each CMVJ. The CMVJ was performed by having the subject stand upright and then performing a rapid descent just before executing the jump (18). The rapid descent, or counter-movement (CM), is due to quick knee and hip flexion and ankle dorsi flexion. The subject then explosively plantar flexes the ankle and extends the knee and hip joints to achieve the greatest height possible.

CMVJ height was calculated using the formula $h = 1.226\, t^2$, where t was the time measured by the Just Jump or Run. The median height from the three CMVJs was recorded and used to rank the subjects highest to lowest. To minimize differences in mean height and standard deviations between each training group, the subjects were assigned to a training group according to a matched pairs ABBA assignment method. Starting at the highest jumping subject we assigned them to the “A” group. The second and third highest athletes were assigned to the “B” group. The fourth highest was assigned to the “A” group. This pattern was repeated until all subjects were divided into either group “A” or “B.” Initially 12 subjects were assigned to the each of the training groups. By week 8 of the training program 10 subjects remained in the back squat training group and 8 remained in the front squat training group. At weeks 4 and 8 each subject was retested in CMVJ and lower body power index using the same testing protocol as week 0. Week 0 was termed the pretest, week 4 was the mid-test, and week 8 was the post-test.

The Just Jump or Run also calculates lower body power index. Each subject performed three lower body power index tests with a thirty second rest interval between each test. Power index was obtained using the 4-jump mode of the Just Jump and Run. The trials were performed by having the athlete step onto the mat and jump for maximal height four times, in rapid succession to minimize contact time with the mat (13). Three trials were performed with a 30-second rest interval between each trial. The computer automatically calculated the power index by taking the mean air time over the four jumps and dividing it by the mean ground time over the three ground contact intervals between the four jumps (13). The higher the power index, the faster the subject can generate power to perform the jump.

Strength Training Program

Each subject participated in an 8-week periodized strength training program following the initial testing at week 0. Subjects in group “A” participated in a strength training program that included back squats, whereas subjects in group “B” participated in a strength program that included front squats. Other than the squat variation performed, the training programs were identical. The lower body exercises used over the 8-week training period other than the squat were the snatch, hang snatch, clean, hang clean, box step-up, lateral step-up, good morning, reverse lunge, jump squat and stability ball leg curls.

During the course of the study, set and rep ranges for the Olympic style lifts (all snatch and clean variations) went from 3 sets of 5 reps and ended at 5 sets of 3 reps. For all other lifts, sets and reps ranges went from 3-5 sets of 6-10 reps each to 4-5 sets of 3-5 reps each.

Statistical Analysis

A 2x3 ANOVA was used to analyze the between and within group dependant variables (CMVJ height and power index) and a Pearson correlation was performed on each test.

When significance was found in the primary analysis, Tukey's post hoc test was used to identify the significance of the differences among the cell means. A power analysis was included to determine if the number of subjects was sufficient for each dependant variable.

RESULTS

There were no differences in CMVJ height between the two training groups (p = 0.921) (Table 1). Interaction between the training groups for CMVJ height was not significant (p = .490) (Table 1). There was no difference in lower body power index between treatment groups (p = .931) (Table 2). Interaction between the training groups for lower body power index was not significant (p = .255) (Table 2).

Within subject differences over the three testing periods in CMVJ height were significant (p = .000) with an F-value of 15.926 (Table 1). Tukey's post hoc test found significant differences between the pretest and the mid-test (p = .001) and between the pretest and the post-test (p = .000) (Table 3). There was no significant difference between the mid-test and post-test (p = .080) (Table 3). Within subject differences in lower body power index was not significant over the three testing periods (p = .471) (Table 2).

A Pearson correlation was performed on each test and it was found that for the pretest there was no significant correlation between CMVJ height and lower body power index (r = .019, p = .470). For the mid-test and post-test there was a significant correlation between the dependent variables (r = .735, p = .000 and r = .657, p = .002 respectively).

Within subject statistical power between trials for CMVJ height was .999. Within subject power between trials for lower body power index was .169. Sample size was sufficient for determining significance in CMVJ height difference, but was insufficient for determining significance in lower body power index differences.

DISCUSSION

Results indicate that over a 4 and 8 week period there is no significant difference in effect on CMVJ height between the two different training programs, and both significantly increased CMVJ height. These results indicate either variation of the squat is useful for enhancing CMVJ performance. Although results indicate there was no significant effect on lower body power index between the two training programs, the statistical power test showed the number of subjects was insufficient to be completely confident when applying these results to a different population, but we are confident with these results for the group of subjects studied. The correlation between CMVJ height and lower body power index showed that there was a relationship between both variables brought about by the training programs, even though effect on CMVJ height was significant and the effect on lower body power index was not significant.

Between the pretest and mid-test there was a significant CMVJ performance increase while between the mid-test and post-test there was a decrease in the amount of CMVJ gains made. Most of the subjects had recently returned to a regular training schedule at the onset of this study. When examining the effectiveness of training protocols, the first 4-weeks of training may be the most critical in developing and improving CMVJ ability in volleyball players.

The two squat variations have been shown to have very similar knee extensor requirements (15). The quadriceps extend the knee while the hamstrings counteract the anterior pull generated by the quadriceps (11). During the ascent of both squat types, the gluteus maximus and hamstrings work together to extend the hips (12). The musculature recruited and trained when performing either squat variation is the same musculature responsible for generating the joint moments at the hips, knees and ankle during the CMVJ (18). The similarities in increases of CMVJ height over the 8 week period may be due to the development of this musculature.

The back squat has been a staple in most strength and conditioning programs. It has been shown to develop great lower body strength and power, and is a good indicator of vertical jumping ability (10, 12, 19). With the bar resting across the back of the shoulders there is significant spinal compression and greater hip and lumbar flexion (4). Increased hip and lumbar flexion increases lumbar shear forces (8).

The front squat, like the back squat, develops strength and power in the lower body. It was reported that in the front squat with the bar resting across the front of the shoulders there was less lumbar compression than in the back squat, however, this tended to create greater trunk extensor demands which in turn caused greater lumbar shear forces (15).

Greatest risk of injury seems to depend on the magnitude of trunk extensor moments and on the lumbar compressive forces. It was reported that relative magnitude of the squat load was not an effective indicator of injury risk, but that it was the amount of trunk inclination used (15). This is due to the technique employed by lifters. A lifter employing greater hip flexion will increase the lumbar shear forces during either of the squat variations. A lifter employing greater hip extension, thus maintaining a more erect torso, would experience less shear forces and greater compression forces (15).

During the back squat if a lifter utilizing greater trunk flexion fatigues or fails, there is a greater risk of injury to the spine if they are unable to drop the bar from off their back. In the front squat, should a lifter fatigue or fail, the bar can be dropped by removing the hands, and pushing the bar forward, minimizing risk of injury.

The results of this study revealed no difference in the gains in CMVJ height and lower body power index between the front and back squat training programs. Since the potential for injury is always a consideration in the training of athletes, the selection of appropriate exercises becomes very important. The front squat may be a more suitable exercise to use due to the ability of the lifter to release the bar when unable to complete the lift, and still obtain equal performance benefits.

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Table 1: Factorial ANOVA of CMVJ Height of Front and Back Squat Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Groups	.579	1	.579	.010	.921
Error	909.745	16	56.859		
Testing periods	266.353	2	133.176	15.926	.000
Interaction	12.209	2	6.104	.730	.490
Error	267.584	32	8.362		

Greenhouse-Geisser Epsilon = .938

Huynh-Feldt Epsilon = 1.000

This shows that there is no significant difference between squat groups (p = .921) and that there is no significant interaction (p = .490). Effects were significant over the testing periods (p = .000).

Table 2: Factorial ANOVA of Power Index for Front and Back Squat Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Groups	.001	1	.001	.008	.931
Error	2.642	16	.165		
Testing periods	.078	2	.039	.77	.471
Interaction	.145	2	.072	1.426	.255
Error	1.626	32	.051		

Greenhouse-Geisser Epsilon = .858

Huynh-Feldt Epsilon = 1.000

This shows there is no significant difference for power index between groups (p = .931), between testing periods (p = .471) and there is no significant interaction (p = .255).

Table 3: Tukey's Post Hoc Test of Differences Between Tests of CMVJ Height.

Test (A)	Test (B)	Marginal Means Difference (A-B) (cm)	Significance
Pretest	Mid-test	-3.75*	.001
	Post-test	-5.25*	.000
Mid-test	Pretest	3.75*	.001
	Post-test	-1.5	.080
Post-test	Pretest	5.25*	.000
	Mid-test	1.5	.080

*The Marginal Mean Difference is significant.

The main effect on CMVJ height was significant between the pretest and mid-test (p = .001), and the pretest and post-test (p = .000), but not the mid-test and post-test (p = .080).

Table 4: Descriptive Statistics of CMVJ Height of Front and Back Squat Groups.

Testing period	Back Squat (*n*=10) (cm)	Front Squat (*n*=8) (cm)
Pretest	65.5 ± 5.5	64.5 ± 2.8
Mid-test	68.1 ± 5.3	69.4 ± 4.4
Post-test	70.2 ± 5.9	70.6 ± 4.6

Means of CMVJ Height plus or minus standard deviations.

Table 5: Descriptive Statistics of Power Index for Front and Back Squat Groups.

Testing Period	Back Squat (*n*=10)	Front Squat (*n*=8)
Pretest	2.254 ± .239	2.385 ± .289
Mid-test	2.342 ± .283	2.224 ± .404
Post-test	2.397 ± .294	2.355 ± .275

Means of Power Index plus or minus standard deviations.

Appendix A

Prospectus

Chapter 1

Introduction

In many cases successful athletic performance depends on the athlete's ability to generate power from their lower body to perform tasks and skills specific to their sport. Basketball players need to rebound and be able to block shots. Volleyball players need to jump high to make a good block or spike. Offensive linemen need to be able to hold their ground against defensive linemen, or open up holes in the defensive line. Track and field athletes in most events have to generate large amounts of power to throw, jump, or sprint.

This lower body power is generated in what is termed the power zone, made up of the musculature of the hips, thighs, and lower back (11, 24), and in the musculature of the posterior lower leg (12).

The counter-movement vertical jump (CMVJ) is a commonly used field test to evaluate an athlete's lower body power output, because it is easy to administer and closely resembles sport specific activity (32). The counter-movement of the CMVJ allows energy to be stored in the tendinous structures of the lower limbs in anticipation of the upward phase of the jump. During the upward phase of the CMVJ this stored elastic energy is released at a higher rate than when it was initially stored allowing for a greater peak power to be produced (22).

Strength training has been shown to increase muscular strength in the power zone (19). Squats and cleans have been shown to affect vertical jump more than any other comparable exercises (4, 19). Strength training programs that did not include Olympic lifts were compared to determine which had a greater affect on vertical jump height. The programs that included squats caused a greater improvement in vertical jumping ability than the programs that did not include squats (5, 28).

Two commonly utilized variations of the squat are the back squat and the front squat. The differences in these variations are in the placement of the bar. In the back squat, the bar is positioned across the back of the shoulders. This causes the lifter to increase hip flexion which puts more stress on the hip musculature and spinal column. This stress can cause bending (both flexion and extension), rotation, and compression of the lumbar spine, which can lead to discomfort, pain and injury (26, 34). The front squat has the bar positioned across the front of the shoulders, which decreases the hip flexion and increases knee flexion (26). This bar position of the front squat also allows the lifter to drop the bar to lessen or prevent injury.

Little to nothing is known as to the difference in these two squat variations with respect to their effects on vertical jump and power output of the lower body in athletes who rely on their vertical jumping ability for their sport.

Statement of Problem

The purpose of this study is to compare the effects of a strength training program including the front squat and a strength training program including the back squat on vertical jump and lower body power index of Division 1 male volleyball players.

Null Hypothesis

There will be no difference in vertical jump or lower body power index between the front squat and back squat training programs. The null hypothesis will be rejected if the probability of error is .05 or less.

Operational Definitions

Counter movement vertical jump (CMVJ) – A jump performed without any horizontal direction with a two-foot take off and no preliminary steps. This jump is performed with a rapid initial flexion of the hips and knees, and dorsi flexion of the ankle prior to take off. This jump is performed with arm swing to simulate game performance of this skill.

Jump height – Jump height will be calculated by time spent in the air during the CMVJ. The time in air will be obtained using the Just Jump or Run by Probotics, Inc. The equation used to calculate jump height is $h = 1.226t^2$. It has been found that in individuals who are consistent in their jumping technique, with legs and hips fully extended, this method of measuring vertical jump height is accurate and reliable (20, 6, 23).

Power index – Power can normally be expressed as an average over a range of motion or time, or it can be expressed as a single value taken at a specific instant during the displacement of an object (6). The Just Jump or Run calculates an individual's power index. This is a ratio of time spent in the air versus time spent on the ground. The Just Jump or Run takes the average air time of four jumps and divides it by the average time of the three intervals between each jump to calculate an individual's power index. For this study the power index will be used in data collection instead of power output.

Strength – The ability of a muscle to exert force against resistance at a specific velocity (21).

Back Squat – A strength training exercise in which a lifter squats down till their thighs are parallel to the ground and then returns to a standing position while keeping their back as upright as possible and holding a weighted barbell supported on the back of the shoulders (figure 1).

Front Squat - A strength training exercise in which a lifter squats down till their thighs are parallel to the ground and then returns to a standing position while keeping their back as upright as possible and holding a weighted barbell supported on the front of the shoulders (figure 2).

Figure 1.
On the right is the starting position for the back squat and on the left is the bottom position of the squat. Note the position of the bar across the back of the shoulders. Used with permission from Kendall/Hunt Publishing Company.

Figure 2.
On the right is the starting position for the front squat and on the left is the bottom position of the front squat. Note the position of the bar across the front of the shoulders Used with permission from Kendall/Hunt Publishing Company.

Assumptions

The assumptions inherent to this study include the following:

- The vertical jump test protocol will accurately and reliably measure the intended variables.
- A combination vertical jump height is a valid measure of lower body power output.

- The subjects are representative of the collegiate men's volleyball player population.
- The subjects will perform with maximal effort in all tests.

Delimitations

This study is limited to the subject population of NCAA Division 1 collegiate men's volleyball players at Brigham Young University. The training will take place over an 8-week training period. Any potential performance improvements that may occur outside of this period of time will not be included.

Limitations

Maximal jump effort by the athletes may be enhanced by game situation and environment. The instrument used for measuring vertical jump will display both the time spent in the air and the jump height calculated using the time spent in the air. The instrument only measures flight time which occurs from toe off to landing and does not take into account the change in the vertical height of the center of mass from when the foot is flat on the ground to toe off.

Significance

Knowledge of the effectiveness of each squat variation in contributing to vertical jump height and power generated will further aid strength and conditioning professionals and coaches in preparing athletes for the tasks they perform. The back squat is an exercise that, if performed wrong, can cause serious injury or discomfort. If the front squat can be shown to be equivalent to the back squat, or to enhance vertical jump performance and power output, then the recommendation would be made that the front squat be used for athletes instead of the back squat in order to avoid injury.

Chapter 2

Review of literature

Muscular strength is defined as the maximal force that a muscle or group of muscles can develop at a certain velocity (21). Muscular strength is an important component of the muscular power of an athlete. Power is defined as the amount of work done in a specific period of time. Power can be expressed as an average over a range of motion or time (e.g., marathon) or it can be expressed as a single value taken at a specific instant during the displacement of an object (e.g., vertical jump) (6). Quite simply, when an individual generates force that causes movement of themselves or an object it can be expressed in terms of power. Peak power is the greatest amount of power produced during a movement (6).

Power Zone

In many sports, athletes must be able to generate great amounts of power from their lower body to accomplish tasks specific to their sport. Basketball players need to rebound and be able to block shots. Volleyball players need to jump high to make a good block or spike. Offensive linemen need to be able to hold their ground against defensive linemen, or open up holes in the defensive line. Track and field athletes in most events have to generate large amounts of power to throw, jump, or sprint.

In each of these instances the force generated to perform each of these tasks comes from the coordinated effort of the muscles of the power zone and posterior lower leg. The power zone is made up of the thighs, hips, and lower back musculature (10,24). The thigh consists of the quadriceps (vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris) and hamstrings (biceps femoris, semimembranosus, and semitendinosus). The hips and lower back musculature primarily consist of the gluteus maximus and erector spinae (24). The quadriceps are primarily knee extensors with the rectus femoris also being a hip flexor. The hamstrings are knee flexors and work in conjunction with the gluteus maximus to extend the hips. The primary posterior lower leg muscles are the gastrocnemius and soleus which perform plantar flexion.

The Squat

It is known that participating in appropriately applied strength training programs can increase muscular strength and power of the hip, thigh and lower back (19). The two exercises that have been shown to greatly affect vertical jump performance in experienced weight lifters (noncompetitive) and athletes are the back squat and clean (4, 19). When applied to the vertical jump, Baker (4) classified the squat as a general strength training exercise and the clean as a special strength training exercise. General strength training exercises are those that aim at increasing maximal muscular strength, and the aim of specific strength training exercises are for developing power. Exercises are categorized as either general or specific strength training exercises according to their biomechanical structure and their affect on the neuromuscular system (4). General strength training exercises are used to improve the contractile properties of the muscle and specific strength training exercises are used to more efficiently take advantage of the stretch reflex (3).

According to the judgment of O’Shea (24), the back squat is such an indispensable exercise for the athlete that it is considered the “king of all weightlifting exercises," and it "stands supreme in its ability to maximize athletic potential." General strength training programs (programs without Olympic lifts), that did not include specific strength training exercises, but included back squats, were compared with general strength training programs that used exercises other than back squats. The programs that utilized back squats were found to be better at improving vertical jump performance (5,28).

Hakkinen and Komi (17) found that in non-elite, experienced athletes, general strength training using the back squat increased vertical jump height by 10.6% in CMVJ. Baker (4) noted that athletes with low strength levels will see large increases in vertical jump height through general strength training, and elite trained athletes will not, due to an increased need for neuromuscular and elastic augmentation not found in general strength training.

The amount of strength gained through heavy back squat training does not seem to have a strong correlation with the changes in vertical jump in trained athletes (3). Baker et al. (3) found that in trained athletes the relationship between their 1RM back squat and vertical jump performance was non-significant ($r = 0.11$). Hakkinen et al. (16) had similar findings when they reported that elite weightlifters had no correlation between maximal strength for the clean and jerk and vertical jump with just body mass. There was also found to be no change in vertical jump performance after 24 weeks of heavy back squat training regardless of large improvements in 1RM back squat strength (1). Stone et al. (31) found that the correlation between 1RM back squat strength and power output, as measured by weighted back squat jumps, increased to about 50% of the 1RM after which the correlation decreased.

The two most commonly utilized forms of the squat are the back squat and the front squat. The back squat is the most typical, basic form of the squat. It is the easiest to master and this form also has the greater potential to cause injury when performed incorrectly. The starting position for the squat is having the barbell rest on the back slightly above (high bar position) or below the acromial process (low bar position) of the scapula in an upright position with the knees and hips fully extended. The lifters hands grasp the bar to maintain its position and balance. The lifter then squats down, similar to sitting in a chair, by flexing their hips and knees, and dorsiflexing their ankles in a controlled manner till their thighs are parallel with the ground. The person then stands up, extending through their hips and knees, and plantar flexing their ankles while keeping their back as upright as possible during the entire motion (2, 26, 7).

The front squat is performed with a motion similar to the back squat. The difference being that the barbell is resting across the anterior deltoids and clavicles. With the hands holding the bar in place, the person then squats down as in the back squat until their thighs are parallel with the ground (2). The person then stands up, extending through their hips and knees, and plantarflexing their ankles while keeping their back as upright as possible during the entire motion. The person has the option of having their forearms crossed with the hands holding the bar in place while it rests on the anterior deltoids, or by having the hands resting on its selfsame shoulder while holding the bar with the palms facing upwards. This latter method cushions the bar against the shoulders and decreases shoulder discomfort. The front squat also mirrors the last part of the clean in that after the bar is caught across the front of the shoulders, the lifter then squats the weight up into a full standing position (15).

When performing the squat, the knee and hip extensor moments are coupled due to the effects of trunk flexion about the line of gravity with respect to the joint centers of the knee and hip. The line of gravity is the line that passes from the center of gravity of the body towards the center of the earth. Greater trunk flexion moves the line of gravity closer to the knee and further from the hip. This decreases the extensor moment about the knee and increases the extensor moment about the hip (11). Greater trunk extension through the hips moves the line of gravity closer to the hips and farther from the knees. This increases the extensor moment about the knees and decreases the extensor moment about the hips. Simply put, this means that the farther you are leaning forward at the hips, the more strain is being placed on the hip extensors. The more erect the posture during the squat, the more strain is being placed on the musculature of the knee (11).

The front squat places more stress on the knee extensors and less stress on the hip extensors than the back squat, due to the position of the bar (24). In order for the lifter to maintain their balance throughout the front squat, the lifter employs a more erect posture.

With the placement of the bar across the back or front of the shoulders there is the possibility of having significant shear and compressive forces acting on the spine (26). Even when using submaximal loads while performing the back squat, large compressive (6704 N-6980 N) and shear forces (3070 N-3219 N) at the L5/S1 joint have been reported (26). It was found that in the lumbar spine under a 1.0 body weight compressive load, spine shrinkage occurred primarily due to lumbar spine bending (flexion and extension) and rotation (34). When considering these compressive and shear forces combined with the spine bending and rotation, it is understandable that 85% to 95% of spinal disc herniations occur at the discs between L4 and L5 or L5 and S1 (18).

Inexperienced lifters modify the squatting technique to include greater trunk flexion, which decreases the extensor moment at the knees and increases the extensor moment at the hips by shifting the line of gravity anteriorly. This can lead to a greater increase in the spinal flexion in the thoracic and lumbar regions. This increased spinal flexion greatly increases the shear forces on the thoracic and lumbar region of the spine, which in turn increases the risk of spinal injury (9). If the lifter were to utilize a more upright posture when performing the squat, the risk of injury and the shear forces acting on the spine would decrease. The front squat is one method of ensuring that the lifter has a more upright posture with decreased spinal flexion (26). Because the front squat places the weight across the front of the shoulders, the line of gravity shifts from originating on the spine to originating anterior to the spine. This causes the lifter to increase knee flexion and decrease hip flexion so as to maintain a more upright torso and balance. The knee extensor moment arms are increased while the hip extensor moment arms are decreased (26). If the lifter fatigues or fails during the performance of the exercise, the weight can be dropped from the front of the shoulders causing less harm to the lifter than if the bar was across the back of their shoulders.

Counter-movement Vertical Jump

A widely used field test to measure the performance capability of the power zone and ankle plantar extensors is the counter-movement vertical jump (CMVJ). The CMVJ is frequently used to test an athlete’s lower body power output because it is easy to administer and closely resembles sport specific activity. The height jumped is an indicator of the explosive leg power of an individual and can act as a measure of the effectiveness of a strength training program (32). Markovic et al. (23) conducted a study to determine reliability and validity of squat jump (SJ) and CMVJ tests. Their secondary purpose was to compare 3 common methods for estimating jump height. They found the SJ and CMVJ, when measured with a timing mat, were the most valid and reliable methods for determining lower body explosive power.

The CMVJ is performed by having the subject stand upright initially and then descending rapidly just before executing the jump (32). The rapid descent, or counter-movement (CM), is due to quick knee and hip flexion and ankle dorsi flexion. The subject then explosively plantar flexes the ankle and extends the knee and hip joints to achieve the most height possible. This CM enables the jumper to take advantage of the stretch shortening cycle of the movement to increase their jump height. A SJ is a vertical jump that is not preceded by the CM (4). It is performed from a squat position without the initial descending movement. The height of a CMVJ is usually higher than a SJ. When performing either the CMVJ or the SJ the jumper usually has the hands on the hips or behind the head for the duration of the jump.

It was observed that during the downward phase of the counter-movement, the muscle-tendon complex (MTC) of the gastrocnemius medialis shortens by only 1.6% of its initial length and fascicles shorten by up to 10.4% of their initial length. This fascicle shortening caused an elongation of the tendinous structures by 2.2%. During the initiation of the upward phase the MTC shortens rapidly by 5.3% of its initial length (22). Considering these observations, Kurokawa et al. (22) postulated that the tendinous structures stored elastic energy during the CM and during the initiation of the upward phase (push off phase). This elastic energy was then released during the remainder of the jump at a higher rate than when it was stored allowing for a greater amount of peak power to be generated.

Most vertical jump tests have been adapted from the Sargent Jump (20). The Sargent Jump is performed by an individual marking the maximum height on a wall that they can reach prior to them jumping with a piece of chalk. The individual then jumps as high as they can and they make a mark at the peak of the jump on the wall. The height jumped is the vertical distance between the two marks (20). This vertical jump test involves an arm swing. The arm swing is a technique used by many athletes during jumping tasks. Feltner et al. (14) observed that this arm swing increased vertical velocity of the center of mass at take off 9.3% and raised the center of mass an average of 9 cm at takeoff when compared to similar jumps without arm swing. During a separate study Feltner et al. (13) found that the vertical velocity of the center of mass increased by 12.7% and that peak height of the center of mass increased by 14.3 cm over vertical jumps without arm swing.

Training – Periodization

The strength training program is designed using the principle of periodization which addresses the problems of overtraining, plateauing, injury, and decreasing strength gains by manipulating exercise intensity and volume. Periodization also increases the probability of retaining training and performance enhancement (2, 27, 29, 30). Periodization involves dividing the training year into phases called cycles. During each of these cycles the training stress is manipulated by varying the volume and intensity of the training according to the specific training phase. The goal of this manipulation of the volume and intensity is to prevent the muscle from adapting to a specific level of resistance and entering into a stage of overtraining. The main cycles or stages of periodization are hypertrophy, basic strength, strength and power, peaking or maintenance, and rest cycle (2, 29).

The hypertrophy cycle is a preparation phase which leads into the other phases of periodization. During the hypertrophy stage the athlete performs high volume training of 8-12 repetitions (reps) per set and 3-10 sets per exercise at a relatively low intensity (2, 29). There are two main adaptations that occur during this phase. The first is a positive change in body composition, lean body mass increases and fat mass decreases which also lead to an increase in the strength of the lifter (2, 29). The second adaptation is an increase in short term endurance due to the high volume training (2, 29).

The basic strength cycle aims to increase the 1RM of exercises used. The volume will be moderate to high using 4-6 reps per set and 3-5 sets per exercise. The intensity will be relatively high and an increase in strength will be realized during this cycle (2, 29).

During the strength and power cycle strength continues to increase. Overall volume will decrease to 2-3 reps per set and 3-5 sets per exercise. Intensity is high during this cycle (2, 29).

During the peaking or maintenance cycle the athlete will usually be competing in their sport and trying to maintain their strength gains. The workout volume will be very low using 1-3 reps per set and 1-3 sets per exercise. Intensity will vary depending on the day from very high to low (2, 29).

The rest cycle gives the athlete a chance to recover after their competitive season. Normally the athlete will participate in a different type of activity or in the same activities at low volumes and low intensities. This phase is sometimes overlooked, but it can sometimes be the most important phase (2, 29). This allows the athlete to mentally and physically recover so that overtraining does not become a reality and the whole periodization cycle can be restarted (2, 8)

Conclusion

There has not been a study performed that has compared the effects of a training program that included the back squat and a training program that included the front squat on an athletes vertical jump performance and power output.

Chapter 3

Methods

Subjects

Twenty-four members of the Brigham Young University Men's volleyball team will participate in this study. The subjects will participate in a strength training program throughout the preseason training period of September through November. All participants will sign an informed consent form (see Appendix A-1).

Procedures

The athletes will be supervised during their strength training sessions by the researcher and the assistant strength coach at Brigham Young University. Attendance and a log will be kept for each athlete and their workouts. (Appendix A-2)

Testing will occur during fall semester 2006, at the start of the preseason training period, at four weeks into the training protocol and then at eight weeks into the training protocol. The strength training programs for each athlete will include the same number of reps and sets, and the same exercises except for type of squats. The athletes will be divided into back squat and front squat groups immediately after the pretest. When their workouts include squats, they will do either the back or front squat as designated. At four weeks into the training period, the subjects will perform a midtest. After eight weeks the athletes will then undergo the posttest.

The method that will be used to assign the athletes into the training groups will be the matched pairs ABBA assignment procedure according to vertical jump height attained in the pretest. The athletes will be ordered according to vertical jump height, highest to lowest. To minimize differences in the between group means and standard deviations we will use the ABBA method. Starting at the highest jumping athlete we will assign them to the “A” group. The second and third highest athletes will be assigned to the “B” group. The fourth highest will be assigned to the “A” group. This pattern will be repeated until all athletes are divided into either group “A” or “B.”

Instruments and Testing

For all phases of testing, the recommendations and guidelines set forth by the American College of Sports Medicine (ACSM) for exercise testing and participation will be followed (33). Testing for this study will be conducted in the Brigham Young University Intercollegiate Strength Training Complex and on the Elaine Michaelis volleyball court.

Prior to participating in the strength training program a pretest will be performed to determine each athletes’ power index and vertical jump height. The midtest and posttest procedures will be identical to the procedures of the pretest.

The instrument that will be used to measure and calculate vertical jump height and power output will be the Just Jump and Run timing mat made by Probotics, Inc. (Huntsville, AL). The Just Jump and Run displays both the time in the air to .01 seconds and the power index. This instrument will be used to calculate each athlete’s power index (25). All jumping performed will be bilateral. Vertical jump height will be calculated using the formula $h = 1.226t^2$, where t is the time measured using the Just Jump or Run.

Counter-movement vertical jump height will be measured by having the athlete step onto the mat and give a maximal effort two-foot jump. Three trials will be performed with a 10-second rest interval between each trial. For each trial the Just Jump and Run computer will record time in the air and calculate jump height. Results will be recorded on a data sheet as found in Appendix A-2. The median value for height over three jumps will be used in the data analysis.

The athletes' leg power index will be obtained using the 4-jump mode of the Just Jump and Run. The trials will be performed by having the athlete step onto the mat and jump for maximal height five times, in rapid succession and as fast as possible to minimize contact time with the mat. Three trials will be performed with a 30-second rest interval between each trial. The computer will automatically calculate the average air time over the first four jumps and the average ground time over the four ground contact intervals between the five jumps. It will then calculate the power index. The power index is derived by dividing average time in air by average time on the ground (25.). Data will be recorded on the data sheet in Appendix A-2. The median value for power index over three trials will be used in the data analysis.

Statistics

A factorial ANOVA (2 groups x 3 trials) will be applied to each dependant variable (vertical jump height and power output) to determine if there are significant differences between the two training groups, the three trials of each group, and interaction. If significant F-values are found between groups and/or within trials, Tukey's post hoc test will be used to identify specific mean differences. A power analysis will be included to determine how large a difference could have been detected. The null hypothesis will be rejected if the probability of error in any component of the analyses is equal to or less than .05.

Findings

As a result of the testing and statistical analysis, findings will be reported.

Conclusions and Recommendations

Conclusions and recommendations will be drawn as a result of the findings.

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APPENDIX A-1

Strength Training Workouts

Back Squat training Program

Week 1 of Study 10/9/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	3	5	0.845
2	Back Squat	5	8	0.77
3	Pull Down	5	8	0.77
4	Any Bicep	3	10	0.735
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	4	6	0.4
2	Bench Press	5	8	0.77
3	Reverse Hyper	3	8	0.77
4	Any Tricep	3	10	0.735
5	YTWL	2	15	0.55

Week 2 of Study 10/16/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	3	4	0.69
2	Back Squat	3	6	0.65
3	Chin-up	3	6	0.65
4	BB Step-up	3	10	0.66
5	Bent Over Row	3	6	0.73
6	Any Bicep	3	8	0.69
7	Weighted YTWL	2	12	0.705
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	3	4	0.5
2	Bench Press	3	6	0.65
3	Good Morning	3	4	0.675
4	Over Head Press	3	6	0.73
5	Eccentric Hamstring	3	5	0.74
6	Any Tricep	3	8	0.69
7	SD SL Balancing	15	2	0.89
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	3	4	0.69
2	Back Squat	3	6	0.65
3	Seated Row	3	6	0.65
4	Reverse Lunge	3	10	0.66
5	BB Pull Over	3	6	0.73
6	Any Bicep	3	8	0.69
7	Rotator Cuff PNF Circuit	1	12	0.705
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	3	4	0.69
2	Incline Press	3	6	0.65
3	RDL	3	4	0.675
4	DB Bench Press	3	6	0.73
5	SB Leg Curl	3	5	0.74
6	Any Tricep	3	8	0.69

Week 3 of Study 10/23/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	4	4	0.775
2	Back Squat	4	5	0.74
3	Chin-up	4	5	0.74
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	Weighted YTWL	2	15	0.55
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	4	4	0.5
2	Bench Press	4	5	0.74
3	Good Morning	4	4	0.76
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	6	0.805
6	Any Tricep	3	8	0.77
7	SD SL Balancing	2	15	0.55

Week 4 of Study 10/30/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	5	4	0.865
2	Back Squat	5	5	0.825
3	Chin-up	5	5	0.825
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	YTWL	3	12	0.705
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	5	4	0.5
2	Bench Press	5	5	0.825
3	Good Morning	4	4	0.85
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	7	0.785
6	Any Tricep	3	8	0.77
7	Lying Hip Circuit	3	12	0.705
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	5	3	0.89
2	Pause Squat	10	2	0.45
3	Seated Row	3	5	0.825
4	Reverse Lunge	3	10	0.735
5	BB Pull Over	3	6	0.805
6	Any Bicep	3	8	0.77
7	Rotator Cuff Circuit	3	12	0.705
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	5	3	0.89
2	Incline Press	4	5	0.825
3	RDL	4	4	0.85
4	DB Bench Press	3	6	0.805
5	SB Leg Curl	3	7	0.785
6	Any Tricep	3	8	0.77
7	SD SL Balancing	45	2	0.89

Week 5 of Study 11/6/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	4	3	0
2	Back Squat	4	4	0
3	Chin-up	4	4	0
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	YTWL	2	15	0.55
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	6	3	0.55
2	Bench Press	4	4	0
3	Good Morning	3	4	0.85
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	8	0.77
6	Any Tricep	3	8	0.77
7	Lying Hip Circuit	2	15	0.55
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	4	2	0
2	Pause Squat	12	2	0.5
3	Seated Row	4	4	0.85
4	Reverse Lunge	3	10	0.735
5	BB Pull Over	3	6	0.805
6	Any Bicep	3	8	0.77
7	Rotator Cuff Circuit	2	15	0.55
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	4	2	0
2	Incline Press	4	4	0
3	RDL	4	4	0.85
4	DB Bench Press	3	6	0.805
5	SB Leg Curl	3	8	0.77
6	Any Tricep	3	8	0.77
7	SD SL Balancing	60	2	0.89

Week 6 of Study 11/13/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	4	4	0.865
2	Chain Squat	6	2	0.6
3	BB Lateral Step-up	3	8	0.69
4	Chin-up	3	4	0.76
5	Cross Over Row	3	5	0.74
6	Any Bicep	3	6	0.73
7	Scap Circuit	1	8	0.77
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	5	3	0.55
2	Bench Press	4	3	0.865
3	Snatch Pull	4	3	0.865
4	DB Over Head Press	3	5	0.74
5	Glute/Ham Raise	3	3	0.775
6	Any Tricep	3	6	0.73
7	SD SL MB Pass	15	2	0.89
8		0		0
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	3	4	0.865
2	Back Squat	4	5	0.825
3	DB Row	4	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.74
6	Any Bicep	3	6	0.73
7	Partner SB Push-up Bridge (fof)	15	2	0.89
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	3	4	0.865
2	Incline Press	4	5	0.825
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.74
5	SB SL Leg Curl	3	3	0.775
6	Any Tricep	3	6	0.73
7	4-way Band Slide	2	1	0.915

Week 7 of Study 11/20/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	5	4	0.865
2	Chain Squat	8	2	0.6
3	BB Lateral Step-up	3	8	0.77
4	Chin-up	4	4	0.85
5	Cross Over Row	3	5	0.825
6	Any Bicep	3	6	0.805
7	Scap Circuit	1	8	0.77
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	6	3	0.55
2	Bench Press	5	3	0.865
3	Snatch Pull	3	3	0.865
4	DB Over Head Press	3	5	0.825
5	Glute/Ham Raise	3	4	0.85
6	Any Tricep	3	6	0.805
7	SD SL MB Pass	15	2	0.89
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	5	4	0.865
2	Back Squat	5	3	0.865
3	DB Row	3	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.825
6	Any Bicep	3	6	0.805
7	Partner SB Push-up Bridge (fof)	15	2	0.89
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	5	4	0.865
2	Incline Press	4	3	0.865
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.825
5	SB SL Leg Curl	3	4	0.85
6	Any Tricep	3	6	0.805
7	4-way Band Slide	2	1	0.915

Week 8 of Study 11/27/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	5	3	0.89
2	Chain Squat	10	2	0.6
3	BB Lateral Step-up	3	8	0.77
4	Chin-up	4	2	0.89
5	Cross Over Row	3	5	0.825
6	Any Bicep	3	6	0.805
7	Scap Circuit	1	12	0.705
8		0		0
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	7	3	0.55
2	Bench Press	6	2	0.89
3	Snatch Pull	4	3	0.865
4	DB Over Head Press	3	5	0.825
5	Glute/Ham Raise	3	5	0.825
6	Any Tricep	3	6	0.805
7	SD SL MB Pass	45	2	0.89
8		0		0
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	5	3	0.89
2	Back Squat	6	2	0.89
3	DB Row	3	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.825
6	Any Bicep	3	6	0.805
7	Partner SB Push-up Bridge (fof)	45	2	0.89
8		0		0
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	5	3	0.89
2	Incline Press	4	3	0.865
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.825
5	SB SL Leg Curl	3	5	0.825
6	Any Tricep	3	6	0.805
7	4-way Band Slide	2	1	0.915

Front Squat Training Program

Week 1 of Study 10/9/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	3	5	0.845
2	Front Squat	5	8	0.77
3	Pull Down	5	8	0.77
4	Any Bicep	3	10	0.735
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	4	6	0.4
2	Bench Press	5	8	0.77
3	Reverse Hyper	3	8	0.77
4	Any Tricep	3	10	0.735
5	YTWL	2	15	0.55

Week 2 of Study 10/16/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	3	4	0.69
2	Front Squat	3	6	0.65
3	Chin-up	3	6	0.65
4	BB Step-up	3	10	0.66
5	Bent Over Row	3	6	0.73
6	Any Bicep	3	8	0.69
7	Weighted YTWL	2	12	0.705
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	3	4	0.5
2	Bench Press	3	6	0.65
3	Good Morning	3	4	0.675
4	Over Head Press	3	6	0.73
5	Eccentric Hamstring	3	5	0.74
6	Any Tricep	3	8	0.69
7	SD SL Balancing	15	2	0.89
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	3	4	0.69
2	Front Squat	3	6	0.65
3	Seated Row	3	6	0.65
4	Reverse Lunge	3	10	0.66
5	BB Pull Over	3	6	0.73
6	Any Bicep	3	8	0.69
7	Rotator Cuff PNF Circuit	1	12	0.705
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	3	4	0.69
2	Incline Press	3	6	0.65
3	RDL	3	4	0.675
4	DB Bench Press	3	6	0.73
5	SB Leg Curl	3	5	0.74
6	Any Tricep	3	8	0.69

Week 3 of Study 10/23/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	4	4	0.775
2	Front Squat	4	5	0.74
3	Chin-up	4	5	0.74
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	Weighted YTWL	2	15	0.55
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	4	4	0.5
2	Bench Press	4	5	0.74
3	Good Morning	4	4	0.76
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	6	0.805
6	Any Tricep	3	8	0.77
7	SD SL Balancing	2	15	0.55

Week 4 of Study 10/30/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	5	4	0.865
2	Front Squat	5	5	0.825
3	Chin-up	5	5	0.825
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	YTWL	3	12	0.705
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	5	4	0.5
2	Bench Press	5	5	0.825
3	Good Morning	4	4	0.85
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	7	0.785
6	Any Tricep	3	8	0.77
7	Lying Hip Circuit	3	12	0.705
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	5	3	0.89
2	Pause Squat	10	2	0.45
3	Seated Row	3	5	0.825
4	Reverse Lunge	3	10	0.735
5	BB Pull Over	3	6	0.805
6	Any Bicep	3	8	0.77
7	Rotator Cuff Circuit	3	12	0.705
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	5	3	0.89
2	Incline Press	4	5	0.825
3	RDL	4	4	0.85
4	DB Bench Press	3	6	0.805
5	SB Leg Curl	3	7	0.785
6	Any Tricep	3	8	0.77
7	SD SL Balancing	45	2	0.89

Week 5 of Study 11/6/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Snatch	4	3	0
2	Front Squat	4	4	0
3	Chin-up	4	4	0
4	BB Step-up	3	10	0.735
5	Bent Over Row	3	6	0.805
6	Any Bicep	3	8	0.77
7	YTWL	2	15	0.55
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Full Jump Squat	6	3	0.55
2	Bench Press	4	4	0
3	Good Morning	3	4	0.85
4	Over Head Press	3	6	0.805
5	Eccentric Hamstring	3	8	0.77
6	Any Tricep	3	8	0.77
7	Lying Hip Circuit	2	15	0.55
Thursday				
	Exercise	Sets	Reps	%1RM
1	Clean	4	2	0
2	Pause Squat	12	2	0.5
3	Seated Row	4	4	0.85
4	Reverse Lunge	3	10	0.735
5	BB Pull Over	3	6	0.805
6	Any Bicep	3	8	0.77
7	Rotator Cuff Circuit	2	15	0.55
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Press	4	2	0
2	Incline Press	4	4	0
3	RDL	4	4	0.85
4	DB Bench Press	3	6	0.805
5	SB Leg Curl	3	8	0.77
6	Any Tricep	3	8	0.77
7	SD SL Balancing	60	2	0.89

Week 6 of Study 11/13/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	4	4	0.865
2	Chain Squat	6	2	0.6
3	BB Lateral Step-up	3	8	0.69
4	Chin-up	3	4	0.76
5	Cross Over Row	3	5	0.74
6	Any Bicep	3	6	0.73
7	Scap Circuit	1	8	0.77
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	5	3	0.55
2	Bench Press	4	3	0.865
3	Snatch Pull	4	3	0.865
4	DB Over Head Press	3	5	0.74
5	Glute/Ham Raise	3	3	0.775
6	Any Tricep	3	6	0.73
7	SD SL MB Pass	15	2	0.89
8		0		0
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	3	4	0.865
2	Front Squat	4	5	0.825
3	DB Row	4	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.74
6	Any Bicep	3	6	0.73
7	Partner SB Push-up Bridge (fof)	15	2	0.89
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	3	4	0.865
2	Incline Press	4	5	0.825
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.74
5	SB SL Leg Curl	3	3	0.775
6	Any Tricep	3	6	0.73
7	4-way Band Slide	2	1	0.915

Week 7 of Study 11/20/06:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	5	4	0.865
2	Chain Squat	8	2	0.6
3	BB Lateral Step-up	3	8	0.77
4	Chin-up	4	4	0.85
5	Cross Over Row	3	5	0.825
6	Any Bicep	3	6	0.805
7	Scap Circuit	1	8	0.77
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	6	3	0.55
2	Bench Press	5	3	0.865
3	Snatch Pull	3	3	0.865
4	DB Over Head Press	3	5	0.825
5	Glute/Ham Raise	3	4	0.85
6	Any Tricep	3	6	0.805
7	SD SL MB Pass	15	2	0.89
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	5	4	0.865
2	Front Squat	5	3	0.865
3	DB Row	3	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.825
6	Any Bicep	3	6	0.805
7	Partner SB Push-up Bridge (fof)	15	2	0.89
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	5	4	0.865
2	Incline Press	4	3	0.865
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.825
5	SB SL Leg Curl	3	4	0.85
6	Any Tricep	3	6	0.805
7	4-way Band Slide	2	1	0.915

Week 8 of Study 11/27/2006:

Monday				
	Exercise	Sets	Reps	%1RM
1	Hang Clean	5	3	0.89
2	Chain Squat	10	2	0.6
3	BB Lateral Step-up	3	8	0.77
4	Chin-up	4	2	0.89
5	Cross Over Row	3	5	0.825
6	Any Bicep	3	6	0.805
7	Scap Circuit	1	12	0.705
8		0		0
Tuesday				
	Exercise	Sets	Reps	%1RM
1	Quarter Jump Squat	7	3	0.55
2	Bench Press	6	2	0.89
3	Snatch Pull	4	3	0.865
4	DB Over Head Press	3	5	0.825
5	Glute/Ham Raise	3	5	0.825
6	Any Tricep	3	6	0.805
7	SD SL MB Pass	45	2	0.89
8		0		0
Thursday				
	Exercise	Sets	Reps	%1RM
1	Hang Snatch	5	3	0.89
2	Front Squat	6	2	0.89
3	DB Row	3	5	0.825
4	Box Jump	3	3	0.55
5	Straight Arm Pull Down	3	5	0.825
6	Any Bicep	3	6	0.805
7	Partner SB Push-up Bridge (fof)	45	2	0.89
8		0		0
Friday				
	Exercise	Sets	Reps	%1RM
1	Push Jerk	5	3	0.89
2	Incline Press	4	3	0.865
3	Clean Pull	4	3	0.865
4	DB Bench Press	3	5	0.825
5	SB SL Leg Curl	3	5	0.825
6	Any Tricep	3	6	0.805
7	4-way Band Slide	2	1	0.915

APPENDIX A-2

Informed consent form

Data collection sheet

INFORMED CONSENT TO BE A RESEARCH SUBJECT

Explanation of the Exercise Tests

The purpose of this study is to compare the effect of the back squat and the front squat on vertical jump height and power output in male collegiate volleyball players.

This study will require you to participate in three five minute testing sessions every four weeks for eight weeks to test whether or not training protocols using the back squat or the front squat have a positive effect on vertical jump height and power output. The testing will require one test as outlined below.

1. Vertical jump and power test

    After an initial warm up period of dynamic range of motion exercises you will then perform three maximal vertical jumps off of two feet, on a Just Jump or Run switch mat by Probotics, Inc. Each jump will be separated by a 10 second interval. You will then maximally jump four times in rapid succession off of two feet. Each series of jumps will be separated by a 30 second rest interval. This will be repeated three times for each of the pretest, mid-test and post-test.

*You may stop any part or the whole test for any reason at any time.

Risks and Discomforts

The risks associated with this test are minimal and include risks associated with a normal practice and game. Every effort will be made to minimize risks by supervision and explanation of test procedure during testing.

You may experience some discomfort during this test. There is a slight possibility of straining a muscle or tendon and spraining ligaments during this test. In addition you may experience delayed muscle soreness 24 to 48 hours after testing.

Responsibilities of the Participant

Information about your health status or possible health conditions and discomfort during exercise may affect the safety and value of the vertical jump test. Your prompt reporting of feelings of discomfort during the vertical jump test is also of great importance.

Expected Benefits from Testing

The results obtained from the testing inform you of your present attainable vertical jump height. The information based on the results made during the testing sessions will be treated as privileged and confidential unless specifically specified by you, the participant. This information may be used for statistical or scientific purpose with your right to privacy retained.

Inquiries

If you have any questions regarding any aspect of this research study you may contact Manu Peeni (home phone 812-0578, cell phone 592-5402) or Dr Phil Allsen (work phone 422-4650) of the Exercise Sciences Department. If you have any questions regarding your rights as a participant in this research study, you may contact Dr. Renea Beckstrand Chair of the Institutional Review Board for Human Subjects, phone 422-3873.

Confidentiality

Data will be kept confidential. Each subject will be assigned a subject identification number for the duration of the study. The data sheet will be kept with the researcher in a secure place.

Freedom of Consent

Your permission to perform this testing is voluntary. Your standing on the Brigham Young University men's volleyball team will not be affected by your participation in this study. You are free to stop testing at any point without penalty, if you so desire. If you have any serious health concerns, please avoid any unnecessary risk by dismissing yourself from participation in this research.

I have read this form and I understand the test procedures that I will participate in.
I consent to participate in this research as described.

____
Signature of Participant

____________________ ______________________________________
Date Signature of Witness

Data Sheet

	Pre-test						Mid-test						Post-test					
Participant ID number	Height			Power Index			Height			Power Index			Height			Power Index		