IMPLEMENTING HANG CLEANS FOR THE IMPROVEMENT OF VERTICAL JUMP IN HIGH SCHOOL ATHLETES

by

Eric C. Scherfenberg

An Abstract
of this thesis presented in partial fulfillment
of the requirements for the degree of
Master’s of Science
in the Department of Nutrition and Kinesiology
University of Central Missouri

August, 2012
ABSTRACT

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The focus of this study was to determine if adding hang clean (HC) to a structured weight training program can make an improvement in vertical jump (VJ). High school student athletes (N=173), were randomly assigned to three groups that all performed the same secondary lifts. The control group (SQG) performed six sets of squat (SQ). Another group performed three sets of HC and three sets of SQ (CSG). The remaining group performed six sets of HC and no SQ (HCG). Pre- and post-assessments of VJ were recorded at the beginning and end of the six week study using a Vertec. The study determined a significant difference of average VJ improvement between both the CSG (1.48 inches) and HCG (1.05 inches) when compared to the SQG (.26 inches). There was also a significant difference between the CSG and HCG leading to the recommendation to implement HC equally with SQ to maximize VJ.
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UNIVERSITY OF CENTRAL MISSOURI
WARRENSBURG, MISSOURI
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High school coaches are always looking for ways to improve their athletes' athletic ability to be able to compete at a higher level. One of the ways that coaches measure athleticism is the countermovement vertical jump (VJ). The VJ is defined as the measured difference between an individual's reach height and their jump reach height. The jump can be aided by the arms, but must not involve a step. Volleyball and basketball are examples of sports that rely on the ability to jump, reload, and jump again. It is widely accepted that plyometric jump training can increase VJ, but excessive training can also lead to overuse type injuries. Triple extension is the explosive extension of knee, hip, and ankle that generates power. A triple extension type exercise such as hang clean (HC) and/or squat (SQ) exercise could have a positive effect on increasing VJ. Biomechanically the HC and VJ have distinct similarities in their load phase as well as their triple extension jump phase. Kawamori, Crum, Blumert, Kulik, Childers, and Wood (2005) go into great detail on the different intensities of triple extension exercises and how they can have a profound effect on power output. Kawamori et. al. state that triple extension exercises exhibit a large amount of force in a short amount of time, thus creating muscular power. The intensity or percentage of loads used determine the speed of the lift and the measurable peak power output.

**Research Questions**

**Question 1:** What effect does implementing HC in place of SQ in a workout program have on VJ?
Question 2: What effect does equally implementing HC and SQ into a workout program have on VJ?

**Purpose of the Study**

The purpose of this study was to determine if implementing HC into a structured weight training program can make an improvement in VJ. This study focused on high school student athletes and the ability to increase VJ without using plyometric bodyweight exercises.

It is commonly accepted that weight training in high school students helps them to become better athletes. Todd (2008) reminds us that Coach Al Roy, a gym owner, brought to national attention the benefit of weight training to develop better high school athletes. In the 1950’s Coach Roy was one of the first to introduce weight training to high school and collegiate athletes with astonishing results. The first high school team he trained in the weight room went undefeated and he was soon called to help Louisiana State University develop a weight training program. Shortly after Louisiana State University won the national football championship in 1958, the San Diego Chargers called him to install the first comprehensive strength and conditioning program for a National Football League team (Todd, 2008).

Canadian strength coach Charles Poliquin, a world renowned strength and conditioning coach (SCC), has designed workout programs for over 400 Olympians. Poliquin (2006) contends that strengthening the posterior chain significantly impacts VJ and power for jumping derives from 40% gluteus and 25% hamstrings. When accounting for the spinal erectors and gastrocnemius he
claims that over 65% of the VJ comes from the posterior chain. What seems to be missing is identifying particular lifts, or combination of lifts, best suited to enhance an individual’s VJ at the high school level. The information gleaned from this study could identify if HC or SQ are more likely to produce this desired result. The new information may help equip more high school strength and conditioning coaches with the knowledge needed to properly train their athletes, specifically basketball and volleyball players, so that the athlete improves their VJ and maximizes their athletic potential.

This study focused on training methods to increase VJ of high school athletes over a six week period without incorporating plyometric training. There seems to be a lack of published studies utilizing large groups of high school athletes with regard to weight training exercises that improve VJ. The following review of literature reports the increased power output of Olympic weight training exercises such as HC and their variations in comparison to more traditional lifts.

**Hypotheses**

The implementation of HC to traditional high school weight training programs significantly increases an individual’s VJ when compared to a program without HC or one of the Olympic lifts.

H<sub>1</sub>) There would be an increase in VJ in the group that fully implemented HC as opposed to the control group with SQ only.

H<sub>2</sub>) There would be an increase in VJ in the group that combined HC and SQ as opposed to the control group with SQ only.
H₃) There would be an increase in VJ in the group that implemented HC over the group that implemented HC with SQ.

**Delimitations**

This implementation was delimited to:

1) being conducted in the Spring of 2011;
2) taking place at Belton High School weight room;
3) 183 male and female participants currently enrolled in an Advanced Physical Fitness elective weight training class, grades 10-12;
4) each subject performed three trials for both pre-test and post-test, with the best VJ of the three recorded;
5) measurements were taken using a Vertec to assess the VJ of participants;
6) Six week training session in between pre- and post-assessment of VJ.

**Limitations**

This investigation was limited by:

1) the test subjects participated in different sports during the six week interval and did not alter their particular sport practice schedule at any time during data collection;
2) when an athlete had weight training class on a day of varsity competition they were only required to do 70% of the weight listed for each set on their workout sheet for that day: soccer, baseball,
and track athletes often missed or participated in reduced load workouts four plus training sessions in a row due to competition;

3) distance runners in track are daily training slow twitch muscle fiber which is counterproductive in producing a good vertical jump;

4) groups of subjects were not evenly balanced for levels of weight training experience.

Assumptions

It was assumed that:

1) subjects produced maximum effort in intensity during testing and training;

2) classes were relatively balanced with experience of weight training;

3) subjects remain relatively healthy and injury free during this six week period;

4) subjects followed specific workout plan

5) subjects followed post-workout nutrition plan;

6) the Vertec was a valid assessment tool in measuring VJ.

Definition of Terms

The following definitions of terms appropriate to this study are:

Muscular power. Main determinants of dynamic athletic performance that require high force generation in a short amount of time (Kawamori, Crum, Blumert, Kulik, Childers, &Wood, 2005).

Power. The mechanical quantity defined as the rate of doing work and is obtained as work divided by time or force time’s velocity (Hori, Newton,

Triple extension. The sequential unlocking of flexed ankles, knees, and hips to a fully extended and erect position (Kawamori, Crum, Blumert, Kulik, Childers, and Wood, 2005).
CHAPTER 2
REVIEW OF LITERATURE

This current review summarizes the literature regarding the benefits of plyometric training as a means to improve VJ and also details the mechanics of a HC and how they can be associated with a VJ. The review also evaluates studies pertaining to the power output of certain weight training exercises and the evaluation of various VJ assessments to determine the best fit for this particular study. The literature review was organized under the following topical headings: (a) plyometric training, (b) hang clean mechanics, (c) power output exercises, (d) vertical jump evaluations, and (e) review summary. The relevancy of this study will link the association of muscular power and the evaluation of VJ height.

Plyometric Training

In the field of health and human performance it has long been understood that plyometric training has a positive effect on VJ. Arabatzi, Kellis, and Villarreal (2010) provide insight into plyometrics training and the type of muscle contractions involved:

Plyometric Training refers to the performance of stretch-shortening cycle movements that involve a high-intensity eccentric contraction immediately before a rapid and powerful contraction. The effects of plyometrics training on VJ performance have been extensively studied. Although the mechanisms by which plyometrics training improves VJ are not fully understood, it has been suggested that plyometrics training increases jumping height because of a greater muscle activation level and a higher mechanical output of the contractile machinery. Particularly, the power
produced when performing plyometrics training movements enables the hip, the knee, and the ankle joints to reach high angular velocities at the end of the push-off phase. (p. 2440)

Kutz (2003) states that plyometrics is a compilation of a number of exercises, but not limited to skipping, bounding, lunging, footwork drills, depth jumps, and standing jumps. Plyometric training is very efficient at producing a better VJ. Another interest is investigating what other factors might lead to a high level of muscle activation and thus improving VJ. Khifa, Aouadi, Hermassi, Chelly, Jlid, et. al., (2010) reports that plyometrics training with weighted vests has a significant advantage in comparison to training without the weighted vests during a ten week training period. Weighted vests are a means of the overtraining principle utilizing added resistance. Ronnenstad, Kvmme, Sunde, and Raastad (2008) confirm the data that combining heavy strength training and plyometrics is far superior to just incorporating one modality. Dodd and Alvar (2007) stated that by incorporating heavy resistance training and plyometric training the collegiate baseball player’s attained greater increases in speed and lower body power. Additionally, VJ is directly linked to playing time for elite collegiate basketball players because of their ability to make plays above the rim due to their VJ (Hoffman, Tenenbaum, Maresh, & Kreamer, 1996).

**Hang Clean Mechanics**

The mechanics involved in a HC are very similar to that of a VJ. According to the National Strength and Conditioning Association’s (NSCA) Exercise Technique Manual for Resistance Training (2008) the HC mainly targets the
gluteals and hamstrings during hip extension, quadriceps during knee extension, the gastrocnemius and soleus during ankle plantar flexion, and the anterior and medial deltoids, and trapezius during shoulder flexion, abduction, and elevation. The first phase of a HC is a load phase, in which there is flexion of hips, knees, and ankles that place an athlete in virtually the same position of a load phase in preparation for a VJ. The second phase of the HC is a jump shrug which is initiated by hip and knee extension and finishes with ankle plantar flexion. The jump shrug is essentially a VJ executed by extending hips, knees, and ankles with the bar at arm’s length held as close to the body as possible. The load phase and jump shrug with a loaded bar could be considered a variation of the weighted plyometric training previously mentioned above. The third phase of HC is the hip drop or catch phase. The hip drop is initiated at the completion of the jump shrug at full triple extension when the shoulders are flexed, abducted and elevated. It begins with simultaneously flexing elbows, hips, knees, and ankles as the lifter attempts to pull the body under the bar and catch the weight in a front squat position with chest tall and elbows up. The hip drop can be associated with an athletes need to recoil and reload the hips in an attempt to quickly jump again. An example would be a middle blocker for a volleyball team that has to make quick consecutive jumps, or a basketball player making multiple jump attempts for a rebound. The final phase of a HC is the recovery phase that is simply a front squat from the catch position to standing upright. The front squat is great at building strength in the quadriceps, hamstrings, gluteus, and core which are all active muscles in the VJ.
Power Output Exercises

Hori, Newton, Andrews, Kawamori, McGuigan, and Nosaka (2007) identified means to measure power output concerning the hang power clean and the weighted jump squat and why measuring is so important. The authors define power as the rate of doing work and it is achieved as work divided by time. Hori et. al. also state that a high power output should be one of the main goals of strength and conditioning programs and it needs to be tested before and after each phase of training. According to Kawamori, Crum, Blumert, Kulik, Childers, and Wood (2005), muscular power is a major player in athletic performances that require a large amount of force in a short amount of time. Continuing to develop power is essential to reaching genetic potential as an athlete. The ability for SCC’s to measure that power is essential to help each athlete reach genetic potential.

Hori et. al., (2007) concluded the weighted jump squat has elicited a similar power output to HC. The authors also indicate similar results in peak power training by implementing the weighted jump squat as an alternative lift to the HC for the less experienced lifter. On the opposite end of the spectrum, Berning, Adams, DeBeliso, Sevène-Adams, Harris, and Stamford (2010), conducted a study with both resistance trained and untrained men utilizing functional isometric squats (FI) with 150% of their one repetition maximum for three seconds in a half squat and then tested their VJ. The resistance trained men showed improvement in their VJ from performing the FI before testing, while the untrained men did not have improvement. Functional isometric squats could
be perceived as a liability at the high school level because it requires an individual to use one and a half times the amount of their one repetition SQ max and hold it on their back in a half SQ for three seconds. In the high school setting the dangers of racking and un-racking the weight and stepping out to get into squat position may not be worth the possible benefit of performing a FI.

According to Johnson and Bahamonde (1996) the mechanical power output of a VJ generated a peak of 5782 ± 1,123 watts in a study involving 69 male collegiate athletes. It was also reported that if a person improves their power output they will increase their VJ. Garhammer (1993) reported that in a world class 275 pound Olympic athlete that was attempting a 573 pound clean and jerk, the second pull phase of the clean generated an unprecedented 6981 watts. The second pull phase of a clean and jerk is in fact the jump shrug portion of the HC. The Olympic lifts and its variations are unmatched when compared to powerlifting exercises such as bench and SQ. Garhammer shows that in a 165 pound athlete benching 440 pounds that the power output is only 343 watts and for a world class squat it is only about 1100 watts generated. According to Markovic and Jaric (2007) vertical jump height is a body size-independent measure of muscular power that was validated in a study of 159 physical education students. Developing a higher level of muscular power is directly associated with VJ capacity.

Another question to address is the influence of different relative intensities on power output during HC. Kawamori, Crum, Blumert, Kulik, Childers, and Wood (2005) go into great detail on the different intensities of work load and how
that can have a profound effect on the power output. Optimal load for power output had previously been reported as 30% of a one repetition maximum (Kaneko, Fuchimoto, Toji, & Suel, 1983). However, the research was not conducted on a triple extension lift such as HC. Hang clean is a generation of a high amount of force in a short amount of time as is the base of most dynamic athletic performance events.

Kaneko, Fuchimoto, Toji, and Suel (1983) summarized that peak power output was reached at 70% of a one repetition maximum for HC, but that a repetition at 90% only dropped peak output less than 100 watts. This is important in HHP because SCC put their athletes through weight training exercises daily and need to make sure that their athletes are working at optimal loads to make the most out of their time. It does not seem maximally beneficial for high school athletes to train for only one repetition sets at 70% of a workload. However, SCC need to closely monitor the repetitions at loads above 70% to insure the speed of the lift does not slow too much as then it is no longer activating fast twitch muscle fiber.

For Olympic weight lifting athletes they only do one repetition in competition, but high school athletes don’t generally compete in areas that require one performance event outside of field events in track. According to Zatsiorsky and Kraemer (2006), Olympic athletes performing snatch and clean and jerk attempt to keep the repetitions between one and three which is considered a maximal effort method. The authors indicate the maximal effort method is used by superior athletes and is ideal of training both the muscles and
the central nervous system. For high school athletes it is common place to keep the repetitions between three and five for technical lifts that tax the central nervous system. Zatsiorsky and Kraemer state that the central nervous system will improve to the loads placed on them, but imply that it is not recommended to exceed five repetitions in Olympic lifts and their variations.

**Vertical Jump Evaluations**

There are different methods to measure vertical jump and they all seem to have their strengths and weaknesses. The standing board jump and Vertec are field tests that measure VJ, but have been questioned because of the arm movement necessary to perform the test (Young, MacDonald, & Flowers, 2001). The Vertec does provide an external focus which the force platforms and contact mats do not. According to Wulf and Dufek (2009), individuals that have an external focus jump higher than those that do not have that visual tool to reach. Moir (2008) addresses three different methods to calculate vertical jump height from force platform data. While the force platform data is probably the most accurate it is also very expensive for a reliable platform.

The instrumented triangle jump platform is a viable alternative to a ground mat, Vertec, or force plate platform. (Caruso, Daily, McLagan, Shepherd, Olson, et. al., 2010). The instrumented platform was tested in conjunction with the Vertec with a high rate of reliability. It is interesting to see the validity and accuracy of the contact mats in comparison with force jump platforms. The contact mats, which are much cheaper, carry a positive correlation with the more expensive force jump platforms as long as the body posture is identified at
landing (Moir, 2008). This could allow for a quicker assessment which would encourage testing more frequently without giving up valuable class time.

As identified by Casartelli, Muller, and Maffiuletti (2010), VJ assessment tools can be classified as field tests (e.g., Vertec and contact mats) or laboratory tests (e.g., force platforms and video analysis). Laboratory tests are not a viable option for most high school SCC due to finances. Another field test is the Myotest system which is small and transportable and can be tested on the same surface that the athlete performs on. The test is not accurate to determine actual number of inches or centimeters, but it is accurate to measure improvement if only using the Myotest as the pre-test and post-test (Caruso, et. al., 2010).

Review Summary

It has been determined that VJ is a valid assessment of an athlete and their power output. It is also widely accepted that SCC’s can improve an athlete’s VJ with a training program that utilizes plyometrics training and weight training exercises (Ronnenstad, Kvaamme, Sunde, & Raastad, 2008). This review of literature identifies studies that show how certain lifts and loads advocate better results. As mentioned previously, snatches and cleans are unprecedented when it comes to power output. Increasing power output increases VJ. What seems to be missing is that all the power output studies were performed in adult males in their twenties and later. Berning et. al., (2010) performed the only study in the review of literature that incorporated untrained individuals. These studies are not easily generalized to high school weight training classes of male and female students that may or may not have any weight training experience.
Channell and Barfield (2008) conducted a study with 27 high school football players and the effect Olympic lifting and power lifting had on VJ. The eight week study showed significant improvement in VJ from the Olympic group and power lifting group over the control group, but only modest benefit from the Olympic group over the power lifting group. The study by Channell and Barfield was the closest related study found, but was limited to only nine male football players per group. It is the purpose of the current study to provide a large sample of high school athletes, male and female, trained and untrained with the main variable being the inclusion of HC.

While recognizing the benefit of plyometrics and traditional resistance training exercises, the intention of this study is to support the hypotheses that if a SCC implements HC into their athlete’s regular workout twice per week there will be an improvement in VJ within six weeks.
CHAPTER 3
METHOD

The purpose of this study was to determine if incorporating HC into an existing weight training program can make an improvement in VJ. This study was a pre-post test research design that focused on high school athletes and the ability to increase VJ without the overload of plyometric training. The scope of the study is specialized to only high school age athletes. It is opened to both genders and to both trained and untrained individuals. This chapter discusses the participants, instrumentation, procedures and methods of training, data collection, and the method of statistical analysis.

Participants

Participants for this study included 173 male and female high school student athletes in grades 10-12 who were enrolled in an Advanced Physical Fitness weight training class. Participation in high school athletics is the only requirement to qualify for the class. Each class was a mixture of weight training experience, sport participation, and athletic competence. While the sampling of athletes was a convenience sample, the school principal randomly selected two classes for each of the three groups utilizing the fishbowl technique, a blind draw out of a bowl (Baumgartner & Hensley, 2006). A week prior to the study all subjects completed demographic information such as: name, gender, grade, years of weight training experience, race, sport, and any additional training.

Instrumentation

While there seem to be a number of valid assessment tools for VJ, the Vertec was used due to cost effectiveness and validity. The cost and design of
the Vertec make it the standard for accuracy for field test assessments of the VJ due to less chance for visual error. The same VJ assessment technique is also utilized by the National Football League during their combine, an athletic testing field day for potential professional football players. The Vertec is a common assessment tool that is utilized by many collegiate and high school athletic programs and is a valid and reliable assessment tool (Caruso, et al., 2010). The Vertec is a user friendly VJ slide rail measurement tool with color coded vanes every half-inch with a corresponding height scale. Athletes will start stretched out in an upright position in contact with the Vertec at the ankle, hip, shoulder, and palm to determine their standing reach. Their standing reach is subtracted from their jump reach to determine their VJ.

Procedures

The study employed a pre-post test research design to determine the improvement of VJ. Student athletes participated in five preparatory sessions learning the correct technique for performing a VJ on the Vertec as well outlining technique and procedures for the lifts utilized in the six week training session. They were given enough trials one week before the study began to become comfortable with both technique and expectations. The pre-test of VJ for baseline data occurred three days prior to beginning the six week program. Each testing session was conducted after a ten minute dynamic warm-up. After the dynamic warm-up the subject performed three jumps and the highest of the three was recorded. During the final two sessions subjects performed five maximum repetitions on Bench, SQ, Deadlift and HC. The five maximum repetitions were
converted to projected one repetition maxes using a repetition conversion chart (Epley, 1986).

All three groups performed the same upper body lifts and lower body auxiliary lifts two days a week for six weeks. Each workout was 80 minutes in duration and included a ten minute standard dynamic warm-up, sixty minute weight training session, and a ten minute cool down and full body stretch using light resistance bands. The standard dynamic warm-up included each of the following 10 exercises: pogo jumps, seal jacks, flings, wideouts, split jumps, tin man, a skip, b skip, standing broad jump, and hop-hop-stick. The exercises were performed for 30 seconds followed by 30 seconds of recovery.

The independent variables were the differences in the methods of exercise selection for the three different groups. The squat group (SQG) performed six sets of SQ and was deemed the control group because it appears the majority of high school SCC’s utilize SQ in their program as their main lower body lift. The combination clean and squat group (CSG) performed three sets of HC and three sets of SQ. The hang clean group (HCG) performed six sets of HC. All three groups performed their specific workouts outlined in Tables 1-6. Each group performed each workout once a week for a total of two workouts a week with two days of rest in between workouts. Amount of sleep and eating habits were not monitored for this study. Student athletes participated in three nutrition lessons educating and encouraging them to make the right choices.
### Squat Group Workout Day 1

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat</td>
<td>6@70</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>RDL</td>
<td>12@50</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Bench Press</td>
<td>6@75</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>*Pullups</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

*Pullups are a difficult exercise to put a percentage to for a generalized program for multiple athletes. The repetitions prescribed for each week should be reached at optimal performance, which would require weaker individuals who could not perform 12 repetitions in week one to use resistance bands for assistance, while others may need to do weighted pullups so they can only perform 12 repetitions.

### Squat Group Workout Day 2

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat</td>
<td>6@70</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Deadlift</td>
<td>12@50</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Incline Bench Press</td>
<td>6@75</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Bent Over Rows</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table 3.

**Clean Squat Group Workout Day 1**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hang Clean</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Squat</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>RDL</td>
<td>12@50 12@55 10@60 10@65 8@70 8@75</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bench Press</td>
<td>6@75 6@79 5@83 4@87 3@90 3@93</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>*Pullups</td>
<td>12 12 10 10 8 8</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

RM= rep max, RDL=Romanian deadlift

*Pullups are a difficult exercise to put a percentage to for a generalized program for multiple athletes. The repetitions prescribed for each week should be reached at optimal performance, which would require weaker individuals who could not perform 12 repetitions in week one to use resistance bands for assistance, while others may need to do weighted pullups so they can only perform 12 repetitions.

### Table 4.

**Clean Squat Group Workout Day 2**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hang Clean</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Squat</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Deadlift</td>
<td>12@50 12@55 10@60 10@65 8@70 8@75</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Incline Bench</td>
<td>6@75 6@79 5@83 4@87 3@90 3@93</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bent Over Rows</td>
<td>12 12 10 10 8 8</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 5.

_Hang Clean Group Workout Day 1_

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hang Clean</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>RDL</td>
<td>12@50 12@55 10@60 10@65 8@70 8@75</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bench Press</td>
<td>6@75 6@79 5@83 4@87 3@90 3@93</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>*Pullups</td>
<td>12 12 10 10 8 8</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

RM= rep max, RDL=Romanian deadlift

*Pullups are a difficult exercise to put a percentage to for a generalized program for multiple athletes. The repetitions prescribed for each week should be reached at optimal performance, which would require weaker individuals who could not perform 12 repetitions in week one to use resistance bands for assistance, while others may need to do weighted pullups so they can only perform 12 repetitions.

Table 6.

_Hang Clean Group Workout Day 2_

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weekly Reps@%1RM</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hang Clean</td>
<td>6@70 6@75 5@83 4@87 3@90 3@93</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Deadlift</td>
<td>12@50 12@55 10@60 10@65 8@70 8@75</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Incline Bench</td>
<td>6@75 6@79 5@83 4@87 3@90 3@93</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bent Over Rows</td>
<td>12 12 10 10 8 8</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
**Data Collection**

The pre-test baseline assessment of VJ was collected three days prior to the six week weight training program. Post-test assessment of VJ occurred three days after the six week program had concluded. Each testing session was conducted after the ten minute dynamic warm-up described previously. After the dynamic warm-up the subject performed three jumps with the highest of the three recorded. For objectivity, consistency, and reliability the SCC conducted all pre-test and post-test assessments of the VJ.

**Statistical Analysis**

The data were recorded to within half-inch accuracy with the vanes of the Vertec fixed by the manufacturer at half-inch increments. The differences between the pre-test and the post-test data were calculated and analyzed for group differences to determine if the hypotheses were supported. A one-way ANOVA was implemented and the mean differences between all three groups were calculated. The results of the ANOVA required a post-hoc Tukey’s HSD to determine which groups had differences. Alpha level of significance was set apriori at 0.05.
CHAPTER 4
RESULTS

The purpose of this study was to determine if implementing HC into a structured weight training program can make an improvement in VJ. This study focused on high school athletes and the ability to increase VJ without using plyometric exercises. The test was administered following the protocol outlined in the procedures section above. Each of the three groups had members that were not able to post-test due to injury therefore they were eliminated from the study. Thus two members out of the CSG were eliminated, while four from each the SQG and the HCG were removed. The study started with 183 subjects however 173 completed the entire procedure. The reasons for removal were for injury (4), poor attendance (5), and moving out of district (1).

Statistical Averages

The pre-test VJ mean for each group is depicted in Table 7. A one-way analysis of variance was conducted; results indicated the means for each group were not different $F(2,170) = 0.92$, $p>0.05$. The null hypothesis was accepted stating the pre-test groups VJ were similar with one another.

Table 7. Pre-test Means.

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQG</td>
<td>58</td>
<td>22.78</td>
<td>23.77</td>
</tr>
<tr>
<td>CSG</td>
<td>60</td>
<td>23.78</td>
<td>30.04</td>
</tr>
<tr>
<td>HCG</td>
<td>55</td>
<td>22.61</td>
<td>21.55</td>
</tr>
</tbody>
</table>

The mean improvement of each group is recorded in Table 8.
Table 8. *Mean Improvement (Imp) in Vertical Jump (inches).*

<table>
<thead>
<tr>
<th>Group</th>
<th>Average Imp</th>
<th>Made 1+” Imp</th>
<th>2+” Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat Only</td>
<td>0.26</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Hang Clean &amp; SQ</td>
<td>1.48</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>Hang Clean Only</td>
<td>1.05</td>
<td>32</td>
<td>12</td>
</tr>
</tbody>
</table>

The greatest improvement was made by the CSG with a 1.48” improvement in VJ. The second largest gain was made by the HCG with an improvement in VJ of 1.05”. The SQG had a modest gain in VJ at .26”, which supports the theory that implementing HC has a significant impact on VJ compared to traditional weight training programs.

**Clean and Squat Group**

The CSG showed the greatest improvement. Only one individual showed a loss of vertical with a .5” decrease. The greatest improvement came from a foreign exchange student who played soccer and had never participated in weight training. This participant made a 10” improvement in the six week study. The drastic improvement in VJ might also have come from never testing VJ and not understanding proper jump mechanics. Further analysis of the top ten largest improvements in the CSG indicated that only one subject was participating in a spring sport.

**Hang Clean Group**

The HCG showed improvement close to that of the CSG. This group finished with an average improvement of 1.05” per individual. Of the top ten individuals seven of them were not participating in a spring sport. The HCG had
three individuals who showed a decrease in their VJ ranging from 1” to 1.5”. All three of these individuals were in-season baseball players. The greatest improvement in this group was an individual that made a 4.5” improvement.

**Squat Group**

The SQG was considered the control group and did not show the gains of that of the other two groups. The SQG finished with an average gain of a quarter of an inch. The biggest gain an individual made in the group was 1.5” improvement in VJ. The group finished with ten individuals that produced a reduced VJ.

**ANOVA of Group Improvement**

A one-way analysis of variance was conducted on group changes which revealed there indeed was a difference in the groups. F(2,170) = 13.84, p<0.05. Pairwise comparisons were conducted to determine which groups were significantly different. The first two hypotheses were accepted because the two groups including HC were significantly different from the SQG. Tukey’s post hoc test determined a significant difference of average VJ improvement between both the CSG (1.48in) and HCG (1.05in) when compared to the SQG (.26in). There was also a significant difference between the CSG and HCG which actually rejected the final hypothesis that fully replacing SQ with HC would result in higher VJ improvement.
Table 9. ANOVA Group VJ Improvement (inches).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Mean(in)*</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQG</td>
<td>58</td>
<td>0.26</td>
<td>0.76</td>
</tr>
<tr>
<td>CSG</td>
<td>60</td>
<td>1.48</td>
<td>2.71</td>
</tr>
<tr>
<td>HCG</td>
<td>55</td>
<td>1.05</td>
<td>1.40</td>
</tr>
</tbody>
</table>

*Change pre to post
The purpose of this study was to determine if implementing HC into a structured weight training program can make an improvement in VJ. The results indicate that there was a significant improvement for both the HCG and the CSG that implemented HC into their workout. The SQG did not implement HC and had a modest gain of a quarter of an inch on average compared to over an inch for each of the other two groups. The athletes that participate in demanding sports tend to have a difficult time making gains in season. For some athletes in season the lack of gains may be related to overtraining, not enough rest, and/or not keeping up with nutritional demands. On the opposite end of the spectrum it could be due to them not pushing themselves in the weight room so that they do not fatigue themselves anticipating their varsity competition that evening.

**Related Literature Review**

Hoffman, Tenenbaum, Maresh, and Kreamer (1996), discussed VJ was directly linked to playing time for elite athletes. There is a correlation between the best athletes on paper and the most successful ones on the court and field for those that participate in sports that require muscular power. Plyometric training has shown to produce an explosive amount of power created by the angular velocities of the hip, knee, and ankle joints working together in the push-off phase (Arabatzi, Kellis, & Villarreal, 2010). Implementing HC, which is a lift that creates explosive power with angular velocities, has similar effects over a six week period as a plyometrics workout without as much strain on the knees.
A good portion of the literature review was conducted on power output which is important for every SCC to learn how to improve in their athletes. Kawamori, Crum, Blumert, Kulik, Childers, and Wood (2005) concluded that the optimal load to generate the highest power output for a triple extension type lift, such as HC, would be one repetition of 70% max lift. While this may be true for peak power output, SCC’s have long used the overtraining principal to accomplish bigger gains. While the greatest power output was at 70% the athlete cannot make significant improvement by training one repetition at that intensity. At 90% only 100 watts of power output was lost which is not as significant when applied to the potential gains in strength and work capacity (Kawamori et al.). For this study athletes trained with the repetitions between three and six at 70% to 93% on HC and SQ to elicit the greatest strength gains so that their one repetition max would improve over the course of the six week period. The intensity standards followed for this study were based off of 83% of a max being commonly associated with six repetitions while 92% is associated with 3 repetitions. With the improvement in one repetition maximum in HC it is also perceived to have made significant gains in overall power output. The improvement in HC and VJ result in a perceived improvement in power output which has been cited in the review of literature to be closely related by Johnson and Bahamonde (1996) and Garhammer (1993).

Summary

The focus of the present study was an area where limited previous research had been conducted concerning the ability of high school athletes to
increase VJ without focusing on plyometric bodyweight exercises. The study utilized six high school weight training classes that performed three different workouts. The independent variables were the differences in the randomly selected three different groups. The control group referred to as SQG, performed six sets of SQ and showed very little improvement in VJ. The CSG performed three sets of HC and three sets of SQ and showed the best gains in VJ of any group at almost one and half inches per individual. The remaining HCG performed six sets of HC and showed good improvement at just over one inch per individual. Both the HCG and CSG were significantly better than the SQG and the CSG was better than the HCG.

Further Investigation

Many high school coaches continually look for ways to improve their athletes' athletic ability to be able to compete at a higher level. This study has outlined previous research that a good VJ has a strong correlation to being a good athlete. This study further outlines a strong correlation between adding HC to training and the improvement it can make on VJ. Future studies should include a HC post-test to see if the greatest improvements of VJ also correlated strongly with the greatest improvements of HC. Many of the younger less experienced athletes seemed to make more significant gains when compared to the 12th graders that had been performing resistance training for a longer period of time. It might be worthwhile to conduct the study on all previously untrained subjects such as a freshman physical education class. Or at the opposite end of the spectrum to administer the test on collegiate athletes that participate in a sport.
that involves jumping, such as volleyball or basketball, and have been resistance training for at least four years, but have never performed hang clean. Future research should account for the fact that most of the improvement seemed to take place in athletes that were not in season, while 12 of the 14 athletes who decreased in VJ were all currently in the middle of their season.

**Conclusion**

The implementation of HC into a structured resistance training program does seem to provide an increase in VJ when compared to the traditional resistance training program without HC. Completely replacing SQ with HC is not advised as the gains were not as significant as the combination of both exercises together. The thesis of this research is confirmed by the analysis of data. The practical application is for high school SCC to implement HC into their strength training programs to elicit greater gains in VJ, which has been implicated as an important factor in overall athletic performance.
References


TRANSMITTAL FORM

Student Name: Eric Scherfenberg
Graduate Degree Program: MS Kinesiology
Thesis Completion Date: August 14, 2012
Thesis Title: Implementing Hang Cleans For The Improvement Of Vertical Jump In High School Athletes

Print Name of Committee Chair
Chair Signature

Print Name of Committee Chair
Committee Signature

Print Name of Committee Chair
Committee Signature

DEPARTMENT APPROVAL:

Signature of Department Chair