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Implementing Hang Cleans for the Improvement of Vertical Jump in High School Athletes

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ABSTRACT

Scherfenberg E, Burns S. Implementing Hang Cleans for the Improvement of Vertical Jump in High School Athletes. **JEPonline** 2013;16(2):50-59. The focus of this study was to determine if adding hang clean (HC) to a structured weight training program can make an improvement in countermovement vertical jump (VJ). This study used high school athletes over a 6-wk period without incorporating any plyometric or jump training exercises. Six high school weight training classes performed strength training exercises 2 $d \cdot wk^{-1}$. All six classes performed the same upper body lifts and lower body auxiliary lifts. High school student athletes (n = 173) were randomly assigned to three groups. The control group (SQG) performed 6 sets of squat (SQ) in addition to the lifts that all classes performed. Another group (CSG) performed 3 sets of HC and 3 sets of SQ. The remaining group (HCG) performed 6 sets of HC and no SQ. Pre- and post-assessments of VJ were recorded at the beginning and at the end of the 6-wk study using a Vertec. The findings indicate a significant difference in VJ improvement between both the CSG (3.8 ± 4.2 cm) and HCG (2.7 ± 3.0 cm) when compared to the SQG (0.7 ± 2.2 cm). Thus, the study supported the hypothesis with larger gains in VJ height for athletes who performed HC over athletes who performed only the SQ. There was also a significant difference between the CSG and HCG leading to the recommendation to strength and conditioning coaches to implement HC equally with SQ to maximize VJ.

Key Words: Weight Training, Squat, Power

INTRODUCTION

High school coaches are always looking for ways to improve their athletes' fitness and performance so they can compete at a higher level. One of the ways that coaches measure short term speed and strength performance is the countermovement vertical jump (VJ). The countermovement jump can be aided by the arms, but must not involve a step. 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 extension of knee, hip, and ankle that generates force. A triple extension type exercise such as the hang clean (HC) 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. Different intensities of triple extension execises can have a profound effect on power output (15). Kawamori et al. (15) 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, determines the speed of the lift and the measureable peak power output.

In the 1950s weight training was introduced into high school and college athletic training programs with positive results including decreased injuries, and increased speed (18). Ever since then resistance training has remained an integral component for sports teams. Scientific investigations have shown that significant benefits such as increased power (5,6), kicking performance (25), vertical jump (4), overhead throwing velocity (24), and explosive strength (20) can be gained from the systematic and proper application of resistance-training principles (7,9,18,21). It has also been established that neurological adaptations are the primary cause for the improvement in strength within the first 3 to 4 wks of resistance training (5,6,19). Muscle hypertrophy (i.e., the increase in the size and function of muscle fibers), is commonly experienced 8 to 12 wks from the start of the training program (10,21,22).

The current study focused on training methods to increase VJ of high school athletes over a 6-wk period without incorporating plyometric training. There seems to be a lack of published studies using large groups of high school athletes with regard to weight training exercises that improve VJ. The information gleaned from this study could identify if HC or squat (SQ) are more likely to produce this desired result. The information may also help equip more high school strength and conditioning coaches (SCC) with the knowledge needed to properly train athletes in sports requiring high levels of VJ performance such as basketball and volleyball players. An improvement in the athletes' VJ should help maximize their athletic performance.

The mechanics involved in the HC are very similar to that of a VJ. According to the National Strength and Conditioning Association the HC mainly targets the gluteal and hamstrings during hip extension, the quadriceps during knee extension, the gastrocnemius and soleus during ankle plantar flexion, and the anterior and middle deltoids, biceps brachii, and coracobrachialis during shoulder flexion along with the trapezius and serratus anterior in protracting and elevating the scapula (17).

The first phase of the 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 the VJ (17). 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 the 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. The third phase of the 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 and/or abducted and elevated. The HC

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 athlete's 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, gluteal muscles, and core which are all active muscles in the VJ.

Hori et al. (13) identified means to measure power output concerning the hang power clean and the weighted jump squat and why measuring is so important. Power is the rate of doing work. It is calculated as work divided by time. 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. Muscular power is an important variable in athletic performances that require a large amount of force in a short amount of time. The continued development of power is an essential part of the athlete's training to reach his or her genetic potential (15).

The mechanical power output of the VJ generated a peak of 5782 ± 1123 watts in a study involving 69 male collegiate athletes and that if a person improves power output, then, he or she would likely increase VJ (14). Garhammer reported that in a world class 125 kg Olympic athlete who was attempting a 260 kg clean and jerk, the second pull phase of the clean generated an unprecedented 6981 watts (11). 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 (11). In a 75 kg athlete bench pressing 200 kg, the power output is only 343 watts and for a world class squat only about 1100 watts are generated (11). 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 (16).

The purpose of this study was to determine if the addition of the HC to the traditional high school weight training program would significantly increase the athletes' VJ when compared to a training program without the HC or one of the Olympic lifts or variations. Three hypotheses were generated for this study. First, there would be an increase in VJ in those who included the HC exercise compared to individuals who only did the SQ exercise. Second, there would be an increase in VJ in those who combined the HC and SQ compared to only SQ. Third, there would be an increase in VJ in those who replaced SQ with HC over those who included HC with SQ.

METHODS

This study was a pre-post test research design that focused on high school athletes and their ability to increase VJ without the overload of plyometric training. The pre-test baseline assessment of VJ was collected 3 days prior to the 6-wk weight training program. Post-test assessment of VJ occurred 3 days after the 6-wk program had concluded. Each testing session was conducted after a 10-min dynamic warm-up. After the dynamic warm-up the subjects performed three jumps with the highest of the three recorded for analysis. For consistency and reliability, the same SCC conducted all pre-test and post-test assessments of the VJ.

Subjects

The subjects included 173 (125 males, 48 females) high school student athletes in grades 10 through 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 athlete signed an assent form and their parent signed informed consent forms approved by the Institutional Review Board of the University of Central Missouri. Each class was a mixture of weight training experience, sport participation (football, soccer, tennis, cross-counttry, basketball, wrestling, swimming, track, and baseball), and athletic competence. While the sampling of the subjects was a convenience sample, the classes were randomly selected with two classes making up each of the three groups utilizing the fishbowl technique (i.e., a blind draw out of a bowl) (2). A week prior to the study all the subjects completed the demographic information form that included: name, gender, grade, race, and current sport participation.

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 used in the 6-wk training session. The Vertec is a common assessment tool that is used by many collegiate and high school athletic programs. It is a valid and reliable assessment tool (3).

The subjects were given several trials 1 wk before the study to help them become comfortable with technique. The pre-test of VJ for baseline data occurred 3 days prior to beginning the 6-wk training program. Each testing session was conducted after a 10-min dynamic warm-up. The subjects started the VJ measure stretched out in an upright position at the ankle, hip, and shoulder with the palm in contact with the Vertec to determine their standing reach.

After the dynamic warm-up, the subjects performed three jumps of which the highest of the three was recorded. During the final two sessions, the subjects performed 5 maximum repetitions on Bench, SQ, Deadlift, and HC. The 5 maximum repetitions were converted to projected 1 repetition max using a repetition conversion chart (8).

All three groups performed the same upper body lifts and lower body auxiliary lifts 2 $d \cdot wk^{-1}$ for 6 wks. Each workout was 80 min in duration, which included a 10-min standard dynamic warm-up, a 60-min weight training session, and a 10-min 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
- hop-hop-stick.

The warm-up exercises were performed for 30 sec followed by 30 sec of recovery. The squat group (SQG) performed 6 sets of SQ. It was deemed the control group because it appears the majority of high school SCC's use SQ in their program as their main lower body lift. The combination clean and squat group (CSG) performed 3 sets of the HC and 3 sets of the SQ exercise. The hang clean group (HCG) performed 6 sets of HC. All three groups performed each workout once a week with 2 days of rest in between workouts (see Tables 1 and 2 for sample workouts). The subjects' sleep and eating

habits were not monitored. All subjects participated in three nutrition lessons with the intention to educate and encourage right food choices.

Table 1. Clean Squat Group (CSG) Workout Day 1.

Exercise	Weekly Reps@%1RM						Sets	Rest
	1	2	3	4	5	6		
Hang Clean	6@70	6@75	5@83	4@87	3@90	3@93	3	4
Squat	6@70	6@75	5@83	4@87	3@90	3@93	3	4
Romanian Deadlift	12@50	12@55	10@60	10@65	8@70	8@75	4	3
Bench Press	6@75	6@79	5@83	4@87	3@90	3@93	4	3
***Pullups**	12	12	10	10	8	8	4	3

*Pullups are a difficult exercise to put a percentage to for a generalized program for multiple athletes. The reps 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 bands for assistance, while others may need to do weighted pullups so that they can only perform 12 repetitions.

Table 2. Clean Squat Group (CSG) Workout Day 2.

Exercise	Weekly Reps@%1RM						Sets	Rest
	1	2	3	4	5	6		
Hang Clean	6@70	6@75	5@83	4@87	3@90	3@93	3	4
Squat	6@70	6@75	5@83	4@87	3@90	3@93	3	4
Deadlift	12@50	12@55	10@60	10@65	8@70	8@75	4	3
Incline Bench Press	6@75	6@79	5@83	4@87	3@90	3@93	4	3
Bent Over Rows	12	12	10	10	8	8	4	3

Statistical Analyses

The data were recorded to within 1.3 cm accuracy with the vanes of the Vertec fixed by the manufacturer at those increments. The differences between the pre-test and post-test data were

calculated and analyzed for group differences to determine if the hypotheses were supported. To determine if there were differences among the three groups, a one-way ANOVA was used. Pairwise comparisons were done using a post-hoc Tukey's HSD. Alpha level of significance was set aprioi at 0.05.

RESULTS

The purpose of this study was to determine if including the HC in a structured weight training program would improve VJ. Each of the three groups had members that were not able to post-test due to injury. Therefore, they were eliminated from the study. The study started with 183 subjects. It ended with 173 subjects who completed the entire procedure. The reasons for removal were for injury (4), poor attendance (90% attendence required) (5), and moving out of district (1). To determine if the groups were equal before the 6-wk intervention, a one-way analysis of variance was conducted. The results indicated that the means for each group were not different $F(2,170) = 0.92$, $P>0.05$ (Table 3).

Table 3. Pre intervention VJ.

Group	N	Mean (cm)	SD (cm)
SQG	58	57.86	60.37
CSG	60	60.40	70.30
HCG	55	57.43	54.74

A one-way analysis of variance was conducted on group changes. It revealed there 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 supported because the two groups including the HC were significantly different from the SQG. Tukey's post hoc test determined a significant difference of average VJ improvement with both the CSG (3.8 cm) and HCG (2.7 cm) compared to the SQG (0.7 cm). There was also a significant difference between the CSG and HCG, which rejected the final hypothesis that replacing SQ with HC would result in higher VJ improvement.

Table 4. Vertical Jump Pre-Post Improvement.

Group	Mean (cm)	%>2.5 cm	%>5.0 cm
SQG	0.7 ± 2.2*‡	28	0
CSG	3.8 ± 4.2*‡	66	31
HCG	2.7 ± 3.0*‡	58	21

Note. Columns >2.5 cm and >5.0 cm represent percent of subjects in that group. *All pre-to-post mean improvements significant $P<0.05$. ‡Denotes all pairwise comparisons significantly different $P<0.05$

The greatest improvement was made by the CSG followed by the HCG and SQG having a modest gain in VJ at 0.7 cm, thus supporting the theory that implementing HC has a significant impact on VJ compared to traditional weight training programs.

Clean and Squat Group
Only one individual in the CSG had a nominally reduced VJ with a 1.3 cm decrease with the greatest improvement of 25 cm in a student athlete who played soccer. However, he had never participated in a weight training program. 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
Of the top ten subjects, 7 of them were not participating in a spring sport. The HCG had 3 subjects decrease their VJ ranging, which ranged from 2.5 to 3.8 cm. All of these subjects were in-season baseball players. The greatest improvement in this group was a subject who completed the study with a 11 cm improvement.

Squat Group
The SQG did not participate in HC and did not show the gains as great as the other two groups. The biggest gain a subject made in the group was a 3.8 cm improvement in VJ. The group finished with 10 subjects who produced a decrease in VJ.

DISCUSSION

The purpose of this study was to determine if including the HC in a structured weight training program would result in an improvement in VJ of a diverse group of high school athletes. The results indicate that there was a significant improvement for both the HCG and the CSG that included the HC in their workout. The SQG did not implement the HC and made 0.7 cm gain on average compared to over 2.7 cm and 3.8 cm for each of the other two groups. The athletes who participate in demanding sports tended to have a difficult time making gains in season. For some athletes in season the lack of gains may have been related to overtraining, not enough rest, or not keeping up with nutritional demands. On the opposite end of the spectrum it could be due to the athletes' failure to push themselves in the weight room. That is, they may not have fatigued themselves in anticipation of varsity competition that evening.

Vertical Jump and Power in Sports
Vertical jump has been directly linked to playing time for elite athletes (12). There is a correlation between the best athletes on paper and the most successful ones on the court and field for those who participate in sports that require muscular power. Plyometric training has been 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 (1). Implementing the HC exercise (a lift that creates explosive power with angular velocities) has similar effects over a 6-wk period as a plyometrics does, and the increased power is realized without as much impact on the knees or the risk of injury to the joints and related muscles.

Kawamori et al. (15) concluded that the optimal load to generate the highest power output for a triple extension type lift, such as the HC exercise, would be one repetition of 70% max lift. While this may be true for peak power output, SCC's have historically used the overload principal to accomplish bigger gains. While the greatest power output may be at 70%, athletes cannot make significant gains 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 (15).

For the present study, athletes trained with the repetitions between 3 and 6 at 70% to 93% on the HC exercise and the SQ exercise to elicit the greatest strength gains so that their 1 RM would improve over the course of the 6-wk period. The intensity standards followed for this study were based off of 83% of a max being commonly associated with 6 repetitions while 92% is associated with 3 repetitions. With the improvement in 1 RM in the HC, it is also perceived to have made significant gains in overall power output. The improvement in the HC and the VJ results in a perceived improvement in power output that has been previously studied as being closely related (11,14).

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 utilizing plyometric bodyweight exercises. Many high school coaches continually look for ways to improve their athletes' ability to compete at a higher level. This study has outlined previous research that a good VJ has a correlation with being a good athlete. It also provides a research base from which to support the addition of the HC exercise to regular strength training programs to improve VJ.

CONCLUSION

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

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REFERENCES

1. Arabatzi F, Kellis E, Villarreal E. Vertical jump biomechanics after plyometric, weight lifting, and combined (weight lifting + plyometric) training. ***J Strength Cond Res.*** 2010;24(9):2440-2448.

2. Baumgartner TA, Hensley LD. ***Conducting and Reading Research In Health and Human Performance.*** (4th Edition). Boston, MA: McGraw-Hill, 2006.

3. Caruso J, Daily J, McLagan J, Shepherd C, Olson N, Marshall M, Taylor S. Data reliability from an instrumented vertical jump platform. ***J Strength Cond Res.*** 2010;24(10):2799-2808.

4. Channell B, Barfield J. Effect of Olympic and traditional resistance training on vertical jump improvement in high school boys. ***J Strength Cond Res.*** 2008;22(5):1522-1527.

5. Cormie P, McGuigan M, Newton R. Developing maximal neuromuscular power: part 1—biological basis of maximal power production. ***Sports Med.*** 2011;41(1):17-38.

6. Cormie P, McGuigan M, Newton R. (2011). Developing maximal neuromuscular power: Part 2 -biological basis of maximal power production. ***Sports Med.*** 2011;41(2):125-146.

7. Duehring M, Feldmann C, Ebban W. Strength and conditioning practices of United States high school strength and conditioning coaches. ***J Strength Cond Res.*** 2009;23(8):2188-2203.

8. Epley B. ***Poundage Chart. Boyd Epley Workout***. Lincoln, NE: Body Enterprises, 1985.

9. Faignbaum A, Kraemer W, Blimkie C, Jeffreys I, Micheli L, Nitka M, Rowland T. Youth resistance training: Updated position statement paper from the National Strength and Conditioning Association. ***J Strength Cond Res.*** 2009;23(5):S60-S79.

10. Gabriel D, Kamen G, Frost G. Neural adaptations to resistive exercise: mechanisms and recommendations for training practices. ***Sports Med.*** 2006;36(2):133-149.

11. Garhammer, J. A review of power output studies of Olympic and powerlifting: Methodology, performance prediction, and evaluation tests. ***J Strength Cond Res.*** 1993;10(2):76-89.

12. Hoffman J, Tenenbaum G, Maresh C, Kreamer W. Relationship between athletic performance tests and playing time in elite college basketball players. ***J Strength Cond Res.*** 1996;10(2):67-71.

13. Hori N, Newton RU, Andrews WA, Kawamori N, McGuigan MR, Nosaka K. Comparison of four different methods to measure power output during the hang power clean and the weighted jump squat. ***J Strength Cond Res.*** 2007;21(2):314-320.

14. Johnson D, Bahamonde R. Power output estimates in university athletes. ***J Strength Cond Res.*** 1996;10(2):161-166.

15. Kawamori N, Crum AJ, Blumert PA, Kulik JR, Childers JT, Wood JA. Influence of different relative intensities on power output during the hang power clean: Identification of the optimal load. ***J Strength Cond Res.*** 2005;9(3):698-708.

16. Markovic G, Jaric S. Is vertical jump height a body size-independent measure of muscular power? ***J Sports Sci.*** 2007;25(12):1355-1363.

17. ***National Strength and Conditioning Association Certification Commission. Exercise Technique Manual for Resistance Training.*** (2nd Edition). Champaign: Human Kinetics, 2008.

18. Pearson D, Faigenbaum A, Conley M, Kraemer WJ. The national strength and conditioning association's basic guidelines for the resistance training of athletes. ***Strength Cond J.*** 2000;22(4):14-27.

19. Sale, DG. ***Strength Training in Children: Youth, Exercise and Sport.*** Indianapolis: Benchmark,1989.

20. Santos E, Janeira M. Effects of complex training on explosive strength in adolescent male basketball players. ***J Strength Cond Res.*** 2008;22(3):903-909.

21. Staron RS, Karapondo DL, Kraemer WJ, Fry AC, Gordon SE, Falkel JE, et al. Skeletal muscle adaptations during early phase of heavy-resistance training in men and women. ***J Appl Phys.*** 1994;76(3):1247-1255.

22. Tesch PA. Skeletal muscle adaptations consequent to long-term heavy resistance exercise**.** ***Med Sci Sports Exerc.*** 1988;20(5):132-134.

23. Todd T. Al Roy: The first modern strength coach. ***J Phy Edu Rec Dance.*** 2008;79(8):14-16.

24. Van den Tillaar R, Marques M. A comparison of three training programs with the same workload on overhead throwing velocity with different weighted balls. ***Sports Med.*** 2001;41(2):125-146.

25. Young W, Rath, D. Enhancing foot velocity in football kicking: The role of strength training. ***J Strength Cond Res.*** 2011;25(2):561-566.