Hang cleans and hang snatches produce similar improvements in female collegiate athletes

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ABSTRACT: Olympic weightlifting movements and their variations are believed to be among the most effective ways to improve power, strength, and speed in athletes. This study investigated the effects of two Olympic weightlifting variations (hang cleans and hang snatches), on power (vertical jump height), strength (1RM back squat), and speed (40-yard sprint) in female collegiate athletes. 23 NCAA Division I female athletes were randomly assigned to either a hang clean group or hang snatch group. Athletes participated in two workout sessions a week for six weeks, performing either hang cleans or hang snatches for five sets of three repetitions with a load of 80-85% 1RM, concurrent with their existing, season-specific, resistance training program. Vertical jump height, 1RM back squat, and 40-yard sprint all had a significant, positive improvement from pre-training to post-training in both groups ($p \leq 0.01$). However, when comparing the gain scores between groups, there was no significant difference between the hang clean and hang snatch groups for any of the three dependent variables (i.e., vertical jump height, $p=0.46$; 1RM back squat, $p=0.20$; and 40-yard sprint, $p=0.46$). Short-term training emphasizing hang cleans or hang snatches produced similar improvements in power, strength, and speed in female collegiate athletes. This provides strength and conditioning professionals with two viable programmatic options in athletic-based exercises to improve power, strength, and speed.

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INTRODUCTION

Strength and conditioning coaches routinely employ resistance training to enhance performance-based neuromuscular capabilities such as force and power. Resistance training improves one's ability to increase force and power through both neural and morphological adaptations. Neurologically, key adaptations include enhanced afferent neural drive, motor unit recruitment and firing frequency, contractile rate of force development (RFD), and contractile impulse at any time point [1, 2]. During rapid movements these adaptations allow for increased force and velocity (and therefore power) early in the force-time curve, key to optimal sport performance in activities like sprinting, jumping, and throwing. Morphologically, resistance training also induces adaptations that increase one's ability to generate force and power, such as increased cross-sectional area of muscle fibers, preferential hypertrophy of type II fibers, and a shift in fiber subtype expression (e.g., IIX to IIA) [3, 4].

Weightlifting exercises, such as the snatch and clean and jerk, are high force, high velocity movements that are routinely used in the training of athletes for increased strength and power [5, 6, 7]. Researchers have recognized that limited intervention research exists to support the effectiveness of these movements, especially in female athletes [6, 8-13]. However, despite the lack of scientific evidence, practitioners and researchers maintain a widespread belief that weightlifting exercises, and their variations (e.g., hang cleans and hang snatches), are highly effective at improving athletic performance [5-7, 10, 11, 14-16]. Practitioners and researchers hypothesize that due to their involvement of sport-related, explosive triple extension movements (i.e., hip, knee, and ankle), weightlifting exercises mimic specific requirements involved in athletic movements (e.g., rapid agility actions, sprinting, jumping etc.) [5-10]; and combined with weightlifting's ability to require an individual to exhibit high velocity against heavy loads while performing complex movement, suggests high potential for increasing RFD and transfer to sport performance [5-11]. Weightlifting variations, such as hang cleans and hang snatches, are derivatives of full weightlifting movements that also involve triple extension with high velocity, high force loads. These weightlifting variations are often used in strength and conditioning programs, as these movements likely achieve the same goals, yet require less time for the athlete to learn and become proficient [14, 17-20].

Of the many variations of weightlifting movements, the hang positions of the clean and snatch are considered to be the "power positions". Furthermore, it is well known that the highest peak power output and ground reaction forces occur during the explosive pulling phase (e.g., from the mid-thigh into triple extension, which also defines the hang position) [17, 19, 21-24]. In female athletes, the hang position has been shown to be faster and more power oriented than the more strength oriented first phase of the full pull [21-24]. For these reasons, many practitioners argue that hang cleans and hang snatches allow the athlete to produce a high rate of force development (RFD) and a high power output without completion of the more technical complete lift from the floor [14, 18-20, 25].

The purpose of this study was to address gaps in the literature related to weightlifting variations, since to our knowledge, despite widespread belief of efficacy, no previous studies have investigated performance outcomes from training that emphasized hang cleans or hang snatches in female collegiate athletes. We assessed the effects of six weeks of training, emphasizing either hang cleans or hang snatches, on the power, strength, and speed of female collegiate athletes. Using actual competitive female athletes who were participating in their sport-specific strength and conditioning programs allowed for the investigation of a "real-world" training scenario and helped place the results in context. We hypothesize that training with hang cleans or hang snatches will increase the athlete's power, strength, and speed. Furthermore, based on similar biomechanics [22] and relative loading, there will be no difference between the training groups.

MATERIALS AND METHODS

Subjects. Participants were 23 NCAA Division I female athletes from the teams of volleyball (n = 10) and softball (n = 13). Mean age was 20.1 ± 1.0 yrs (range = 18 - 22 yrs); mean mass was 73.6 ± 9.3 kg; mean height was 173.6 ± 8.6 cm. As in most collegiate teams, the athletes represented a range of training history; specifically, in this case, they had a certified strength and conditioning coach employed by the university who trained them in weightlifting, including specific training in hang cleans and hang snatches, with individual experience ranging from a minimum of 6 months to more than 4 years (i.e., from second semester freshman through senior status). This ensured that all participants had a training foundation for the specific movements used in this study. Participants were volunteers, and all signed informed consent forms approved by the University Institutional Review Board (IRB) prior to data collection. Permission was also obtained from all coaches prior to recruiting the participants for this study. Participants were asked to maintain their normal nutritional and recovery practices during the six-week intervention. However, no food logs or recovery diaries were used by participants in this study.

Procedures

Two different sports teams were used in this study to ensure adequate sample size. A matched pair process was used for group assignment to ensure that each group was closely balanced and had participant representation from each team. To do this, the randomization process was repeated individually for both the volleyball and softball teams, using initial vertical jump scores as the matching variable. Participants were divided into either the hang clean group (n = 11) or hang snatch group (n = 12) as follows: vertical jump height scores were rank ordered from highest to lowest within each team. Participants with the top two highest scores were then randomly assigned into the experimental groups. The third and fourth highest scores were then randomly assigned into groups, continuing until all participants were assigned. Vertical jump was chosen as the matching variable due to its practical relationship to power and simplicity in testing. Of note, after pre-testing, the groups were reassessed and no difference existed between groups in the dependent variables (vertical jump height, 1RM back squat, and 40-yard sprint). There was no control group that performed different weightlifting movements, since the sport coaches did not approve of having some athletes do a third type of programmed team training. We recognize this as a limitation.

Testing

Power, strength, and speed and were measured by the vertical jump, one-repetition maximum (1RM) back squat, and 40-yard (37 m) sprint test[26]. These dependent variables were chosen to represent sport-related targets for transfer of training from weightlifting movements. For all testing, participants warmed up according to their normal training program. Next, a countermovement vertical jump test using a Vertec (Sports Imports, Columbus, Ohio) was performed. Three maximal attempts were allowed, with 45 – 60 sec. rest between attempts; the highest jump score was used for analysis. Then, the 1RM back squat. For a successful attempt, the athlete had to break parallel (i.e., her hips had to go below her knees). Three to five maximal attempts took place, with three to four minutes between each maximal effort. For the 40-yard (37 m) sprint test, after warm-up each athlete ran a trial sprint with her next two sprints recorded. Three to four minutes of rest occurred between sprints. Time was recorded manually with a stopwatch by one test administrator experienced in manual timing of sprints. The average of two trials was recorded to the nearest 0.1 second.

All training and evaluation sessions were held in campus facilities under the instruction of the strength and conditioning coach. In order to ensure consistency and reliability with test administration, post-testing after the six week training program was identical to each participant's pre-test, including administrator, time of day, warm-up, environment, and facilities. The aforementioned dependent variables are all considered valid and reliable when following recommended testing protocols [26].

Training Programs

This study was carried out during the 2013 spring semester.Hang clean and hang snatch training sessions took place twice a week for six weeks, with a minimum of 48 hours between each session, totaling 12 training sessions for this study. During each session, athletes performed either hang cleans or hang snatches for five sets of three repetitions (5 x 3) at 80-85% 1RM as their primary movement, representing a volume and intensity that may enhance both strength and power simultaneously [5, 6, 16]. The 1RM was determined from prior testing by the strength and conditioning coach, who also monitored and adjusted the training load to maintain ~ 3 RM per set. The hang position started above the knee (midthigh) for both lifts, and the catch was employed for all repetitions (i.e., rack position in a quarter-squat with subsequent extension into a fully upright stance). Athletes were encouraged to be ballistic and move the loaded bar through the range of motion with maximal acceleration during each repetition. The volleyball team incorporated these sessions into their strength-based, off-season workouts (Table 1). The volleyball players also participated in routine individual and small group sport-specific practices two to three times per week. The softball team was approaching in-season training and their peak strength and maintenance workouts are reflected in Table 2. Softball team practices also took place five to six times per week. As previously mentioned, the groups were closely balanced with members of each team, thereby helping to control for differences in team-specific training prescriptions.

Statistical Analysis

The three dependent variables in this study (i.e., vertical jump height, 1RM back squat, and 40-yard sprint) were compared pre- and post-training with a dependent t-test. A gain score was also calculated for each dependent variable (post-pre training intervention). Dependent variable gain scores were then compared between each group with an independent t-test. Statistical significance was set at $p<0.05$.

TABLE 1. Volleyball Training for Weeks 1 – 6 (exercises, sets x repetitions)

Day 1	Day 2	Day 3
Hang Clean or Snatch* 5 x 3	Hang Clean or Snatch* 5 x 3	BB Rev. Lunge 3 x 8 w/DB Bench 3 x 15
Bench Press x 3, 3, 10, 8, 6, 4 w/Chinup	Front Squat x 3, 3, 10, 8, 6, 4 w/Hip Stretch	Pullup 3 x 15 w/RDL 3 x 10
S-Arm DB Bench 3 x 10 w/Ring Row 3 x 10	Bulgarian DL 3 x 6 w/Pistol Squat 3 x 6	S-Arm OHP 3 x 10
External Rotation 2 x 6	Hamstring Slider 2 x 10	S-Leg DB Row 3 x 10
Face Pull 3 x 15	TKE 2 x 10	3-Way DBR 3 x 10

Note: * depending on group assignment; BB=barbell; DB=dumbbell; S=single; DL=deadlift; RDL=Romanian DL; TKE=terminal knee extension; OHP=overhead press; DBR=DB raise

TABLE 2. Softball Training for Weeks 1 – 6 (exercises, sets x repetitions)

Day 1	Day 2	Day 3
Weeks 1 - 2		
Hang Clean or Snatch* 5 x 3 Bench Press x 3, 3, 2, 2, 2 Chinup 4 x 6 Push Press 3 x 8 w/DB Row 3 x 6 BB Rollout 3 x 10	Hang Clean or Snatch* 5 x 3 Front Squat 5 x 3 Glute/Ham Raise 4 x 6 DL 3 x 5 w/Bulgarian Split Squat 3 x 5 Toes to Bar 3 x 10	Broad Jumps 5 x 3 Squat x 2, 2, 1, 1, 1 RDL 4 x 6 DB Lat. Lunge 3 x 8 DB Rev. Lunge 3 x 6 Med. Ball Toss 3 x 8
Weeks 3 - 4		
Hang Clean or Snatch* 5 x 3 Squat 4 x 3 Bench Press 4 x 3 w/Chinup 4 x 5 BB Rev. Lunge 3 x 5 w/Bar Rotation 3 x 10	Hang Clean or Snatch* 5 x 3 DL 4 x 3 w/Pullup 4 x 5 Push Press 3 x 6 w/DB Stepup 3 x 6 DB Crawl 3 x 20m	NA
Weeks 5 - 6		
Hang Clean or Snatch* 5 x 3 Squat 4 x 4 Incline Press 4 x 3 w/Pullup 4 x 5 BB Rev. Lunge 3 x 5 w/Bar Rotation 3 x 10	Hang Clean or Snatch* 5 x 3 DL 4 x 3 w/Bench Press 4 x 5 Front Squat 3 x 4 w/DB Stepup 3 x 6 Overhead Press 3 x 5 w/Toes to Bar 3 x 10	NA

Note: *depending on group assignment; BB=barbell; DB=dumbbell; DL=deadlift; RDL=Romanian DL.

TABLE 3. Group Scores on Vertical Jump, 40-yard Sprint, and 1RM Back Squat.

	Pre	Post	Gain
	Vertical Jump (cm)		
Snatch	52.3 ± 8.6	57.2 ± 8.6	5.1 ± 3.3*
Clean	51.3 ± 7.4	56.4 ± 7.4	5.1 ± 1.8*
	40-yard Sprint (sec)		
Snatch	5.81 ± 0.32	5.60 ± 0.30	-0.20 ± 0.25*
Clean	5.93 ± 0.31	5.72 ± 0.31	-0.21 ± 0.25*
	1RM Back Squat (kg)		
Snatch	78.4 ± 11.4	84.9 ± 11.7	6.5 ± 3.2*
Clean	81.4 ± 9.6	88.9 ± 9.2	7.5 ± 2.4*

Note: *significantly different pre to post, p≤0.01, with no difference in gain scores between groups

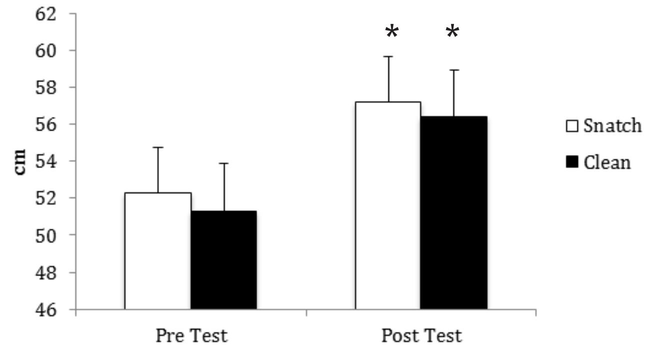

FIG. 1. Vertical jump height scores (cm) for each group.
Note: * Significant improvement from pre-training to post-training, p≤0.01.

Assuming an effect size of 1.2 standard deviations is meaningful, a statistical power of .76 can be achieved with 11 participants per study group [27].

RESULTS

Twenty-three female athletes participated (hang clean group, n = 11; hang snatch group, n = 12). At pre-test, no difference existed between the groups in age, mass, or height, nor (as previously stated) in the dependent variables (vertical jump height, 1RM back squat, and 40-yard sprint). Results indicated a significant, positive improvement from pre-training to post-training for both groups in vertical jump height, 1RM back squat, and 40-yard sprint (p≤0.01) (Figures 1-3). When comparing the gain scores between each group, there was no significant difference between the hang clean and hang snatch groups for any of the three dependent variables tested (vertical jump height, p=0.46; 1RM back squat, p=0.20; and 40-yard sprint, p=0.46) (Table 3).

DISCUSSION

This study investigated the effects of two movement variations of weightlifting (i.e., hang cleans or hang snatches), on power, strength, and speed in Division I female collegiate athletes. Original predictions were that six weeks of either hang clean or hang snatch training would significantly increase the athlete's power, strength, and speed. Our results support this hypothesis, hang cleans and hang snatches appear to be approximately equal in effectively improving vertical jump (± 9.9%), 1RM back squat (± 8.8%), and 40-yard sprint (- 3.5%). These results may potentially help practitioners make science-based decisions in training design when attempting to optimize outcomes related to power, strength, and speed in a wide-range of female athletes in terms of training experience, proficiency, and training phase. As previously stated, limited research exists on outcomes related to weightlifting movements, such as hang cleans and hang snatches [5,

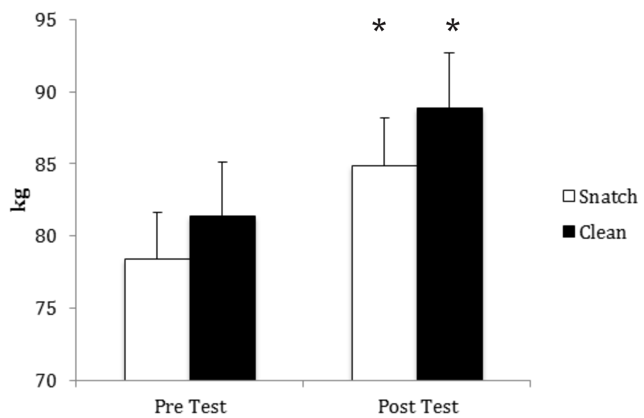

FIG. 2. 1RM back squat scores (kg) for each group.
Note: * Significant improvement from pre-training to post-training, p≤0.01.

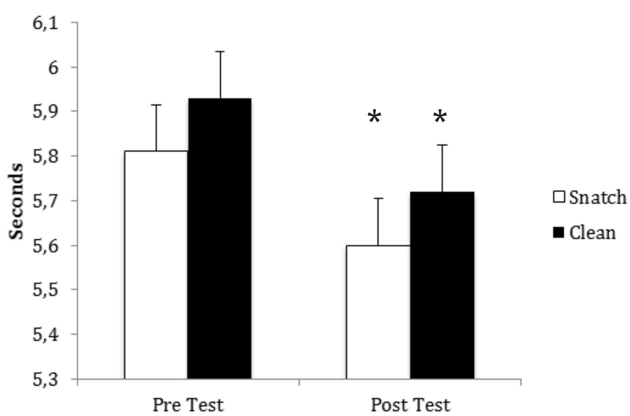

FIG. 3. 40-yard sprint scores (seconds) for each group.
Note: * Significant improvement from pre-training to post=training, p≤0.01.

6, 8-13, 28]. Specifically, a review of the literature revealed no studies on the effects of hang cleans or hang snatches on power, strength, and speed in Division I female athletes. However, in agreement with other generalized weightlifting research [8, 9, 12, 13], expert opinion [5-7, 10, 11, 14, 16, 29-33], and biomechanical observations [21, 22], our results support that hang cleans and hang snatches, performed over the short term with the same relative loads, offer similar potential for significant improvements in power, strength, and speed in female collegiate athletes. Both movements require high force at high velocity, are ballistic, require a high RFD, and have similar biomechanics and acceleration profiles as many athletic actions such as jumping and sprinting [4-7, 9, 12, 13, 15, 28]. Training intensities of both lifts can also span a wide range of the force-velocity curve, which is critical to optimizing both the force and velocity components of power [4, 6, 7, 10, 11, 16].

In their writings, O'Shea [11] and others [4-10, 12, 16, 28,33] routinely discuss the relationship of these athletic-type full body lifts to explosive-based athletic performance involving strength, speed, and power, and this study supports their contentions. Combined with mental focus by the athlete on the intent to be ballistic and accelerate through the entire range of motion, our results support the high potential for transfer of this type of training to athletic performance [5-7, 10-14, 18, 19, 28, 33].

Regarding possible limitations, first, as mentioned earlier, the lack of a control group limits interpretation of the results. Second, this was a six-week study that focused on a narrow window of time representing a typical strength and conditioning training block; longer term training may reveal different results. As previously stated, this study was conducted during real-world, university-based, competitive training and as such had limitations in duration, secondary movements, etc. Third, both teams were in different parts of their training year, incorporating the added movements during appropriate phases of their program [6]. While primary exercises were similar, secondary exercises had some variation between teams. The authors believe this limitation was practically addressed by the balanced training groups in both team composition and performance measures. Each training group had equal representation from the two teams who participated in their specific team's supplemental training and were matched in the dependent variables. A fourth limitation may be maturation, due to each athlete being at different levels of physiological development (e.g., second semester freshman to senior). Per this, our results demonstrate the possible effectiveness of hang cleans and hang snatches in improving athletic-based performance outcomes despite individual training history. Finally, assessing the magnitude of strength changes for the two weightlifting variations would have also helped elucidate possible meaning of this short term study.

Practically speaking, our results support hang cleans and hang snatches as valid choices for the strength and conditioning coach to utilize when designing short-term training cycles for potentially increasing power, strength, and speed in female collegiate athletes. Since increases in power, strength, and speed were similar between movements, either variation may be used interchangeably in the training program. Practitioners who favor one movement over the other may feel more comfortable in their training choice; and this study supports flexibility in choice as merited. For example, if an athlete has difficulty mastering the skills of a specific weightlifting exercise, they can focus their efforts on the variation they feel more comfortable and confident with performing; which may ultimately provide an atmosphere more conducive to technical proficiency. This means that training of the athlete may optimize transfer of performance improvements from practice to competition.

CONCLUSIONS

To our knowledge this is the first study to demonstrate the athletic-based performance responses of Division I female collegiate athletes to a short-term training program emphasizing either hang cleans or hang snatches. Our results demonstrate the significant positive effects this type of weightlifting training may have on power, strength, and speed. Though only volleyball and softball athletes participated in this study, it is reasonable to presume that these findings may be applied to female athletes of all sports which require power, strength, and speed. More research is merited to support this notion of athletic transfer of power, strength, and speed between multiple sports. Thus we suggest that future studies on weightlifting training employ a control group, compare weightlifting variations to the full weightlifting movements, assess the effects of the catch, monitor nutrition and recovery practices, use athletes in similar phases of training and competition, and add pre- and post-testing on measures such as RFD, body composition, and the changes in the specific lifts utilized.

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