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Research Article

Comparison of Deadlift Versus Back Squat Postactivation Potentiation On Vertical Jump

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Abstract

Strength coaches are searching for the best ways to train athletes to be bigger, faster, and stronger in order to increase performance. A unique form of training is to invoke postactivation potentiation whichis based on the premise of performing a heavy resistance exercise followed by anexplosive exercise, resulting in increased power performance. Back squats are normally used, but a less researched tool is the hex bar deadlift. Therefore, the purpose of this study was to compare the potentiating effects of back squats vs. hex bar deadlifts on vertical jump performance. Twenty resistance-trained men (age = 22.15 ± 2.66 yrs, ht = 178.10 ± 7.20 cm, mass = 78.91 ± 8.67 kg) volunteered to participate and performed 3 pre countermovement jumps then 3 repetitions of back squat or hex bar deadlift at 85% of their 1-repetition max. To perform the countermovement jump, subjects jumped with arm swing on a force plate. The back squat was performed with a standard barbell in a power rack with a safety squat device to insure a thigh parallel positionwhile the hex bar deadlift was performed using the low handles without straps. Following the lifts, subjects rested 8 minutes then performed 3 post countermovement jumps. A control condition consisted of 3 pre countermovement jumps, 8 minutes of standing rest, then 3 post countermovement jumps. For jump height, there was an interaction of condition x time where the control (pre 62.17 ± 7.48cm, post 60.90 ± 7.17cm) and squat (pre 62.33 ± 7.57cm, post 60.87 ± 7.42cm) conditions resulted in significant decreases in post vertical jump with no difference for deadlift (pre 61.54 ± 7.14cm, post 61.47 ± 7.73cm). Performing a hex bar deadlift mainained vertical jump compared to a heavy back squat and may be preferential for acute performance. Careful manipulation of critical variables is paramount to eliciting postactivation potentiation.

Keywords

Choice of exercise; Ground reaction force; Impulse; Peak power

Introduction

Coaches are searching for the best way to train their athletes to be bigger, faster and stronger. Research is also investigating new ways to manipulate training to produce an increase in performance. Vertical jumping is important in numerous sports such as volleyball, basketball, soccer, as well as others using triple extension for power production. It is also used as a test of lower limb power. One unique form of training in regards to power is Postactivation Potentiation (PAP) which has been largely researched in regards to heavy resistance with back squats [1-3].

The phenomenon of PAP is based on the premise of performing a heavy resistance exercise, followed by anexplosive exercise. The mechanism behind PAP has been postulated asincreased phosphorylation of the regulatory light chains of myosin, a Ca^{2+} dependent process [2,4-7]. Thereby, muscular performance is enhanced acutely after a relatively high intensity activity [5,8,9]. Training status, rest periods, volume and intensity have all been shown to affect PAP. In addition, Chiu et al., [5] found that force and power parameters were enhanced for athletes when compared to recreationally trained individuals. Previous research has also shown vertical jump to increase with PAP [2,9,10].

The back squat is one of the most commonly used training exercises performed by fitness enthusiasts, and athletes. Manipulation of critical variables, including subject population, has shown that PAP is more robust in athletes compared to non-athletes [5]. Numerous previous studies have used the back squat as an exercise to elicit PAP [2,5,11,12]. However, little research has investigated the deadlift exercise on PAP.

Traditionally deadlifts are performed with a standard barbell, but research has demonstrated that use of a hex bar results in greater force, power, and Rate of Force Development (RFD) and more highly correlated with a vertical jump due to similar body positions [13,14]. Performance of hex bar deadlift keeps the load close to the center of mass enabling athletes to closely reproduce the bottom position of a vertical jump [13]. Whereas holding the load on the top of the shoulders for a squat requiresa more upright torso. Additionally,prior work has shown that use of a hex bar deadlift resultsin greater increases in vertical jump performance [3,15]. Therefore, the purpose of this study was to compare the potentiating effects of back squats vs. hex bar deadlifts on vertical jump performance.

Materials and Methods

All procedures were approved by the University Institutional Review Board for human subjects. Participants signed an informed consent prior to testing, and were asked to refrain from lower body resistance exercise 48 hours prior to each session.

Participants

Twenty male recreational basketball players between the ages of 20-29yrs (age=22.15 ± 2.66yrs, ht=178.10 ± 7.20cm, mass=78.91 ± 8.67kg) volunteered.Their training experience in the weight room ranged between 1-3 times per week for the previous 6 months to 2 years.They completed a total of five testing sessions separated by 48-72 hours over a 3-week period.

On day one, participants were measured for height and mass using a stadiometer (752KL, Seca; Ontario, CA, USA) and a digital scale (ES200L; Ohaus Corporation Pinebrook, NJ, USA). They then performed a dynamic warm-up consisting of alternating leg swings, knee pulls, and walking lunges, twice for a distance of 10 meters. Day one also involved testing baseline Countermovement Vertical Jump (CMJ), and One Repetition Maximum (1RM) of either Hex Bar Deadlift (HBDL) or high bar Back Squat (BS). Following 1RM testing they were familiarized with BS or HBDL. Subjects were familar with CMJ and BS, but less so with the HBDL.

Countermovement vertical jump

Participants stood on an AMTI force plate (Advanced Mechanical, Inc., Watertown, MA, USA), sampling at 1000Hz which was interfaced with custom Lab VIEW (version 2014, National Instruments, Austin, TX USA) data collection and analysis software. They performed a countermovement to a self-selected depth then maximally jumped as high as possible with arm swing and touched the highest vanepossible. Jump height was assessed pre and post on days 1, 3, 4 and 5. A jump station (EPIC device) was used to measure height for the CMJ.

Days 1 and 2: 1RM testing

The BS was performed using a standard barbell (placed at C7) inside a power rack. Participants started by warming up with 10 repetitions at 50% of their predicted 1RM, 5 repetitions at 70%, 3 repetitions at 80%, and one repetition at 90%, each followed by 2 minutes rest. Three to five attempts were performed to determine 1RM. If they successfully completed the repetition, weight was increased by 5-20 pounds. If they were not able to complete the lift, weight was reduced by 5-10 pounds. The same procedures were used for the HBDL (low handles, no straps). Participants had to stand fully erect with knees locked for the lift to be considered successful. For the BS, participants wore an electronic device (Safety Squat; Bigger Faster Stronger, Salt Lake City ,UT) wrapped around their right quadriceps. When a beeping noise was heard it meant they had reached the quads parallel position. This device was used for the entire study and the squat was not successful if they did not reach the parallel position. 1RM tests were counterbalanced on days 1 and 2.

Day 3, 4, and 5: Experimental trials

Participants returned after 48-72 hours rest and performed the same dynamic warm-up as day one. Then, 3 pre-CMJ were measured followed by 3 repetitions at 85% of either HBDL or BS. Eight minutes standing rest [16] was then given followed by 3 post-CMJ. A control condition consisted of 3 pre-CMJ, 8 minutes standing rest, then 3 post-CMJ. Conditions were counterbalanced across days.

Statistical analyses

ICC for CMJ was 0.98. Previous work [15] has shown ICC for HBDL and BS were between 0.8 and 0.98. Multiple 2x3 (time x condition) repeated measures ANOVAs were performed to determine differences for each variable with dependent t-tests used for post-hoc comparisons. Normality and homogeneity of variance were satisfied for all analyses. Dependent variables

	Control		Hex Bar Deadlift		Squat		Grand Means	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
EPIC jump HT (cm)	*62.17 ± 7.48	60.90 ± 7.17	61.54 ± 7.14	61.47 ± 7.73	*62.33 ± 7.57	60.87 ± 7.42		
Force platejump HT (cm)	45.94 ± 6.63	43.83 ± 6.46	45.72 ± 7.21	44.61 ± 7.21	46.10 ± 7.29	44.69 ± 7.42	*45.92 ± 6.86	44.37 ± 6.79
Impulse (Ns)	247.39 ± 26.14	242.99 ± 28.02	245.52 ± 26.22	243.65 ± 26.22	246.50 ± 28.26	240.89 ± 22.73	*246.47 ± 25.74	242.51 ± 24.18
Take-off velocity (m/s)	2.93 ± 0.22	2.88 ± 0.24	2.92 ± 0.21	2.91 ± 0.26	2.92 ± 0.20	2.87 ± 0.21	*2.93 ± 0.19	2.88 ± 0.19
Peak power (W)	5129.55 ± 662.09	4652.77 ± 675.47	5098.26 ± 629.37	5065.12 ± 766.91	5180.53 ± 719.50	5002.63 ± 630.49	*5136.12 ± 621.92	5010.17 ± 626.39
Relative GRF (N/kg)	15.80 ± 2.72	15.43 ± 2.61	15.76 ± 2.68	15.67 ± 2.95	15.95 ± 2.80	15.61 ± 2.90		

Table 1: Means and standard deviations of all variables by condition and time. Grand means arethe averages of pre and post collapsed across groupwhen there are main effects for time. *Greater than post.

were EPIC jump height, force plate jump height, impulse, take off velocity, peak powerand relative ground reaction force. Effect Sizes (ES) were calculated for significant outcomes. All analyses were performed with SPSS 21.0.

Results

For EPIC jump height, there was an interaction of condition x time (F=4.528, p=0.018). This was followed up by three dependent t-tests comparing pre and post for each condition which demonstrated a significant decrease in post vertical jump for the control (t=3.394, p=0.003, ES=0.17) and squat conditions (t=3.523, p=0.002, ES=0.19) with no difference for deadlift (t=0.228, p=0.822, ES=0.01) (Table 1). There were no interactions (all p>0.124) but there were main effects for time (all p<0.05) where post-hoc tests demonstrated a significant decrease in postforce plate jump height (F=34.025, p=0.000, ES=0.22), impulse (F=11.568, p=0.003, ES=0.15), take-off velocity (F=14.079, p=0.001, ES=0.26) and peak power (F=7.614, p=0.012, ES=0.20) (Table 1). For relative ground reaction force, there was no interaction (p=0.612) or main effects for time (p=0.075) or group (p=0.763) (Table 1).

Discussion

The purpose of this study was to compare the potentiating effects of back squats vs. hex bar deadlifts on vertical jump performance. The major findings were that post jump height decreased for the back squats and control conditions with no change following hex bar deadlifts while impulse, take-off velocity, and peak power decreased at post for all conditions. Possible reasons for this may be due to manipulation of critical variables such as training status, intensity, volume, rest period, and exercise choice.

Postactivation potentiation results in an acute increase in muscular power following a heavy preload stimulus (i.e., BS or HBDL) which is due to phosphorylation of myosin regulatory light chains and/or increased recruitment of higher order motor units [16]. However, there is a balance between PAP and fatigue which is modulated via operational mangement of the aforementioned critical variables [1,5,10].

Training status is an important factor for PAP [1,4,5,13,16]. Chui et al. found that athletic individuals responded with greater PAP compared to those who were recreationally trained. However, Batista et al., when considering only strength training background, concluded it had no influence on PAP. There was no PAP effect for any of the conditions in the present study.However, previous studies have shown PAPto be highly individualized [1,17,18]. Jo et al. examined the effects of recovery duration after a potentiating stimulus on muscular power in recreationally trained individuals and saw that stronger subjects were able to potentiate with lest rest whereas weaker subjects required more rest [1]. McCann et al. also found PAP to be highly individualizedas they saw that some potentiated greater with the squat and some with the clean exercise [17]. Additionally, some responded greater with 5-min rest and some with 4-min rest. Therefore, when trying to induce PAP, training experience and athletic ability should be considered for optimization. The recreational basketball playersin the present study had a large variety of training experience and strength levels which might have masked any PAP effects.

Intensity can also influence PAP and several studies have shown that heavy loaded squats fail to produce PAP in recreationally trained individuals [1,4-6,8,19,20]. In contrast, Weber et al. examined the acute effects of a heavy load back squat at 85% 1RM in track and field athletes and found they were able to potentiate their squat jump performance. A meta-analysis of PAP [15] documented significant differences between moderate intensity loadsof 40-60% 1RM and heavy intensities greater than 85% 1RM. Arias et al. [20] examined the acute effects of heavy deadlifts on vertical jump performance in recreational men and found that 85% 1RM did not induce PAP, and caused an acute reduction in vertical jump performance. These studies demonstrate that an intensity of 85% may or may notelicit PAP across different populations. An intensity of 85% was chosen for this study, but training experience of the recreational basketball players could explain the lack of positive findings.

Manipulation of volume is also critical when trying to elicit PAP [6,7,9,11,15]. Khamoui et al. examined the effects of volume in a back squat at 85% 1RM on vertical jump parameters in recreationally trained men and found they were not able to potentiate after performing one set of 2, 3, 4, or

5 repetitions.Wilson et al., in a meta-analysis [15], found that multiple sets were more effective than single sets to optimize PAP. However, Crewther et al. [11] examined the acute potentiating effects of back squats on vertical jump, and found that a single set at 3RM significantly improved performance at 4, 8, and 12 minutes post compared to baseline in sub-elite male rugby players. Mitchell et al. [7] examined the effects of a 5RM back squat in rugby athletes and found that vertical jump height increased when a twitch was evoked followed by 4 min rest, then a 5RM squat, and then another 4-min rest. These studies demonstrate that PAP is highly dependent on volume.Based on the existing literaturethat has demonstrat-edbothsingle and multiple sets effective for PAP, we chose to use a single set of 3 repetitions. However, studies that have previously shown single sets effective utilized sub-elite or athletic individuals. Again, training status of the recreational basketball players in the present study may have masked any positive outcomes.

Rest is often the forgotten variable, but it has an important role in PAP [10,12,15,17,18]. Mola et al. [18] investigated the optimal recovery time to elicit PAP following a bout of high-intensity 3RM squatsin professional soccer playersfollowed by countermovement jumps at 4, 8, 12, 16, and 20 minutes of rest, and found no potentiation. Kilduff et al. [12] also examined optimal recovery time following a 3RM bench press or squat followed by countermovement jumpsat 4, 8, 12, 16, and 20 minutes of rest. They found that 8-12 minutes rest was adequate recovery to produce PAP for lower body and 12 minutes for upper body. PAP is the balance between fatigue and performance. Following heavy resistance exercise, fatigue exceeds PAP and performance is decreased. However, following adequate rest, PAP exceeds fatigue and performance is enchanced [1,21]. A meta-analysis [16] found that moderate rest periods between 7-10 minutes demonstrate the greatest PAP results following a heavy overload stimulus. Therefore, the present study used 8 minutes standing rest after the preload stimulus in an effort to maximize PAP. Depending on their training level some subjects might not have recovered adequately to minimize fatigue and enhance performance. In contrast, rest may have been too long in the control condition, thus allowing muscle cooling and performance to decrease.

Choice of exercise also plays an important role in the production of PAP. Previous research has shown that back squatsare the exercise of choice for PAP related to vertical jumping [7,9,11,19]. However, very little research has been done using the hex bar deadlift. Arias et al. [20] investigated the PAP effects of heavy deadlifts on vertical jump after resting for 15s, 2, 4, 6, 8, 10, 12, 14, and 16 minutes and found no PAP at any time point. Swinton et al. [16] examined the effects of load position on the kinematics and kinetics of weighted vertical jumps in rugby union athletes who performed maximal jumps with the barbell on their shoulders or used a hex barbell at 0, 20, 40, and 60% of their squat 1RM. The hex bar resulted in greater jump height, peak force, power, and peak RFD. In theirstudy, greater peak power was produced with the hex barbell using a load of 20% 1RM, whereas the present study used 85% 1RM.

Conclusion

Proper and careful manipulation of the critical variables associated with PAP is of paramount importance to elicit an effect. Research has yet to determine the perfect combination of exercise choice, volume, rest time, intensity and training status to consistently produce PAP. In the present study, with recreationally trained basketball players, 85% 1RM back squats or hex bar deadlifts failed to increase acute vertical jump performance, however, deadlifts maintained jump height. Therefore, future research should continue to investigate the best combination of critical variables to elicit PAP.

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