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The Acute Effects of Loaded Jump on Vertical Jump and Perception of Performance

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ABSTRACT

The purpose of the study was to investigate whether performance and perception of the vertical jump (VJ) are acutely impacted by application of an external load. Sixteen subjects (age 20.56±0.73 years, mass 77.44±18.26 kg) completed three testing sessions following the same procedures. Subjects completed a 5-min warm-up and performed three sets of five VJ. The first (CON) and last five jumps (PT) were completed without an external load. During the second set of jumps, subjects wore a weighted vest (WV) corresponding to 5, 10 or 15% of body mass (kg). A 15-s rest was given between each jump and a 30-s rest was allowed between each set of jumps. VJ height, average power, average velocity, and the perception of subjects' own performance were measured. The results of the two-way ANOVA with repeated measures yielded a significant ($P < .05$) interaction for all variables. No significant difference was found between conditions (5%, 10%, or 15%); however, there was a significant effect for time (CON, WV, and PT). VJ displacement, average power, and average velocity were significantly higher during the PT than the CON and WV and the WV was significantly lower than the CON. All subjects perceived they jumped higher and felt lighter during the PT while wearing the 10% and 15% WV. Whereas, only 75% subjects reported feeling lighter and jumping higher while wearing the 5% WV during the PT. Performing a VJ with external load can increase acute vertical jump height, average power and velocity following the removal of the load.

Keywords: Weighted vest, power, velocity, external load, performance perception, post-activation potentiation

INTRODUCTION

Vertical jump (VJ) is known to be a major component in a multitude of sports, including basketball, volleyball and football (Chattong et al. 2010). The VJ is not only a skill within certain sports, but it is an integral part of training and performance testing for many sports. The ability to increase one's VJ can translate to improvement in their sport and specific performance testing. Therefore, it is important to investigate factors that may impact the performance of the VJ.

Previous research has suggested the completion of a warm-up prior to activity has resulted in performance improvement as such, various warm-up protocols have been tested to determine which type of warm up can translates to performance improvements on the VJ. For instance, Burkett et al. (2005) reported that the completion of a weighted countermovement jump significantly improved VJ height. Further, this study found that VJ performance was not impacted by the completion of a stretching or submaximal jump warm-up (Burkett et al. 2005). On the contrary, the findings of Chattong and colleagues (2010) found that weighted countermovement jumping warm-up did not improve VJ performance. Rather their results suggested the use of a regular warm-up prior to testing the VJ was more beneficial (Chattong et al. 2010).

The benefits of using of a weighted or loaded warm-up prior to the VJ have been associated with the post-activation potentiation (PAP) effect (Chattong et al. 2010). While the exact mechanisms of the PAP theory are not fully explained, it is thought performance is improved due to the muscle's previous activity and contractions (Chattong et al. 2010). The stimulation of the muscle, at a higher intensity, prior to the

performance of an explosive movement can increase the recruitment of motor units and the muscles' contractile properties (Lorenz 2011). Due to the resistance applied during the warm-up, muscle fiber recruitment and force production is increased; the muscle is able to have a "carry-over" force production effect into the next activity.

Prior studies investigating PAP have shown an increase in performance when combining resistance to dynamic and explosive activities similar to jumping (Chattong et al. 2010). McBribe et al. (2008) reported loading the eccentric phase of a movement resulted in increased muscular force output during the concentric phase. In another study, it was found that a combination of weight training and jump training showed a significant increase in the vastus lateralis and vastus medialis recruitment (Toumi et al., 2004). Increased muscle recruitment can lead to an increase in performance, particularly in a skill such as the VJ. More recently, Arazi et al. (2018) focused on the effect of various weight training programs on VJ performance of volleyball players. It showed that a cluster set resistance training program, which allows for more weight and repetitions with more rest periods in between repetitions, accounted for a larger increase in VJ performance (Arazi et al. 2018).

The use of an external load has been shown to increase performance in sports such as baseball and softball. It is thought the perception of heaviness may impact performance of a sport skill (Otsuji et al. 2002). Perception of performance can influence the confidence in performing a sport or skill, suggesting the advantage of performing a loaded task prior to the actual task may be more psychological than mechanical (Otsuji et al. 2002). For instance, subjects in that study reported they thought the bat swing felt lighter and faster after a weighted ring was removed from the bat. However, results showed that bat speed actually decreased by 3.3% following the removal of the load (Otsuji et al. 2002).

There is minimal research investigating the use of weighted warm-ups completed with incremental external loads during the VJ. More specifically, previous research has used loaded or unloaded box jumps to excite the muscle (Burkett et al. 2005) and limited research has investigated the use of a weighted VJ warm-up prior to the performance of a VJ test. Further, the subject's perception of the loaded warm-up may possibly alter the performance of the VJ. Thus, the purpose of this study was to investigate whether performance and perception of the VJ is influenced by using a loaded warm-up prior to the performance of the VJ. It was hypothesized that the use of an incremental weighted warm-up may result in improvements of the VJ. Further, the subject's perception of the load may positively impact VJ height when the load is removed.

METHODS

Subjects

Seven female and 9 male college-aged individuals (age 20.56±0.73 years, mass 77.44±18.26 kg) were recruited to participate in this study. All subjects were required to be classified as physically active, defined as participating in exercise/physical activity three or more days a week for at least 30 min, based off of American College of Sports Medicine guidelines. Two participants engaged in resistance exercises only, one participant engaged in cardiovascular exercise while 13 other participants engaged in both resistance and endurance training. Exclusion criteria included: sedentary lifestyle, collegiate athletes, and anyone with an injury to the lower back and legs within the past year. Each subject read and signed an informed consent form approved by Shippensburg University IRB before participation. Subjects also complete a health history questionnaire and Physical

Activity Readiness Questionnaire for screening purposes.

Protocol

The subjects were asked to attend three testing sessions, separated by a minimum of 24 hours. Subjects were also asked to avoid lower body exercises at least 24 hours prior to their testing session. Body mass was measured in kg on a scale and standing reach was also measured at the beginning of the first session. Standing reach was obtained by having the subject extend their arms to their furthest reach above their head, while walking under the Vertec (Sports Imports, Hilliard, OH) and pushing the vanes as they walked through.

During each visit, subjects warmed-up on the cycle ergometer (Monark Ergomedic 828 E, Vansbro, Sweden) for 5 min at a self-selected RPM with a resistance of 1 kp. Following the warm-up, an ankle strap was applied to the subject's leg furthest from the Vertec and was connected to the Tendo Weight Lifting Analyzer (Trencin, Slovak Republic) to measure peak and average power and velocity (Oliver et al. 2012).

Subjects then performed a series of 5 baseline VJ with no external load (CON). A 15-s rest period was given between jumps. Following the baseline jumps, a 30-s rest period was given and the weighted vest was applied to the subject. This experiment focused on the acute effects of loaded jump. After investigation, it was decided that 30 s rest would allow for appropriate recovery time without hindering jumping performance. The weight of the vest corresponded to 5%, 10%, or 15% of their body weight (lbs). Subjects then performed 5 VJ, with the weighted vest (WV), with a 15-s interval between jumps. Subjects rested for 30 s and the weighted vest was removed. Subjects then proceeded to perform a series of 5 VJ performance post-test (PT) with a 15-s interval between jumps. The same procedures were followed on all three testing days. The weight of the external load (5%, 10% or 15%) was randomly assigned for each subject.

VJ performance was recorded via vertical displacement using the Vertec. Vertical displacement was derived by taking the jump height and subtracting the subject's standing reach height. The Tendo was used to measure the subject's average velocity (m/s) and average power (W) for every jump. A questionnaire was given to the subjects, after each testing session, to assess perception. The questionnaire included questions to see if the subjects thought they performed better (jumped higher) and how they physically felt (heavier/lighter) after the weight vest was removed (PT) compared to their baseline jumps (CON).

Statistical Analysis

The results of the study were analyzed using IBM SPSS Statistics software Version 24. A two-way ANOVA with repeated measures (condition x time) was used to assess for differences among the conditions (5%, 10%, and 15%) during the three repeated VJ sets (CON, WV, and PT). A pairwise comparison was used to assess for differences. The variables measured included average power, average velocity, and VJ displacement. The average of the five jumps was reported for all variables: VJ displacement, average power, and average velocity. An alpha level of 0.05 was used to determine significance.

RESULTS

The results of the two-way (condition x time) repeated measures ANOVA found there was a significant interaction for the VJ displacement ($F = 308.70$, $P < .01$). While there was not a difference among the conditions, there were significant differences yielded for time ($P < .01$). Regardless of the condition (5%, 10% or 15%), the WV condition was significantly lower than the CON. In

addition, the VJ displacement during PT was significantly higher than the CON and WV (Table 1).

Table 1. Descriptive statistics (M±SD) of vertical jump displacement (N = 16) by weighted vest condition (percent body weight)

Condition	Control (in)	Weighted Vest (in)	Post-test (in)	% Change CON to PT
5%	19.39±5.71	18.53±5.73	20.14±5.90	0.75 (3.9%)
10%	19.41±5.92	17.38±5.39	19.89±5.95	0.48 (2.5%)
15%	19.86±5.69	16.72±5.38	20.48±5.86	0.62 (3.1%)
Total	19.56±5.66	17.54±5.44*#	20.17±5.78*	0.61 (3.1%)

Note: *Significantly different from Control; #Significantly different from Post-test

The two-way ANOVA with repeated measures also found significant differences for average power ($F = 9.08$, $P < .01$) and average velocity during the take-off phase of the jump ($F = 22.23$, $P < .01$). Again, there was not a difference found between the conditions (5%, 10% or 15%); however, there was a significant difference in time across the five jumps for both variables ($P < 0.02$). The WV average power and average velocity were significantly lower than both the CON and PT no matter the condition. The PT average power and average velocity was significantly higher than CON (Figure 1 & 2). Even though it was not significantly different, the 5% condition yielded the largest percent change from CON to PT (Table 2).

All subjects perceived that during the 10% and 15% increments, they jumped higher and felt lighter during their PT compared to the CON. However, only 13 (81%) subjects showed an improvement in their VJ height during the 10% and 15% PT jump. Twelve of the 16 (75%) subjects reported feeling lighter and jumping higher while wearing the 5% vest during the PT compared to their baseline jump and 12 subjects actually jumped higher during this condition.

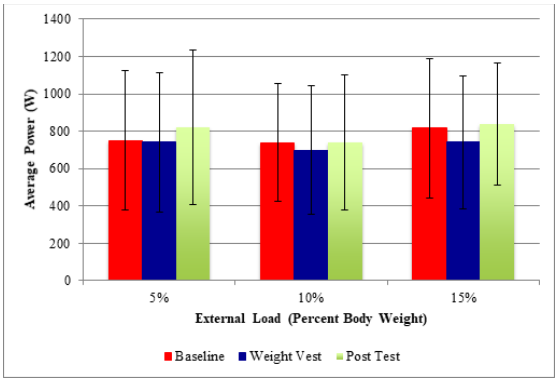

Figure 1. Mean (±SD) of the vertical jump average power (W) during the three weighted vest conditions across the three times. While there was no difference between the conditions, the weighted vest was significantly lower than the baseline and post-test vertical jumps and the post-test was higher than the control jumps.

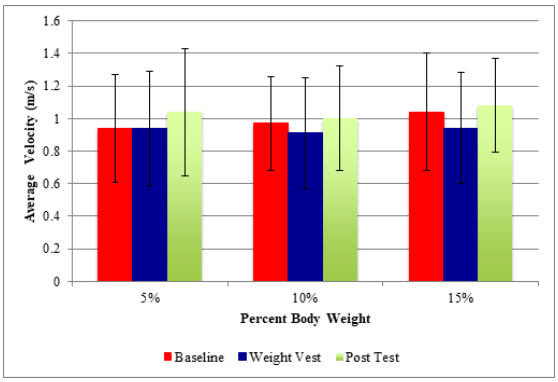

Figure 2. Mean (±SD) of the vertical jump average velocity (m/s) during the three weighted vest conditions across the three times. While there was no difference between the conditions, the weighted vest was significantly lower than the baseline and post-test vertical jumps and the post-test was higher than the control jumps.

Table 2. Percent change from control (CON) to post-test (PT) by weighted vest condition for average power and average velocity

	Average Power (W)			Average Velocity (m/s)		
Condition	CON	PT	% Change	CON	PT	% Change
5%	751±374	821±412	8.5%	0.94±0.33	1.04±0.39	10.6%
10%	739±314	786±364	6.4%	0.97±0.29	1.00±0.32	3.1%
15%	817±373	837±327	2.4%	1.04±0.36	1.08±0.29	3.8%
Total	769±349	814±362*	5.9%	0.98±0.32	1.04±0.33*	6.1%

Note: *Significantly different from Control

DISCUSSION

The purpose of this study was to investigate if performance and perception of the VJ were impacted by applying an external load prior to a VJ performance test. More specifically, the researchers sought to compare various incremental external loads, related to a given percentage of the subject's body weight, to examine the impact on VJ displacement, average power, average velocity, and the subject's perception of their performance. The findings of the study suggested there was an increase in performance, regardless of the percentage of the external load applied to the body. The subjects jumped significantly higher and generated significantly more power and velocity during the PT during all three load conditions (5%, 10%, and 15%). While there was not a significant difference found in the PT between the conditions, the 5% increment tended to lead to greatest increase in mean VJ performance (Table 1) with a corresponding trend to produce greater power and velocity (Table 2).

Moreover, the subjects also felt they jumped higher and felt lighter during the PT trial, similar to previously reported results (Burkett et al. 2005), where they also reported an increase in VJ performance when a 10% external load was applied to the body. In their study, they speculated that the jumping activity recruited more motor units which may have resulted in a greater power output (Burkett et al. 2005). Again, regardless of the condition, average power and average velocity measured within the present study also increased following the removal of the external load.

Further, another study has also noted an increase in the VJ displacement when a weighted vest was worn during a box jump warm-up (Chattong et al. 2010). They found an overall increase of 0.43 inches in VJ height, from pre-test to post-test, when an external load of 5% was applied to the body while performing the box jump. Within the present study, it was shown there was an increase in VJ displacement after the vest was removed. Specifically, the 5% load showed an improvement of 0.75 inches; whereas, the 10% and 15% found a 0.48 and 0.62 inch increase respectively. Besides using a different jumping method, Chattong et al. (2010) used a 2-min rest before the performance vertical jump. Thus, performing the VJ with the weighted load was found to have a greater impact on the PT VJ when compared to performing other weighted warmups or dynamic pre-activity.

Given the improvement in VJ performance and increases in average power and average velocity when an external load is applied, it is imperative to design a warm-up that will generate the greatest benefit for the athlete. An acute VJ increase of over a half-inch may not sound like a lot, but may be meaningful to an athlete's performance; especially during a performance test.

The other main finding of this study was the perception effect accompanied with the weighted load. Perception findings revealed that all subjects experienced the perception of jumping higher and feeling lighter during the PT compared to the CON. However, four subjects (25%) did not report the same feeling of improvement in performance during the 5% load. Of these four subjects, two reported either jumping higher and feeling heavier while the two reported not jumping higher or feeling lighter. These results could be a confusion of perception due to the weighted vest being too light and not giving enough sensory overload effect to the body. However, of the four subjects, only one did not have an increase in VJ performance after the 5% weighted vest was removed. Similarly, Otsuji et al. (2002) found that perception may not always translate to an increase in performance. While their subjects reported that the bat felt lighter and they were able to swing it faster, there was actually a decrease in performance after the

removal of the weighted ring (Otsuji et al. 2002).

The increases in acute power, velocity, and VJ performance, following the removal of an external load, has been associated with the post-activation potentiation (PAP) concept. It is thought the pre-activation of the muscle can positively influence muscular performance in future contractions, resulting in an acute performance response (Lorenz 2011). Research shows that a PAP response can lead to increased force development, but it can also lead to quicker fatigue if the intensity is too high or if there is not adequate rest time. During acute performance PAP enhances vertical jump, that is why we chose the 30-s rest interval (Dabs et al. 2015). However, the literature is not clear how large of a load needs to be applied to the body to elicit the acute power changes. This study found all three loads positively impacted acute VJ performance.

Future research should examine the type of resistance, as well as the amount of the load needed to improve performance acutely. Additionally, researchers should design the warm-up protocol that ensures the safety of the athlete or subject.

The present study was limited by three main factors. There was not a true control condition. It would have been ideal to include a fourth testing day and have the subjects complete the three sets of five VJ without a load applied to the body. While the conditions (5%, 10%, and 15%) were randomized, it would have been appropriate to include a non-weighted trial to see if the performance of the VJ alone could elicit an improvement in performance. Another limitation was having a sample of participants with various activity levels. We sought subjects who were physically active, not those with sports specific training backgrounds. Therefore, their activity levels were either resistance training, endurance training or both. The data were not analyzed for differences between the activity types. However, this would be worth exploring as the type of activity or training could impact the findings. Finally, the study was limited by the time between the WV and PT trials. The present study utilized a 30-s rest period, whereas Chattang et al. (2010) included a 2-min rest. This variation in rest time may contribute to the improvements in VJ height once the load was removed. Accordingly, future research should examine the impact of various rest times on the performance of the vertical jump once the external load is removed from the body.

CONCLUSION

It appears that performing a VJ with an external load of 5%, 10%, or 15% can significantly increase jump height, average power, and average velocity when the load is removed following a short rest period. The increase in performance maybe related to the post-activation potentiation theory such that the application of an externally loaded VJ may translate to increases in jump performance acutely. Finally, it was shown using an external load of 10% and 15% body weight created the perception of jumping higher and feeling lighter during the post-test vertical jump.

LITERATURE CITED

Arazi, H., A. Khanmohammadi, A. Asadi, and G.G. Haff. 2018. The effect of resistance training set configuration on strength, power, and hormonal adaptation in female volleyball players. *Applied Physiology, Nutrition & Metabolism* 43(2): 154-164.

Burkett, L.N., W.T. Phillips, and J. Ziuraitis. 2005. The best warm-up for the vertical jump in college-age athletic men. *Journal of Strength and Conditioning Research* 19(3): 673-676.

Chattong, C., L. Brown, J. Coburn, and G. Noffal, G. 2010. Effect of a dynamic loaded warm-up on vertical jump performance. *Journal of Strength and Conditioning Research* 24(7): 1751-1754.

Dabbs, N. C., J.A. Lundahl, and J.C. Garner. 2015. Effectiveness of different rest intervals following whole-body vibration on vertical jump performance between college athletes and recreationally trained females. *Sports* 3(3): 258-268.

Lorenz, D. (2011). Postactivation potentiation: An introduction. *International Journal of Sports Physical Therapy* 6(3): 234-240.

McBride, J., G. McCaulley, G, and P. Cormie. 2008. Influence of pre activity and eccentric muscle activity on concentric performance during vertical jump. *Journal of Strength and Conditioning Research* 22(3): 750-757.

Oliver, J.M., A.R. Jagim, A.C. Sanchez, J.Y. Kresta, M.A. Mardock, S.F. Crouse, and R.B. Kreider. 2012. Comparative analysis of body composition, strength and power of U.S. soldiers participating in an enlisted to commissioning program and experience matched controls. *Journal of Strength and Conditioning Research* 26(2): S49.

Otsuji, T., M. Abe, and H. Kinoshita. (2002). After-effects of using a weighted bat on subsequent swing velocity and batters perceptions of swing velocity and heaviness. *Perceptual and Motor Skills* 94: 119-126.

Toumi, H., T.M. Best, A. Martin, and G. Poumarat. (2004). Muscle plasticity after weight and combined (weight + jump) training. *Medicine & Science in Sports & Exercise* 36(9): 1580-1588.