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EFFECT OF WEIGHTED JUMP WARM-UP ON VERTICAL JUMP IN FEMALE VOLLEYBALL PLAYERS

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Abstract:

Warm-ups which elicit a post activation potentiation (PAP) effect may increase performance in subsequent activities requiring strength and power. However, finding practical methods to best manipulate and exploit PAP remains elusive. **Purpose:** To determine if a warm-up that included weighted jumps would elicit a PAP effect and increase subsequent vertical jump (VJ) height. **Methods:** Ten female NCAA Division II volleyball players participated (age = 19.8 ± 1.8 yrs; mass = 71.7 ± 9.7 kg; ht = 167.8 ±23.9 cm). Two warm-up conditions were randomly employed: 1) light jogging, high knees, carioca, shuffling, ankle pops, pogos, and tuck jumps; and 2) an identical warm-up, plus 10 maximal VJs while wearing 20% of bodyweight. At 4-minutes post, VJ was randomly assessed in two conditions: 1) 2-hand standing block VJ (SBVJ), and 2) 1-hand 3-step approach VJ (AVJ). Paired Samples T-test determined if there was a significant difference ($p < 0.05$) in VJ height between the two conditions. **Results:** Results were mixed. No significant difference ($p > 0.05$) occurred in the SBVJ (262.1 vs. 263.0 cm, warm-up vs. warm-up with weight vest, respectively). However, the AVJ was significantly higher by 2.7±1.5 cm ($p < 0.05$; 275.1±13.2 vs. 277.8±13.2 cm) with the weight vest added to their warm-up. **Conclusion:** This study demonstrates that a dynamic warm-up with the addition of weighted jumps may increase 3-step AVJ ability in female collegiate volleyball players. However, no effect was seen in 2-hand SBVJ ability. Coaches may consider using a warm-up that includes weighted jumps to

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optimize performance in sports like volleyball where vertical jumps with an approach are key components of competition.

Keywords: post activation potentiation; power; athletics

1. Introduction

Dynamic warm-up strategies are designed to positively impact performance. Research demonstrates that warm-ups which elicit a post activation potentiation (PAP) effect via high intensity muscular contractions may increase performance in subsequent activities requiring strength and power (1-3, 5-9, 11, 13-22, 24, 25, 27, 29-35, 37, 39, 40). However, eliciting PAP in practical, real-world scenarios to enhance game performance remains elusive (6, 7, 15, 16, 25, 29, 30, 34, 40). For example, Berning and colleagues (3) demonstrated a significant increase in vertical jump (VJ) height post functional isometrics in male recreational lifters; but functional isometrics require a heavy duty, modified squat rack that is bolted to the ground and a barbell and heavy weight, making this impractical in most applied settings. Similarly, Ah Sue et al. (1) used heavy squats to elicit a PAP effect and increase VJ in junior college female volleyball players; but again, this protocol required heavy equipment and a complex exercise that required spotters to elicit the effect.

Practitioners and researchers recognize that athletic scenarios typically do not allow for heavy equipment being readily available prior to competition, therefore alternative, sport-specific strategies need to be discovered to elicit PAP (1, 6, 20, 24, 25, 29, 30, 34). For example, Tobin and colleagues (35) demonstrated that plyometric jumps performed in a repeated series was an efficient technique to elicit a PAP effect and increase VJ in professional Rugby players; similarly, Chattong et al. (4) found that a dynamic warm-up with or without weighted jumps increased VJ in resistance trained men; and Dolan et al. (7) used the hang clean and jerk (3 x 80% 1-RM) to stimulate a PAP effect in shot putters (i.e., increased put distance); noting that the hang clean and jerk simply would require a bar and weights near the shot put ring for the competitor to utilize.

Volleyball involves several different jumping strategies specific to position needs and goals (e.g., blocking, serving, spiking, etc.) (10, 23). Vertical jump height, getting one's hands and arms high above the net, and doing this quickly is all of importance (4, 9, 10, 23, 40). If using a dynamic warm-up strategy that involves volleyball athletes performing repeated VJs with a weighted vest can help increase their sport-specific VJs through the effects of PAP, then that warm-up strategy would be a practical use of PAP. Volleyball players have been participants in a few PAP studies (e.g., 1, 4, 9, 22, 31, 40),

however, applied research is limited that explores practical methods of eliciting a PAP effect to enhance subsequent VJ variations utilized by female volleyball players.

Therefore, the purpose of this investigation was to determine if a functional, dynamic, volleyball specific warm-up that included weighted jumps would elicit a PAP effect and increase subsequent VJ height in female volleyball players.

2. Methods

2.1 Participants

Ten trained female Division II volleyball players participated (age = 19.8 ± 1.8 yrs; mass = 71.7 ± 9.7 kg; ht = 167.8 ± 23.9 cm). All subjects were over 18 yrs old and had at least two years of university-based strength and conditioning and collegiate-level volleyball competition experience. Subjects were at week 6 of their off-season conditioning program. Besides volleyball specific strength and conditioning, per NCAA (National Collegiate Athletic Association) guidelines, each player accumulated 2 hrs/wk of individual volleyball practice during this time period. All subjects were experienced in testing their VJ with the Vertec (Sports Imports, Columbus, Ohio) in multiple, volleyball specific VJ styles. Permission from the Institutional Review Board to use human subjects was obtained before conducting any training or assessments of the student-athlete participants. Each participant was also given a written consent form to read and sign before any action in the study was taken. The volleyball coaching staff also approved of the study. Each subject was asked to maintain their normal nutrition and recovery routines during the timeframe of this study.

2.2 Procedures

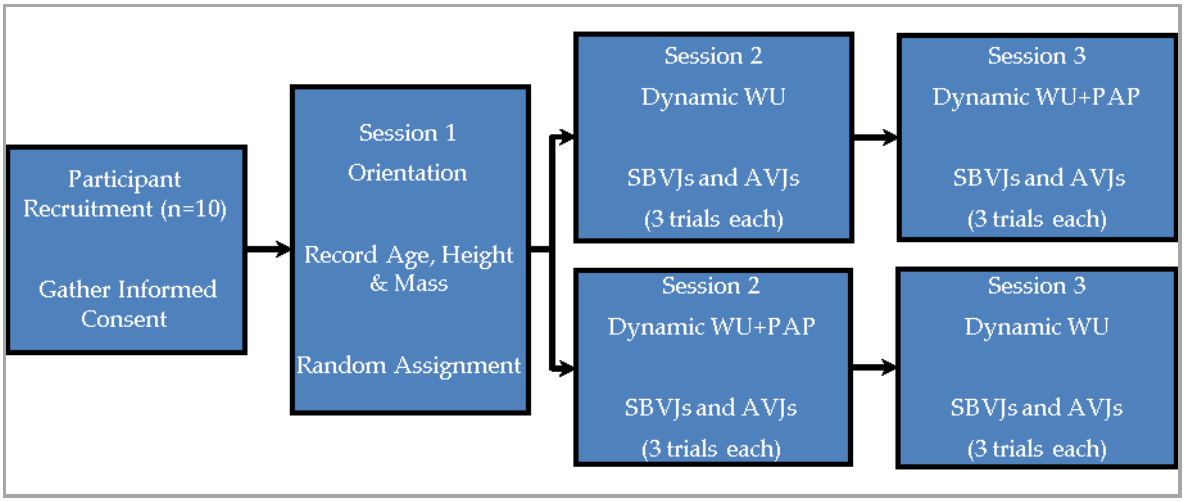

Figure 1: Study time line of events. PAP-post activation potentiation; WU-warm-up; SBVJ-2-hand standing block VJ; AVJ-1-hand 3-step approach VJ; Countermovement VJs wearing a weighted vest at 20% of body weight was used as the PAP conditioning activity.

Two different warm-up conditions lasting 5-7 minutes were individually and randomly employed at two different training sessions, at the same time of day, within one week. The first warm-up condition consisted of a functional, dynamic warm-up of light jogging, high knees, carioca, shuffling, ankle pops (all at 3 sets at 20 yds (18.3 meters) ea.), pogos (2 x 15 sec.), and tuck jumps (1 x 15 sec.). The second warm-up condition was identical to the first, except for the addition of 1 x 10 maximal VJs with countermovement while wearing a weight vest loaded with 20% of their individual bodyweight (See Figure 1 for timeline).

Starting at 4-minutes post warm-up in each condition, maximal VJ was assessed in two conditions in random order using a Vertec: 1) 2-hand standing block VJ (SBVJ) starting with hands in a defensive position, and 2) 1-hand 3-step approach VJ (AVJ) with arm swing. Three trials per each condition were given, with 15 sec. rest intervals allowed between trials. The highest point touched on the Vertec was recorded for each trial (noting that the regulation height of the volleyball net is 225 cms for women's competition). The average of the three trials was used for data analysis. All warm-up and VJ trials were supervised by the principal investigator.

2.3 Reliability

The VJ as measured by devices such as Vertec have demonstrated a reliability coefficient of ICC=0.95 (26). And, Sattler et al. (28) demonstrated these types of volleyball specific jumps have excellent reliability (i.e., 0.97 to 0.99 for Cronbach's alpha coefficients, 0.93 to 0.97 for inter-item correlation coefficients, and coefficients of variation from 2.1 to 2.8.

2.4 Statistical Analysis

This was a test-retest study with two acute experimental conditions. Each athlete served as their own control. Paired Samples T-test was used to determine if there was a significant difference ($p < 0.05$) in VJ height between the two conditions. Statistical calculations and data management were conducted with Microsoft Excel 2013.

3. Results

All of the participants completed the SBVJ trials and one participant did not complete the AVJ trials. Hence the data analysis for the SBVJ measures was based on n=10 participants, whereas the AVJ analysis was based on n=9 participants (Table 1).

Table 1: Participant Descriptive Information

N	Age (years)	Height (cms)	Mass (kgs)	SBVJ	SBVJ PAP	AVJ	AVJ PAP
10	19.8± 1.8	167.8 ± 23.9	71.7± 9.7	262.1±14.9	263.0±12.3	275.1±13.2	277.8±13.2*

Participant means and standard deviations for descriptive information. SBVJ-2-hand standing block VJ; AVJ-1-hand 3-step approach; PAP-post activation potentiation. *significantly different $p<0.05$.

The results of this study were mixed. No significant difference ($p > 0.05$) occurred in VJ height in the SBVJ condition between the two different warm-ups (262.1±14.9 vs. 263.0±12.3 cm, warm-up vs. warm-up with weight vest, respectively). However, the AVJ was significantly higher by 2.7±1.5 cm ($p < 0.05$; 275.1±13.2 vs. 277.8±13.2 cm) after the subjects added the weight vest to their warm-up routine.

4. Discussion

This investigation was performed to determine if a dynamic, volleyball specific warm-up that included weighted jumps would elicit a PAP effect and increase subsequent VJ height. Results demonstrate that a functional, dynamic warm-up with the addition of weighted jumps for 1 x 10 at 20% of bodyweight significantly increased 1-hand, 3-step AVJ ability in female collegiate volleyball players (+2.7 cm). However, no significant effect was seen in 2-hand SBVJ ability (+0.9 cm).

These differences in results between VJ conditions may possibly be explained by the difference in the forces and energy involved during the stretch-shortening cycle in an AVJ vs. a SBVJ, and the ability of a PAP event to capitalize on these forces (10, 12, 20, 23, 29, 30). For example, research by Fukutani et al. (12) demonstrated that potentiation of the stretch shortening cycle (SSC) benefits from preactivation and that eccentric loading enhances the SSC effect; and it is well-established that a rapid transition from eccentric to concentric muscle action minimizes the loss of elastic energy, helping to optimize VJ height (12, 30, 34, 36, 38). These points relate directly to the difference in momentum and impulse that occurs between a 3-step approach VJ with arm swing vs. a standing block VJ with quick countermovement and hands starting in a defensive position; also, eccentric loading would be increased in the 3-step approach as the body accelerates into the ground, creating a high eccentric impulse and rapidly moving through the SSC, helping to propel oneself into the air. In other words, the SBVJ condition may have failed to closely match the dynamic nature of the AVJ in acute forces (e.g., high eccentric loading) and rapid action of the SSC, thereby not capitalizing as much on any given PAP event (30, 34, 36, 38). Similarly, Neves et al. (23) and Ficklin et al. (10) performed an investigation of blocking techniques in female volleyball

players, and found that the swing block with approach, a countermovement, and full arm swing resulted in the highest VJ over other blocking styles.

Looking closer at the data, even though volleyball is a team sport, individual performance matters. The dynamic warm-up with the addition of weighted vertical jumps increased 1-hand, 3-step AVJ in 100% of the participants (range = +0.4 cm to +5.1 cm); and in the 2-hand SBVJ, despite lacking statistical significance 78% of the participants increased their jump height (range of all participants = -6.6 cm to +5.7 cm). With that said, while we recognize the importance of individual characteristics (e.g., strength; fatigue; etc.) on the one's response to a PAP conditioning activity (5, 9, 15, 16, 25, 29, 30, 33, 34, 35), unfortunately we do not have this type of individual data on our participants. We recognize this as a limitation, and future studies are including this information. However, based on personal observation of those responsible for the strength and conditioning of these players (i.e., authors of this study), all participants were well-trained in terms of strength and power and were not in a fatigued state during this study.

While one may say the PAP effect diminishes quickly, Kopp and DeBeliso (18) recently used a back squat and Romanian deadlift superset to elicit a PAP effect for over 24 minutes in recreationally resistance trained males. And, Ah Sue et al. (1) demonstrated a PAP conditioning activity to have a positive effect on VJ of at least10 minutes in female volleyball players. Regardless, it is clear that to optimize the fatigue/recovery relationship, time after the PAP conditioning activity is important for optimal outcomes; and, research over the past two decades suggests we have much to learn in regards to practical application in competition (i.e., time range post PAP = ~ 3 to 24+ minutes in trained athletes) (1, 6, 7, 13, 14, 17, 18, 25, 29, 30, 34). With that said, we agree with previous researchers who suggest that the individuality of the athlete must be considered when designing the PAP conditioning activity and subsequent rest period (15, 16, 30, 34). This includes factors such as training history, fatigue/recovery status, stress levels, etc. (15). Recognizing that these researchers used a variety of subjects and conditioning activities to stimulate a PAP effect, the observed time window still indicates potential merit for practical application and opens the door for additional investigations in applied settings.

Regarding time, in this study the VJs took place starting four minutes post PAP warm-up, with six VJs occurring at 15 second intervals (i.e., time range = 4 minutes [jump 1] to minute 5:15 [jump 6]). It has been suggested that sets consisting of greater than five total repetitions or five seconds of total contraction time are not advisable because of the fatigue induced (11, 14, 25); the current study had 1 x 10 maximal VJs with countermovement while wearing a weight vest loaded with 20% of their individual bodyweight, resulting in a total contraction time of the complete set lasting ~

20 to 30 seconds; which may have caused excessive fatigue and limited potentiation in both VJ conditions.

In conclusion, this study demonstrates that a dynamic warm-up with the addition of weighted jumps may increase 3-step AVJ ability in female collegiate volleyball players, with no negative effect in 2-hand SBVJ ability.

5. Practical Application

Coaches may consider using a warm-up that includes weighted jumps as a PAP conditioning activity to optimize performance in sports like volleyball where VJs with an approach are key components of competition. From a practical standpoint, this suggests that a relatively low cost (i.e., weight vests @ ~ $75.00 (+/-) ea. x 6 starters on a team = ~ $450.00), logistically feasible (i.e., vests with weight can be easily transported, e.g., 20% of 72.0 kgs = 14.4 kgs x 6 starters = 86.4 kgs), warm-up strategy may be effectively employed by the coaching staff to enhance warm-up and possibly game performance in the short term. Coaches may also consider weighted jumps between matches (in sports such as volleyball), but the fatigue-facilitation relationship would have to be explored on an individual basis.

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Conflict of Interest Declaration
No funding was received for this research. The authors have no conflict of interest related to this research.

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