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EFFECTS OF DEPTH JUMP VS. BOX JUMP WARM-UPS ON VERTICAL JUMP IN COLLEGIATE VS. CLUB FEMALE VOLLEYBALL PLAYERS

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Abstract

Introduction: Box jumps and depth jumps might elicit post activation potentiation, which can increase vertical jump performance.

Aim: The purpose of this study was to compare the potentiating effects of a depth jump vs. a box jump warm-up on vertical jump performance.

Methods: Eight collegiate and nine club female volleyball players participated on three testing days separated by 48 hours. Participants performed three pre-test countermovement vertical jumps with arm-swing then completed three experimental conditions in random order: control (no intervention), box jump (onto a box), and depth jump (stepping off a box with immediate maximal rebound). They then performed three post-test jumps.

Results: Analysis revealed no significant ($P < 0.05$) interactions, but there was a main effect for time with all scores decreasing: vertical jump height (pre-34.31 ± 5.89cm; post-33.17 ± 5.86cm), relative ground reaction force (pre-24.18 ± 3.66N/kg; post-23.53 ± 3.66N/kg), and take-off velocity (pre-2.53 ± 0.29m/s; post-2.49 ± 0.30 m/s).

Conclusions: It was concluded that using 10 depth or box jump warm-ups at the box height used in this study, with 10 minutes rest is not recommended to increase subsequent vertical jump performance in female collegiate volleyball players.

Key words: *ground reaction force, take-off velocity, post-activation potentiation*

Introduction

Researchers, coaches and athletes are constantly looking for the most effective and efficient ways to enhance athletic performance. Static stretching as a warm-up has long been thought to enhance performance, but more recent findings have reported differently [1-6]. These studies have shown that static and PNF stretching as a warm-up have resulted in decreases or no change in force and power. However, plyometric and dynamic exercises have been theorized to increase force, power, and explosiveness. Recent studies have explored many dynamic and plyometric exercises as warm-up at various volumes and loads. Many of these moderate to high intensity studies have demonstrated increased vertical jump performance [2, 5-11] and found positive results with and without weights. Most studies that used weights and found an increase in vertical jump performance used submaximal loads [2, 5, 7, 8] yet some research has found that heavy pre-loading enhanced explosive performance, while others have not [12-18]. Therefore, it is still unclear what level of pre-load is optimal.

Load, volume, intensity and rest intervals are all factors that can affect the results of warm-up protocols. Studies that found positive results were most likely due to the phenomena of postactivation potentiation (PAP). PAP is thought to increase force production, which may be the result of phosphorylation of myosin light chains or an increase in Ca^{2+} at the crossbridges that increases excitability [19-21]. PAP occurs as a result of a conditioning stimulus which needs to be intense enough to evoke PAP, but not too intense to cause fatigue. Research has shown that the addition of plyometric and dynamic exercises, specifically depth jumps [9], to a warm-up routine is beneficial to jumping performance [2, 5-7, 9-11, 22]. However, we are aware of no research that has looked exclusively at depth jumps and box jumps as a warm-up to benefit vertical jump performance. Therefore, the purpose of this study was to compare the potentiating effects of depth jump vs. box jump warm-ups on vertical jump performance.

Materials and methods

This was a mixed factor design in which each subject was required to participate in all three test conditions. Eight collegiate (age, 19.00 ± 1.41 yrs; height, 174.35 ± 5.86 cm; mass, 72.46 ± 4.28 kg; box height, 68.58 ± 2.35 cm) and nine club (age, 20.00 ± 2.78 yrs; height, 166.52 ± 7.35 cm; mass, 59.04 ± 3.74

kg; box height, 63.50 ± 4.91 cm) female volleyball players participated. Any subject with current health limitations such as lower body orthopedic or musculoskeletal injuries was excluded. Prior to participating, all subjects read and signed an informed consent document approved by the University Institutional Review Board. Participants completed three test conditions separated by at least 48 hours. Investigators measured each subject's height, mass and standing reach on day one. On each day, subjects performed a five minute warm-up on a cycle ergometer (Monark 893E, Varberg, Sweden) at a moderate self-selected pace with 25 Watts of resistance. Subjects then performed three maximum countermovement vertical jumps with arm-swing on an AMTI force plate (Advanced Mechanical Technology, Inc., Watertown, MA) separated by 15 seconds rest (pre-test) [23, 24]. Subjects then performed one of three experimental conditions in random order: a control condition (no intervention), a box jump condition (10 jumps onto a box), and a depth jump condition (10 trials of stepping off a box onto the force plate with immediate maximal rebound; 15s rest between jumps). Individualized box height equaled the distance from the floor to the halfway point between their greater trochanter and their lateral femoral condyle while wearing shoes. Upon completion of each condition, subjects rested for 10 minutes then performed three final vertical jumps separated by 15 seconds rest (post-test) [23, 24]. Dependent variables included vertical jump height (VJ), relative ground reaction force (rGRF) and take-off velocity (TOV).

Data was sampled at 1000Hz and maximum values from the peak velocity repetition for each condition were analyzed. The force plate was connected to a desktop computer running custom LabVIEW data collection and analysis software (version 7.1, National Instruments Corporation, Austin, TX) to analyze force and velocity curves. VJ (cm) off the force plate was calculated via the formula, $[(a \times t^2)/8]$ where 'a' is the acceleration due to gravity (9.81 m/s^2) and 't' is flight time (s). TOV (m/s) was calculated via integration of the force-time curve and recorded the moment the subject's feet left contact with the force plate while rGRF (N/kg) was determined by dividing peak GRF by body mass for that condition.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS 19.0 for Windows, SPSS, Inc., Chicago, IL) was used for all analyses. Alpha was set a-priori at 0.05. A one-way ANOVA by athletic status was performed for age, height, mass and box height which revealed that collegiate were significantly ($P < 0.05$) taller, heavier and had a greater box height when compared to club. Three 3 x 2 x 2 (condition x time x athletic status) mixed factor repeated measures ANOVA's

Results

VJ, rGRF and TOV revealed no significant interactions but there were main effects for time for each variable with all scores decreasing from pre to post-test (Table 1).

Table 1. *Vertical jump height (VJ), relative ground reaction force (rGRF) and take-off velocity (TOV) scores (mean ± SD) between pre and post-tests. *significantly (P < 0.05) less than Pre*

	Pre	Post	Statistical Power	Effect Size
VJ (cm)	34.31 ± 5.89	33.17 ± 5.86 *	.33	.15
rGRF (N/kg)	24.18 ± 3.66	23.53 ± 3.66 *	.67	.30
TOV (m/s)	2.53 ± 0.29	2.49 ± 0.30 *	.98	.56

Discussion

The purpose of this study was to compare the potentiating effects of depth jump vs. box jump warm-ups on vertical jump performance in female collegiate volleyball players. Results demonstrated a post-test decrease in all variables. This might suggest that rest time was too long or intensity was too low to create a potentiating effect.

Results from previous studies [11, 15, 17, 19, 25] suggest that the depth jump and box jump warm-ups used in this study were not intense enough for collegiate players to elicit a potentiation response. Fatigue and intensity may both have played a role in post vertical jump performance. Fatigue and potentiation are thought to coexist in the skeletal muscle after a maximal or near maximal muscle action [26]. There can be a negative effect on force production when there is too much fatigue and/or not enough intensity. Analysis of the box and depth jumps revealed that there was no change in rGRF across the 10 repetitions, which might imply they were of insufficient intensity to elicit a potentiation response.

Rest intervals may also influence performance following a potentiating stimulus. Since fatigue and potentiation are thought to coexist, in order to achieve an improvement in muscle performance following this activity, rest time needs to be long enough to allow a decline in fatigue, but short enough to allow potentiation to dominantly exist in the muscle [26]. Kilduff [27] had professional rugby players perform 3 RM on the squat and bench press then complete either a CMJ or ballistic bench throw following 4, 8, 12, 16, and 20 minutes of rest. Their results showed that peak power output increased with 12 minutes of rest. Chiu [19] also found power was significantly greater following a rest time of 18.5 minutes when compared to 5 minutes. Comyns [28] found a significant decrease in flight time at 30 seconds and six minutes rest after a 5RM back squat, but no difference with two and four minutes rest, suggesting that the effects of the potentiating stimulus wore off by 6 minutes.

Several other studies [2, 5, 8, 10, 25] have used shorter rest times and found positive results. Burkett [2] had collegiate male football players participate in four different warm-up protocols then rest for two minutes before vertical jump testing and found a significant increase in performance. Similarly, Gourgoulis [8] examined the effects of submaximal warm-up on vertical jump performance in physically active males using a rest time of 5 minutes and found positive results. The results of our study suggest that a rest time of 10 minutes may have been too long since there was a decrease in performance across conditions. This extended time may have allowed the muscle warming-up effect to be lost [2, 6, 11, 12, 23].

The wide range of rest times used in previous studies suggest that the ideal rest time appears to be largely dependent on each individual and may be related to their training status [2, 5, 7, 9, 19, 21, 27, 28]. In a recent study by Dabbs [29] comparing vertical jump performance following whole body vibration across rest intervals of 30s, 1, 2 or 4 minutes, they demonstrated that individual subjects did exhibit a potentiating effect but at their own optimal rest times. In a similar study, Jo [30] measured Wingate power following a PAP intervention of 85% 1RM back squats with rest times of 5, 10, 15 or 20 minutes. They also found that individual subjects potentiated at their own optimal rest times. Thus, the individual changes in these studies appeared to be masked by the group mean results and demonstrated no change. Future research should investigate individual variation in PAP load percentage and rest time in both strength and power exercises relative to training status.

Conclusions

This study did not find an increase in vertical jump performance following either depth jump or box jump warm-ups. This may be explained by rest time being too long or the intensity of the warm-up exercises being too low. Fatigue was probably not a factor as there were no significant differences between warm-up repetitions. Therefore, the outcomes may have resulted from individual optimal warm-up differences in potentiation rest time or intensity.

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A – Study Design
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C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection