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Original paper

The effect of assisted jumping on vertical jump height in high-performance volleyball players

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Abstract

Assisted jumping may be useful in training higher concentric movement speed in jumping, thereby potentially increasing the jumping abilities of athletes. The purpose of this study was to evaluate the effects of assisted jump training on counter-movement vertical jump (CMVJ) and spike jump (SPJ) ability in a group of elite male volleyball players. Seven junior national team volleyball players (18.0 ± 1.0 yrs, 200.4 ± 6.7 cm, and 84.0 ± 7.2 kg) participated in this within-subjects cross-over counter-balanced training study. Assisted training involved 3 sessions per week of CMVJ training with 10 kg of assistance, applied through use of a bungee system, whilst normal jump training involved equated volume of unassisted counter-movement vertical jumps. Training periods were 5 weeks duration, with a 3-week wash-out separating them. Prior to and at the conclusion of each training period jump testing for CMVJ and SPJ height was conducted. Assisted jump training resulted in gains of 2.7 ± 0.7 cm ($p < 0.01$, $ES = 0.21$) and 4.6 ± 2.6 cm ($p < 0.01$, $ES = 0.32$) for the CMVJ and SPJ respectively, whilst normal jump training did not result in significant gains for either CMVJ or SPJ ($p = 0.09$ and $p = 0.51$ respectively). The changes associated with normal jump training and assisted jump training revealed significant differences in both CMVJ and SPJ ($p = < 0.03$) in favour of the assisted jump condition, with large effect (CMVJ, $ES = 1.22$; SPJ, $ES = 1.31$). Assisted jumping may promote the leg extensor musculature to undergo a more rapid rate of shortening, and chronic exposure appears to improve jumping ability.

Keywords: Spike jump; Block jump; Plyometrics

1. Introduction

Jumping ability is critical to success in volleyball, allowing for a competitive advantage in attack (gaining a great height to hit over the block/superior angle of attack) and also in defence (obtaining a higher blocking position).[1–3] To increase vertical jump, loaded jumps are often used to train lower body strength and power.[4,5] This has been shown to be very useful in increasing the force and power of the leg extensors, and as a result, this increase appears to contribute in part to an improvement in vertical jump height.[4–6]

In accordance with the training principle of overload, loaded counter-movement jumps provide an emphasis on rapid force production by providing a greater than normal inertial load for the athlete to overcome in the propulsive phase of the jump motion. Despite this common training practice and the positive results observed,[4–6] it is not common practice to implement reduced load counter-movement jumps to provide extra emphasis on developing higher rates of shortening to enhance jump performance. Although research has examined the nature of variations in contraction rates[7] and the effect of differing external load schemes in jumping,[6,8,9] no studies have examined the potential chronic training influence that reduced load jumping, which could also be considered 'assisted jumping', may have on normal jumping abilities.

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Assisted jumping may be useful in overloading the velocity aspects of jump propulsion, thereby potentially increasing the jumping abilities of athletes. Assisted jumping may encourage the leg extensor musculature to undergo a more rapid rate of shortening, and chronic exposure to this accelerated rate of shortening (in conjunction with typical strength activities) may promote an enhancement in jumping ability. In other words, assisted jumping may present a novel 'overspeed' stimulus. The purpose of this study was to evaluate the chronic effects of assisted jump training on the counter-movement and spike jumping ability of a group of male volleyball players.

2. Methods

A within-subjects, counter-balanced, cross-over study design was used for this study. Assisted jump training and normal jump training interventions were each 5 weeks in duration, with a 3-week wash-out period between interventions. During the wash-out period, the athletes continued their typical volleyball and other strength and conditioning activities, but did not perform additional jump training. Vertical jump testing was conducted twice in the 7-day period (as is their normal routine) the week prior to and at the conclusion of each of the training periods. The best result from the testing conducted within each testing week was used for analysis.

Seven junior national team male indoor volleyball players (18.0 ± 1.0 yrs, 2.00 ± 0.07 m, and 84.0 ± 7.2 kg) from the Australian Institute of Sport (AIS) program participated in this training study. All procedures were approved by the AIS ethics committee, with procedures conforming to the Statement on Human Experimentation by the National Health and Medical Research Council of Australia. Informed consent was obtained prior to participation from all athletes.

The assisted block jump condition of 10 kg of assistance was trialled in a pilot study with this athlete population and compared to normal block jumps. During pilot testing, three-dimensional kinematics were collected using a 15-camera motion analysis system sampling at 250 Hz (VICON MX; Oxford Metrics Ltd, Oxford, UK). Retroreflective markers (14 mm) in accordance with the Plug-in-Gait Model were applied on the skin of the athletes and tracked by the associated cameras and software. The motion analysis system was calibrated using a static calibration frame to orient the cameras to the laboratory coordinate system and then a dynamic wand was used to fine tune camera positions.[10] Each participant completed a standing calibration trial whilst in the anatomical position to reference the coordinate data and determine the position of markers relative to the estimated joint centres. Synchronised ground reaction forces were captured using two force plates embedded into the floor side by side and sampling at 1500 Hz (600 mm × 900 mm Kistler force plates; Model Z12697, Kistler Instrument Corporation, Amherst, NY, USA). Each athlete performed five successful counter-movement vertical jumps landing bilaterally at body mass (Normal) and whilst being assisted by a bungee jumping apparatus, secured via a harness, that unloaded the athlete by ∼10 kg (assisted). The unloading was achieved by having the athlete stand with both feet on one force plate and tightening the bungee until they were approximately 10 kg lighter, at which time the bungee was secured. The bungee was stretched from the athlete through a roof mounted pulley system, and back down to the floor, stretching approximately 35 m, minimizing the relative change in force (assistance) through the counter-movement and propulsive portion of the jump. Kinematic and kinetic data were filtered using a low-pass 4th order Butterworth filter with a cut-off frequency of 12 Hz and 90 Hz, respectively. For each condition, the three highest vertical jumps, based on displacement of the sacrum, were further analysed.

The assisted jump condition demonstrated a peak force of 1937 ± 308 N, peak velocity of 3.38 ± 0.25 m/s, peak acceleration of 19.26 ± 2.67 m/s^2, and jump height of 0.67 ± 0.06 m, whilst the normal jump condition resulted in a peak force of 2039 ± 273 N, peak velocity of 3.25 ± 0.31 m/s, peak acceleration of 18.54 ± 2.53 m/s^2, and jump height of 0.61 ± 0.06 m (all differences $p < 0.05$). As such, it was concluded that when reducing the effective mass of an athlete in the vertical jump, the athletes' peak acceleration and peak velocity are increased, whilst the peak force is decreased, due to the reduced inertial load.

Approximately one half of the athlete pool performed the assisted counter-movement jumps, performing 5–7 sets of 5 jumps, on 3 occasions per week, for a total of 5 weeks (Table 1), using a reduced effective mass (−10 kg) for each jump. Training in the control intervention involved an equated jump volume by performing the same amount of counter-movement jumps under normal conditions. Warm-up for training in either condition was identical, involving 5 min of jogging and skipping activities and 2–3 min of dynamic stretching. All training was in addition to the normal training activities of this group (each week: 7–12 court sessions, 3–4 strength and conditioning sessions, 2–3 stretching sessions). Strength sessions included one Olympic weightlifting variation, and 1 squat variation for the lower body per session (followed by upper body strength training).

At the conclusion of the first 5 weeks of training, all athletes undertook a 3-week wash-out period where no additional jump training of any type was conducted, but normal training was continued as outlined above. At the beginning and conclusion of the wash-out period, athletes were re-tested on their vertical jump, before completing the second 5-week training component (control become training group and vice-

Table 1
Assisted and normal CMVJ jump training volume across each of the 5-week training periods (assisted and normal), performed 3 times each week.

Week	1	2	3	4	5
Sets × Reps	5 × 5	6 × 5	7 × 5	6 × 5	7 × 5
Total volume	25	30	35	30	35

versa), at which time athletes were re-tested on their vertical jump for the final time.

Athletes were tested on their maximum effort counter-movement vertical jump (CMVJ) as well as a spike jump (with approach) (SPJ) using a vaned jump and reach apparatus which allows for recording of the maximum height reached to the nearest centimetre (Yardstick, Swift Systems, Lismore, Australia). In the CMVJ no horizontal approach was allowed, whilst in the SPJ an approach ranging from 3 to 4 steps was used. Intra-class correlation coefficients (ICC) (%TE in parenthesis) of the height of the CMVJ and SPJ were 0.98 (2.5%) and 0.97 (3.2%) respectively.

Differences between conditions, and changes from pre- to post-test for the normal jump and assisted jump training interventions were assessed using paired *t*-tests, with alpha set at $p < 0.05$. Differences between the changes in jump height between the training programs were assessed using paired *t*-tests (alpha $p < 0.05$). Additionally, effect size statistics (*ES*) were applied to assess the magnitude of the changes and the magnitude of the difference between groups, according to the criterion of >0.70 large; 0.40–0.70 moderate; <0.40 small.[11]

3. Results

Assisted jump training resulted in gains of 2.7 ± 0.7 cm ($p = <0.01$, $ES = 0.21$, small) and 4.6 ± 2.6 cm ($p = <0.01$, $ES = 0.32$, small) for the CMVJ and SPJ respectively. In contrast, normal jump training did not result in significant gains for either CMVJ ($p = 0.09$) or SPJ ($p = 0.51$). The improvement following assisted jump training was superior to that of the normal jump training for both CMVJ ($p = 0.03$; Fig. 1) and SPJ ($p = 0.03$; Fig. 2) with large magnitude of effect ($ES = 1.22$ for CMVJ and $ES = 1.31$ for SPJ).

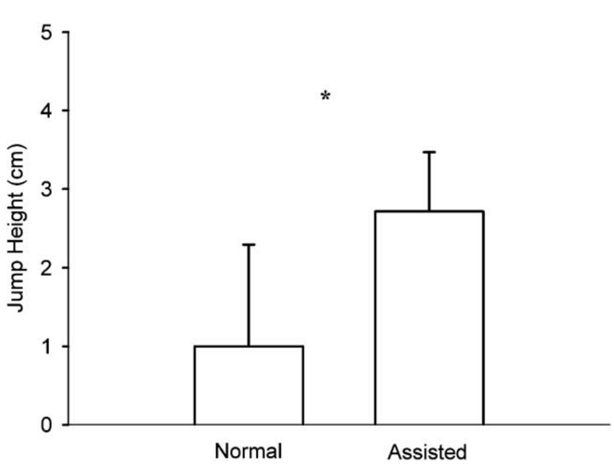

Fig. 1. Change (cm) in CMVJ height of volleyball players after 5 weeks of normal and assisted jump training. *Change in CMVJ for the assisted is significantly ($p = 0.03$) greater than for normal.

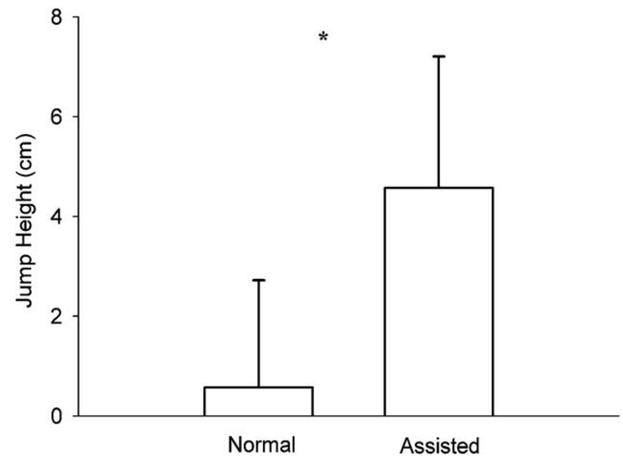

Fig. 2. Change (cm) in SPJ height of volleyball players after 5 weeks of normal and assisted jump training. *Change in SPJ for the assisted is significantly ($p = 0.03$) greater than for normal.

4. Discussion

This is the first study to the authors' knowledge reporting the improvement in jumping abilities of habituated jumpers from assisted jump training. Previous investigations have reported positive results from interventions targeting the force-application components of jump training through loaded jump squats.[4–6,12,13] It was hypothesised that assisted jumps may be an appropriate training stimulus for targeting the velocity of shortening in the vertical jump which would lead to greater jump performance in comparison to normal jump training. In the present study, assisted jump training resulted in superior improvements in CMVJ and SPJ height, with large effect ($ES = 1.22$ for CMVJ and $ES = 1.31$ for SPJ). The normal condition did not elicit significant improvement in vertical jump.

The unique finding of this study is that supplementing assisted jump training to the other forms of training for volleyball players (strength and technical training sessions) resulted in superior gains in jump performance in comparison to simply adding more counter-movement jumps to the training regimen. It is proposed that assisted jumping promotes the leg extensor musculature to develop force whilst undergoing an increased rate of muscle shortening. Chronic exposure to this accelerated rate of shortening (in conjunction with more traditional strength and conditioning activities) may have promoted the improvement in jump height of the volleyball players in this study, possibly through a decrease in antagonist co-activation[14,15] or through an increase in cross-bridge cycling rates and improved calcium kinetics.[16] The assisted jump intervention likely presented a novel 'over-speed' stimulus, as our pilot study showed that acceleration and velocity values gained from the assisted jump intervention were superior to those observed with normal counter-movement jump training.

A potential limiting aspect of performing assisted jumps in the manner described is the reduced eccentric load. In this study, the assisted jumps were performed with a 10 kg reduced eccentric and concentric load. The reduction in eccentric load may have reduced muscle activation and reduced the peak force,[7,17] a contributing factor to pre-stretch augmentation in a counter-movement task.[15,17–19] It is possible that performing assisted jumps in conjunction with a situation where the athlete drops a load at the bottom of the counter-movement[20,21] or performing a drop from a height[17,22–26] (in an effort to normalize or increase the eccentric demand to that of normal jumping) may result in even greater adaptation and gains in jump height.

Considering the athletic population recruited for this study (male volleyball players), were already performing large volumes of jumping in their daily training environment and game play,[2,27–29] it is logical that the normal jump condition did not elicit gains in jump height. The athletes in this study were participating in a 'full time' volleyball program that included 7–10 volleyball sessions, and 3 strength and conditioning sessions per week. As such it is likely that the trainable aspects developed through normal jump training would have already been well developed, thereby limiting the potential for further adaptation to occur using this training method. In contrast the novel stimulus of assisted jumping resulted in improved jump height, whereas additional jumping under normal conditions did not. This is consistent with previous work that demonstrates improvements in jump height when a particularly novel stimulus is used, but no additional benefit in simply adding more counter-movement jumps.[21–23] It may be that assisted jumping is a useful tool, but possibly only when combined with traditional strength and conditioning activities. This observation is in agreement with plyometric training studies that indicate gains in vertical jump through plyometrics are superior when combined with other strength and conditioning activity.[23,30]

Practical implications

- Sport scientists and coaches can utilize assisted jumps to improve the jump height of volleyball players.
- Assisted jumping may be an effective stimulus for athletes who already perform a large number of jumps in training.

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