Effects of Plyometric Training Program With and Without Weights on Increasing Countermovement Vertical Jump among Adolescent Female Volleyball Players: A Comparative Study

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Abstract

Volleyball is a well-known highly competitive team sport. Vertical jump ability is of exceptional importance and is critical for success in the game of volleyball. Plyometric training has been recommended to improve an individual's jumping performance however there is limited evidence of using plyometric training towards adolescent volleyball players towards jumping performance. Thus, the aim of this study is to compare the effects of plyometric training with and without loads in increasing countermovement vertical jump among female adolescent volleyball players. This study utilized an experimental design that measured the pre-test and post-test values of the Sargent jump test. A total of 24 participants were recruited in the study and were subsequently divided into two groups. The first group received plyometric program without weights while the second group was given plyometric training with weights. Each training session was performed twice a week during the first three weeks and thrice a week for the succeeding 7 weeks. Independent sample T-test was used to interpret the data gathered using SPSS 21. The study revealed no significant difference between the effects of plyometric training program with weights and without weights (p-value= <0.05). However, plyometric training with weights showed better results when the effect sizes were compared. This study recommends further research concerning limited participants and no standard value existing for the maximum vertical jump heights which make the ceiling effect impossible to avoid.

Keywords: ***p****lyometrics, volleyball, countermovement vertical jump, vertical jump ability*

INTRODUCTION

Volleyball, as a well-known team sport (Fattahi & Sadeghi, 2014; Sattler, Dervisevic, Hadzic, Sekulic, & Uljevic, 2011), has changed considerably in the past three decades. It is considered a highly competitive sport which requires individual players to be physically, physiologically (Sheppard, Gabbett, & Stanganelli, 2009), and mentally-fit (Rao & Rao, 2016). It is characterized by explosive movement patterns, such as jumping, spiking and blocking (Nejic, Trajkovic, Stankovic, Milanovic, & Sporis, 2013). It involves 12 players per team, (with 6 playing members on the court) which are composed of the following positions: setters, hitters, middle blockers and liberos (Trajkovic, Milanovic, Sporis, & Radisavljevic, 2011; Sattler et al., 2011). Factors considered advantageous in the game of volleyball include speed, agility, greater height and great vertical jump ability aside from high-level of fitness, technical and tactical knowledge (Sattler et al., 2011; Koley, Singh, & Sandhu, 2010; Vassil, Karin, & Bazanovk, 2012). Also, conditional training may be combined with some resistance that are suggested to improve player's vertical jump performance (Milanovic, Milic, Sporis, & Stankovic, 2011).

Performance in volleyball may be determined by the player's vertical jump ability which is considered of exceptional importance and is critical for success in the game of volleyball (Vassil et al., 2012; Perez-Turpin et al., 2014; Rao & Rao, 2016).According to Marcovic and Newton (2007), there are four typical jump types such as squat jump, drop jump, countermovement jumps with arm swing and without arm swing. Among the four types, countermovement vertical jump is considered a key movement during serving, setting, blocking and spiking (Vaverka et al., 2016). Technically, it is performed by volleyball players in various defensive and offensive maneuvers whether in practice or in a game (Vaverka et al., 2016). The player's vertical jump ability along with their total jump height has been the focus of most literature that has studied volleyball (Riggs & Sheppard, 2009).

A study conducted by Fattahi, Ali and Sadeghi (2014) about the effects of combined resistance and plyometric training in children and adolescents' volleyball players showed improvement on physical and jumping performance. However, more researches are needed to evaluate the effect of size of different training modalities. Another research conducted by Lehnert, Lamrova and Elfmark (2009) stated that there is a significant improvement in standing vertical jump among female junior volleyball players when using plyometric exercises, but the researchers cannot conclude whether the results were direct effect of their treatment or the participant's physiologic adaptation.

The plyometric method is considered the most frequently used method for conditioning volleyball players (Lehnert et al., 2009). Its main purpose is to increase the measurement of sports performance such as power and speed among athletes. There are three phases of Plyometrics: Eccentric Pre-stretch, Amortization time (Time to Rebound) and Concentric Shortening Phase, and these terms explain the actual events occurring in the plyometric activity itself (Davies, Reimann, & Manske, 2015). Complex training integrates plyometrics and weight to improve the jumping abilities of volleyball players (Schiffer, 2012). According to Noreddine, Djamel, Houccine, and Mohammed (2016), “the plyometric training at short term is efficient for the development of the muscular strength, vertical jumping and the anaerobic abilities.” The author also mentioned that correlating plyometric training to weight lifting training shows efficiency for volleyball players.

According to Fatouros et al. (2000), vertical jumping performance can be improved considerably by plyometrics and weight training separatelybut the combination of plyometric and weight training was considerably more advantageous in increasing vertical jump height. Therefore, the training regimens must include a combination of both elements. Also, weight training must include exercises focusing on power development.

According to Schiffer (2012), increased jump height is a result of lower extremity plyometric training. Although numerous literature were published regarding the effectiveness of plyometrics in different sports, there is still limited evidence that it would benefit the vertical jumping abilities of volleyball players (Davies, Riemann, & Manske, 2015). Khlifa et al. (2010) conducted a study about plyometrics with weighted vest in increasing vertical jumping abilities using basketball players as their participants. The researchers conducted further investigation to prove the benefit of plyometrics with an added weighted vest to increase the vertical jumping abilities of female volleyball players.

Only few studies were established about using strength training program. However, these studies did not analyze the effects of loads on the jumping performance of the female volleyball players (Moreno, Asencio, & Badillo, 2014). To date, there are no studies conducted about plyometrics with and without weights in female adolescent volleyball players in the Philippines.

This study aimed to compare the effects of a plyometric training program with and without weights in increasing countermovement vertical jump for adolescent female volleyball players. The results of this study will be beneficial to adolescent population in improving the vertical jumping ability of competitive female adolescent volleyball players in Batangas City using plyometrics with and without weights.

MATERIALS AND METHODS

Research Design

Aquasi-experimental design was used to compare the effects of plyometrics with and without load in improving countermovement vertical jump in female adolescent volleyball players.

Participants

Participants were recruited for inclusion in our study from October to November 2017. A total of9 schools with volleyball playing teams were selected in different areas within Batangas City. Participants were considered eligible for plyometric training if they did not present signs of pain and swelling on the lower extremities, with age ranging from 12 to 16 years, have full ROM of all joints more importantly in the lower limbs using Goniometry (Araújo et al., 2014), can balance for 30 seconds with eyes opened and closed which were tested by single leg stance (Atwater, Crowe, Deitz, & Richardson, 1990), have good muscle strength and endurance using manual muscle testing (Florence et al., 1992), has good coordination with no compensationsfor neuromuscular control and able to perform single-leg hop squat, free weight squats, squats (60% of body mass) and lower level plyometric drills with no pain and good qualitative movement patterns. Participants who do not have the foundational strength or training based upon which a plyometric program can be built were excluded from the study (Davies et al., 2015). In addition, liberos of the volleyball teams were also excluded since jumping is not part of their playing position.

The participant's anthropometric characteristics (n=24) are presented in Table 1 which were obtained by an assessor (intra-rater reliability of 0.91) prior to randomly assigning participants to study groups. The assessor was blinded to whether which group was performing plyometrics training with and without weights. Only two out of nine schools were included in the study since the remaining schools were either not able to meet the inclusion criteria or they were already starting with their own training program. Twelve out of fifteen competitive female volleyball players from each school passed the inclusion criteria. To prevent inconsistency, the players in their respective institution were given the same intervention and were randomly assigned. At the time of the study, the players were all in the offseason training and possessed 5.1+-0.68 years of volleyball experience. The participants were not involved in any other kind of training other than the training being provided by the researchers during the study. Written informed consent were distributed and signed by the participant's parents or guardians indicating the demands and risks of the training program prior to the execution of the procedures.

Device

A weighted vest was utilized on the plyometric training group with weights. It weighted 10-11% of the subject's body mass. (Khlifa et al., 2010).

Figure 1. Weighted Vest

Assessment tool

1. Sargent Vertical Jump test

Explosive strength of the lower limbs of athletes was measured by the Sargent jump test. This assessment tool has a higher reliability (ICC=0.99). Based on protocol of Harman et al. (1991), the participants must wear a colored marker on their right hand, As the participants extend their right hand against the wall, the highest point of jump will be marked by maximum height jump.

Procedure

Based on study by Luebbers et al. (2003), two groups, the plyometric with weights and plyometric group without weights, must perform a 10-week training program. The exercises include 2-legged vertical jumps, tuck jumps, 2-legged broad jumps, 1- and 2-legged bounding, and depth jumps. This should be done based from the participants' vertical jump height in sergeant chalk test.

Before the start of each training session, the participants completed a 10-minute warm-up consisting of striding and low-intensity running, and 5-minute coordination movements. Afterwards, a 5-minute warm-up was performed using the same exercise at lower intensity. Three minutes of rest was given before the actual training session.

Each session was performed twice a week during the first 3 weeks and 3 times a week for the last 7 weeks. Recovery times between repetitions and sets were 15-40 seconds and 2-3 minutes, respectively. Participants were instructed to give their best effort in performing each exercise during the training session. Proper execution of the training and safety was ensured through the supervision of the researchers. This protocol was patterned from the study of King et al. (2010) with minor modifications. It showed an increase in countermovement vertical jump among adolescent athletes. The program consists of 282 repetitions per exercise.

Participants were re-assessed before and 48 hours after the 10-week program of plyometric training to allow proper neuromuscular adaptation to occur (Luebbers et al., 2003).

Statistical Analysis

Data were analyzed using SPSS version 21. Pre-test and post-test data were computed using independent sample t-test. All statistical level of significance was set at $p<0.05$.

Ethical Consideration

The protocol was reviewed by the Ethical Review Board of Mary Mediatrix Medical Center. All participants signed an informed consent prior to the implementation of the study. Before the research instrument was distributed, participants were informed about the research objectives, and the potential significance of the study. All participants were assured that theirinformation will be kept confidential and will be used solely for research purposes.

RESULTS AND DISCUSSION

Table 1 shows the demographic profile of twenty-four participantsofthe study. Age of the female adolescent volleyball players ranged from 14-15 years old, with a height of 148 cm – 160 cm and a weight of 41.6 kg – 55.5 kg.

Table 1
Demographic Profile of the Participants

Profile	**Mean ± Std.Dev.**
Age	14.63±0.495
Height (cm)	154.25±2.69
Weight (kg)	46.68±3.61

Table 2 showed that all participants are homogenous in termsofage, height weight and pre-test value of SJT (cm) prior to the start of the procedure. The results showed no statistical significant difference for both groups (p-value= < 0.05). No significant differences were found on the participants' age (p-value= 0.689), height (p-value= 0.460) weight (p-value= 0.510) and pre-test values of SJT (cm) (p-value= 0.253).

Table 2
Baseline Values of the Participants

Group	Variable	N	Mean	T	p
1	Age	12	14.67		
2		12	14.58	.41	0.689
1	Height (cm)	12	153.83		
2		12	154.67	.75	0.460
1	Weight (kg)	12	46.18		
2		12	47.188		0.510
1	Pre-test values of SJT	12	34.62	1.175	0.253
2	(cm)	12	32.38		

Group 1 - Plyometric Training without weights
Group 2 - Plyometric Training with weights
Legend: Significant at p-value < 0.05

Table 3 shows the 10-week training program used by both groups which is based from the study of Luebbers et al. (2003). The protocol include four different jump exercises such vertical jump, bounding jump, broad jump and box jump. This protocol ensures the safety of the participants and was found to be less aggressive after the study was done because the players were already competitive volleyball players.

Table 3
Treatment Protocol for Both Experimental Group

Exercise	1 week	2 week	3 week	4-10 week
Vertical jumping	*3 (8)	*3 (8)	*3 (8)	*3 (10)
Bounding	*3 (8)	*3 (8)	*3 (8)	*3 (10)
Broad jumping	*3 (8)	*3 (8)	*3 (8)	*3 (10)
Drop jump	*3 (8)	*3 (8)	*3 (8)	*3 (15)

*Number of sets
()Number of repetitions

Table 4
Comparison of the Pre- and Post-Test Sargent Vertical Jump Test Values (cm) Within Each Group

	Group	N	Mean	T	P
Pre	1	12	34.62	1.175	
Post		12	36.78	2.395	0.346
Pre	2	12	32.38	1.175	
Post		12	36.03	2.395	0.026

Group 1 - Plyometric Training without weights
Group 2 - Plyometric Training with weights
Legend: Significant at p-value < 0.05

Table 4 revealed that the pre-test and post-test of Sargent jump test of the group receiving only plyometric training did not differ significantly (p-value= 0.346), compared to those that received plyometric training with weights (p-value= 0.026).

The results above are somewhat different from the study of Khlifa et al. (2010) which showed significant difference for the pre-test and post-test Sargent jump test values for both groups (plyometric only and plyometric with weights). However, when the magnitude effect ([post - pre]/prex 100) is computed, this study showed a vertical jump height improvement of 6.40% (plyometric training only) and 11.36% (plyometric training with weights), which are greater than the results demonstrated by Khlifa et al. (2010) at 5.6% and 7.5%, respectively.

Table 5 shows that the post-test values (p-value= 0.699) of the Sargent jump test for both groups have no significant difference. This implies that there is no difference as to the effects of a training of plyometric alone and a training with added weights.

Table 5
Comparison of Sargent Jump Test Values (cm) After Plyometric Training Program Between Groups

	Group 1		Group 2
N	12		12
Mean	36.78		36.03
Difference		0.75	
t-value		0.392	
p-value		0.699	

Group 1 - Plyometric Training without weights
Group 2 - Plyometric Training with weights
*Legend: Significant at *p-value < 0.0*

The computed mean difference of the post-test values minus the pre-test values of the Sargent jump test of each group (p-value= 0.000)was shown in Table 6. It implies a greater magnitude of improvement occurring in the group receiving plyometric training with weights.

Table 6
Computed mean differences of the Pre-Test and Post-Test Values of the Sargent Jump Test After the Plyometric Program Training Between Groups

	Group 1		Group 2
N	12		12
Mean	2.17		3.65
Difference		1.48	
t-value		17.424	
p-value		0.000	

Group 1 - Plyometric Training without weights
Group 2 - Plyometric Training with weights
*Legend: Significant at *p-value < 0.05*

This study showed that there is no significant effect for those who underwent plyometric training compared with those who received plyometric training with weights. This result contradicts the study of Khlifa et al. (2010) which concluded that both plyometric training with and without weights are effective which may be due to some factors such as the modification of repetitions to ensure the safety of the participants. The modification of the protocol with regards to number of repetitions was based on King and Cipriani (2010), which also focused on participants with similar ages. A study by Fattahi and Sadeghi (2014), suggested that plyometric training is useful in both adult and children if the appropriate program and precautions are considered. However, this finding cannot be discounted as Markovic (2007) presented the possibility of publication bias among similar studies exploring the effect of plyometric training only. The same study also presented effect size as an alternative for measuring the magnitude of improvement, saying that an increase of ~5 - 10% of the vertical jump height could already be of high importance in sports like basketball and volleyball relying on jump performance for success. Thus, the magnitude effect obtained in this study for the group receiving plyometric training with weights (11.36%) can still be considered as important.

Comparing the post-test values of both groups, it has been found that the results showed no significant difference and that plyometric training with and without weights show similar effects. This may also be due to the modification of the protocol and other factors such as the chance of the participants attaining their maximum vertical jump height. However, the maximum vertical jump height cannot be predicted since there is no normative value existing for adolescent female volleyball players. Another factor is the mean baseline value for the maximum vertical jump height for both groups. The pretest values showed that even though both groups have statistically similar baseline values, the mean maximum vertical jump height for the group receiving plyometric training only is 2 cm higher. This might have reduced the amount of improvement for this group, inferring from the similar post-test values of both groups.

Only the plyometric training with weight was found to be effective in the study. This could be accounted for a short 10-week training program that caused a significant increase in the plyometric training without weights. In addition, research studies by Sozbir (2016) and Tillaar, Waade, and Roaas, (2015) stated that the repetitions alone may not be enough to show significant difference compared to a training combined with added weights. Also, a larger population would be more likely to present with treatment effects than smaller sample size (Chimera, Straub, Swanik, & Swanik, 2004).

CONCLUSION

Plyometric with weights is an effective protocol for increasing countermovement vertical jump height among female adolescent volleyball players. However, plyometrics without weights did not produce improvement in vertical jump height.

RECOMMENDATIONS

The researchers recommend that plyometric training with added weights should be considered in future training programs of female adolescent volleyball players, as vertical jump height ability is of great importance in volleyball.

Future studies should take into consideration factors such as bigger sample size, fixed set of repetitions for the length of the training program, and the possible presence of ceiling effect. Moreover, increasing the repetitions and resistance, with respect to the exercise tolerance of the players, may have added positive effects towards their countermovement vertical jump height ability hence, the researchers also suggest that assessment of vertical jump height be done on a weekly basis to determine the duration when vertical jump height improvement will reach its peak and plateau. Also, real-time observation of the players' performance in an actual game must be done to verify whether the treatment effects will translate to their actual game play.

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