International Journal of Physical Education, Sports and Health 2020; 7(6): 151-156

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2020; 7(6): 151-156

www.kheljournal.com
Received: 19-08-2020
Accepted: 05-10-2020

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Effects of lower body plyometric training in young Kashmiri female volleyball players

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Abstract
According to the findings of current study, CVJ-L, CVJ-R, RBJ, SLJ, and T agility test performance increase from pre-test to post-test for both UP and BP, but there are no significant differences between groups. Significant interaction effects are observed for the CVJ-R, RBJ, and T agility test, indicating that from pre-test to post-test the UP has greater improvement than the CON, according to the line graphs. The CVJ and SJ do not differ among types of training or from pre-test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is not significantly better than the other in improving the jump ability and agility performance. The results from the current study indicate the effectiveness of unilateral and bilateral plyometric training on lower body power. Increase in lower body power may potentially improve overall volleyball performance by enhancing the jump ability and agility performance.

Keywords: Volleyball players, UP and BP, Kashmiri female

Introduction
Volleyball is an anaerobic sport that combines explosive movements with short periods of rest. High intensity bouts happen frequently to players in the frontcourt during offensive and defensive jumping bouts (Sheppard *et al.*, 2008). The ball takes about 1.2 court, 1.4 s to cover from one side to the other side of the requires the players to adjust their body position quickly (Borras, Balius, Drobnic, & Galilea, 2011). imp rove power production Plyometric exercises have been widely used to and are highly correlated with athletic performance especially in sprinting and possible mechanism that (Wilson & Flanagan, 2008). of subsequent movements jumping. The stretch shortening cycle (SSC) is one explains the effectiveness of plyometric exercises The principle of utilizing SSC to increase the power can be explained by activating the natural elastic components of muscles and tendon as well as the stretch reflex. When utilizing a rapid immediately follow eccentric muscle actioned by a concentric contraction, the activated muscle can produce higher force in the concentric phase. Therefore, exercises activating the SSC such as jumping are widely applied in training recently (Baechle & Earle, 2008). Jumping exercises can be classified under different approaches, whether they are performed bilaterally or unilaterally. Single leg exercises can be performed by using right and left legs alternately, or by repeating with one leg only (Baechle & Earle, 2008). Both methods are commonly use d in varying amounts in volleyball and much other sports training. The fact that plyometric training is usually not performed in isolation type of exercise.
The comparison of seems to be more useful the effects of unilateral and bilateral plyometric training as volleyball players require both single leg and double leg jump depending on their playing position and tactic. Implementing the most effective training stimulus and exercises should be the goal when developing sport specific characteristics in vo phenomenon of lleyball players. Moreover, based on the bilateral deficit that occurs in jumping, it is tempting to hypothesize that power training performed with each leg separately may allow greater loads and thus greater adaptations compared to bilateral (Bobbert, de Graaf, Jonk, & training Casius, 2006). Therefore, the magnitude of training effects of unilateral and bilateral plyometric training is still questionable. Vertical jump performance is an effective assessment tool because the height of the jump has been shown to correlate significantly with maximal power production relative to body mass (McClenton *et al.*, 2008).

Maximal force capacity, rate of force development, muscle coordination and the ability to utilize the SSC are all factors that determi ne vertical jump performance (Arabatzi *et al.*, 2010) [1]. Assessing lower body muscular power with valid and reliable field tests is important for strength and conditioning professionals (Markovic, Dizdar, Jukic, & Cardinale, 2004)

Physical Education is a process through which an individual obtains perfect, physical, mental and social capacities and wellness through physical activity (Lumpkin, 1990) favo. Physical Education can be portrayed as "a critical and rable experience got past interest in physical activities that are physically sound reasonably bracing, satisfying and socially strong." The physical wellness of the individual is the fundamental purpose of physical guideline. The technique can content in physical preparing to improve physical wellness that will be imagined. Fitness is characterized as "an arrangement of characteristics that individuals have or accomplish that identifies with the capacity to perform physical movement." Fitness is an expansive term and a mind boggling subject which can incorporate Health and aptitude related fitness. As of late physical fitness has been partitioned into Health related fitness and Performance or ability related fitness. Each individual needs to know the significance of physical fitness. In particular, one must know about the basic information of life structures and physiology that will empower individual to comprehend physical fitness. Physical fitness implies the limit of a man to work consistently and easily when a circumstance emerges. As indicated by numerous analysts the general activities assist one with keeping solid and sound and to counteract cardio vascular sicknesses. The core of a physically fit individual is that his heart beats at a lower rate and pumps more blood per beat very time. Customary activities can build the person's ability to utilize oxygen deliberately. Vitality creation relies upon inner substance or metabolic change. Wellbeing, Fitness and Performance are interrelated to each other. Wellness is specifically identified with man's capacity to meet the requests of his condition and greatness in execution.

Purpose of the Study

The purpose of present study was to examine the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players of Jammu and Kashmir.

Methodology

This study was designed to address the question of which plyometric training mode is better for improving jump and agility performance in young female volleyball players. The aim of the present study was to examine the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players of Jammu and Kashmir. Sampling In total 100 secondary school female volleyball team players with age between 12 and 17 from different secondary schools were recruited for the study. The subjects had no systematic strength or plyometric training for the last 6 months leading up to the study (less than one session per week). The subjects were randomized and divided into three groups: the unilateral plyometric training group (UP), the bilateral plyometric training group (BP), and the control group (CON). In addition to the school regular volleyball training, the UP and the BP performed a plyometric training session twice a week for 8 weeks. The CON performed the regular volleyball training only throughout the study. Subjects received written and oral information about the study design and measurement procedures. The possible risks and benefits of participating in the study were explained to the subjects before signing an informed consent. Exclusion criteria included athletes with potential medical problems or any history of injury that would affect their physical performance or the results of this study in the three months preceding the study. Subjects were asked to continue their normal daily lifestyle for the duration of the study.

Statistical Analysis

A pre-test post-test randomized groups experimental design was used. Standard statistical methods were used for calculation of means and standard deviation. The independent variables were the types of plyometric training: UP, BP, and CON. The dependent variables included the test results of bilateral countermovement vertical jump (CVJ), unilateral countermovement vertical jump (left leg) (CVJ (CVJR),L), unilateral countermovement vertical jump (right leg) squat jump (SJ), 5 repeated blo (SLJ), and T ck jumps (RBJ), standing long jump agility test. Normality and homoscedasticity assumptions for all data (pre-test and intervention, (3 groups x post-test) were checked respectively. To determine the effect of seven 2way analysis of variance (ANOVAs) with repeated measures 2 times) were applied. If a significant F value is achieved between groups, Bonferroni post hoc procedures would perform to locate the pairwise differences between the means. Standardized effect sizes and percent change were at p conducted to examine the treatment effects. Statistical significance was set = .05, and the Statistical Package for the Social Sciences Version 24.0 for Windows (SPSS Inc., Chicago, IL) program was used for all statistical calculations.

Results and discussion

The purpose of present study was to examine the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players. A total of 100 female subjects completed the 8-week intervention study. Out of 100 participants, 13 were excluded from the study due to the low attendance rate of the training (>2 sessions absence) or absence from the post-test. Descriptive statistics for age, height, and weight are presented in Table 1. The subjects completed a pre- and post-test along with 15 training sessions. Descriptive statistics for pre-and post-test sessions are presented in Table 2 and 3:

Table 1: Descriptive Statistics for Female Subjects (N = 62)

	UP (n = 33) M± SD	*BP* (n = 33) *M± SD*	*CON*(n = 34) *M± SD*
Age (years)	16.16 ± 1.65	16.18 ± 1.80	16.19 ± 1.74
Height (cm)	167.14 ± 6.57	164.07 ± 2.34	161.14 ± 3.55
Weight (kg)	59.51 ± 9.03	55.80 ± 4.36	55.17 ± 5.62

Unilateral plyometric training group (UP), the bilateral plyometric training group (BP), and the control group (CON)

Table 2: Training Effects for the Jump and Agility Performance Variables for the UP (n = 33), BP (n = 33), and CON (n= 34)

	Pre-test M± SD		*Post-test M± SD*	
CVJ (cm)				
UP	37.70	± 4.74	38.43	± 5.60
BP	39.25	± 2.69	40.54	± 3.19
CON	38.28	± 4.22	37.61	± 3.10
CVJ-L				
UP	21.33	± 2.71	23.35	± 2.69*
BP	22.74	± 2.59	24.95	± 1.89*
CON	23.29	± 2.90	24.08	± 2.91
CVJ-R				
UP	21.30	± 2.59	24.69	± 3.07*
BP	24.64	± 1.88	25.95	± 2.19*
CON	24.14	± 3.13	24.16	± 2.96
SJ (cm)				
UP	36.38	± 4.81	37.72	± 5.69
BP	38.49	± 3.09	39.02	± 2.85
CON	37.23	± 5.09	37.03	± 4.74

*Sigificant ($p < 0.05$) pre- to post-test comparisons.

Table 3: Standardized effect sizes, change, and percent change for the jump and agility performance variables for the UP (n = 33), BP (n = 33), and CON (n = 34)

	D	*Change*	*%Change*
CVJ (cm)			
UP	0.24	0.74	3.10%
BP	0.59	1.33	4.59%
CON	-0.33	-0.68	-1.90%
CVJ-L (cm)			
UP	0.81	2.04	12.02%
BP	0.85	2.25	12.20%
CON	0.38	0.78	4.89%
CVJ-R (cm)			
UP	0.75	2.39	13.38%
BP	0.68	1.31	7.10%
CON	0.01	0.02	0.09%
SJ (cm)			
UP	0.43	1.35	5.01%
BP	0.19	0.56	2.49%
CON	-0.08	-0.24	-0.58%
RBJ(cm)			
UP	0.69	1.94	7.77%
BP	0.94	1.55	7.26%
CON	-0.05	-0.10	-0.34%
SLJ			
UP	1.00	7.66	5.52%
BP	0.76	9.31	6.42%
CON	0.24	3.13	2.86%
T agility test (s)			
UP	-1.37	-0.89	-5.01%
BP	-0.68	-0.44	-2.00%
CON	-0.49	-0.36	-1.35%

Seven 3 x 2 mixed factorial ANOVAs were used to analyse the data. Group was an independent variable with three levels: UP, BP, and CON. Test occasion was the repeated measures variable with two levels: pre-test and post-test. Bilateral countermovement vertical jump (CVJ), unilateral countermovement vertical jump (left leg) (CVJ-L), unilateral countermovement vertical jump (right leg) (CVJ-R), squat jump (SJ), 5 repeated block jumps (RBJ), standing long jump (SLJ), and T agility test were the dependent variables. Age group differences (age 12-13, age 14-15, and age 16-17) have been analysed but no differences were found. Analysing the CVJ-R data, a significant mean difference was found from pre- to post-test for the groups. No significant differences ($p > .05$) in CVJ-R existed between groups. A significant interaction effect was observed for the CVJ-R. UP experienced a greater improvement in CVJ-R following 8 weeks training compared to CON. The standardized effect size for test occasion was 0.72 for the UP and 0.01 for the CON. This indicates that the UP jumped higher with a 12.38% increase in the CVJ-R compared to the 0.09% increase in the CON. The present study was designed to examine the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players. The subjects in the study were 62 secondary school female volleyball players, between the ages of 12 and 17 years. CVJ-L, CVJ-R, RBJ, SLJ, and T agility test performance increased after 8 weeks for both UP and BP, but the findings proposed that one program was not significantly better than the other in improving the jump ability and agility performance. Significant interaction effects existed for the CVJ-R, RBJ, and T agility test, indicating that from pre-test to post-test the UP had greater improvement than the CON, according to the line graphs. The CVJ and SJ did not differ among types of training or from pre-test to post-test. Slimani, Chamari, Miarka, Del Vecchio, and Chéour (2016) concluded that more than eight weeks of systematic plyometric training are necessary to improve physical performance in elite players. They also pointed out that shorter period of plyometric training (less than eight weeks) had the potential to enhance a wide range of athletic performance like jumping, sprinting, and agility in children and youth amateur players. Therefore the intervention period of present study was set as eight weeks for the young volleyball players. Makaruk *et al.* (2011) studied the effects of unilateral and bilateral plyometric training on power and jumping ability in women and suggested that unilateral plyometric exercises enhanced power and jumping performance in a shorter period compared to the bilateral plyometric exercises that the gains in performance would last longer. In the current study, the plyometrics training programs involved the same number of cotraining to midntacts with the ground between groups (bilateral and unilateral). The current study lasted for 8 weeks which was similar to the pretraining period of the study by Makaruk *et al.* (2011). According to the results of current study, 4 out of 7 assessments (CVJ term R, SJ, RBJ, and T agility test) had better results in UP than BP in terms of the percentage change. This may be explained by the finding by Makaruk *et al.* (2011), as unilateral plyometric training may be more effective during a short training cycle. The researcher hypothesized that the subjects who received unilateral plyometric training would have better performance than bilateral training group on unilateral power test and agility test, while the subjects who received bilateral plyometric training would have better performance than unilateral training group on bilateral power test. Although the results showed that there were no significant differences between groups, there was a potential showing the differences on the level of improvement when interpreting the percentage change from pre to post-test for UP and BP. For the CVJ-- test R, the UP jumped higher with a 12.38% increase compared to the 6.10% increase in the BP. Through the observation during the study, most of the volleyball p layers (right two dominant hand) seldom jump by single right leg, as left leg would be used to jump for a step fast attack in most situations. During the intervention, the subjects in UP had a lot of right single leg jumps. Therefore the larger extent of improvement on the CVJR may be explained because of the neural adaptation and coordination to the plyometric training for power enhancement (de Villarreal *et al.*, 2009). For the T agility test, the UP ran faster with a 6.01% decrease in the time compared t the 3.00% decrease in the BP. According to Slimani, Chamari, Miarka, Del Vecchio, o and Chéour (2016), previous studies investigating the effect of plyometric training on agility t have shown an average of 9.7% decrease in agility time, with the range test from 2.5% to 23%. The results of present study did match the findings. Slimani *et al.* (2016) also indicated that the combination of unilateral and bilateral jump training seems to have more advantages than bilateral jump training alone in improving agilit y performance. For the differences and BP, between UP it may be explained by the characteristic of running and changing of direction. During running, shuffling, and the moment of changing direction, single leg is used to generate the power for moving our body (McCurdy *et al.*, 2005). It is reasonable that the UP performed better after 8 weeks single leg plyometric training.

For the SJ, both training groups did not have significant improvement after result may be explained by the specificit the training. This y of the training. Squat jump removed the countermovement (eccentric contraction) part of a vertical jump, while the subjects did always focus on plyometric training with countermovement jumps triggering the SSC. Therefore it was reasonable that both train ing groups did not have significant improvement in SJ when there was no specific SJ training throughout the eight weeks intervention. For the CVJ, both training groups did not have significant improvement after the training. Gottlieb, Eliakim, Shalom, Dell oIacono, and Meckel (2014) reported no significant changes on bounding distance and vertical jump height after six weeks of plyometric jump training for young basketball players. Likewise, Lehnert, Hůlka, Malý, Fohler, and Zahálka (2013) studied the effec ts of 6 week plyometric training programme on countermovement jump and two step run up jump. However no significant effect was found in the posttest. Slimani, Chamari, Miarka, Del Vecchio, and Chéour (2016) pointed out that these results were probably due to the characteristics of the subject, such as the training level, sport activity, age, gender, and familiarity with plyometric exercises. The result of current study may be explained by the characteristic of a volleyball game. Volleyball players tend to jump bilaterally in a game in usual, such as traditional side spiking and blocking. Therefore, the subjects already performed a lot of bilateral jumps during the regular volleyball training and competition. This may attenuate the effect of the plyometric t raining as the subjects did always executed the bilateral countermovement vertical jump in addition to the plyometric training program. As a result, little improvement on the CVJ was observed. Significant interaction effects existed for the CVJ that from pretest to post-- R, RBJ, and T agility test, indicating test the UP had

significant greater improvement than the CON. This implies that unilateral training can obviously improve certain jumping abilities and agility especially the performance involving sing le leg movement. Therefore, unilateral training should be included if the sports involve much single leg jumping skills. The results of this study improve the understanding of the effects of different types of plyometric training on jump and agility performance, and can help develop an effective and efficient training program for sport practice and competition. The results suggest that both unilateral and bilateral plyometric training are valuable and should be considered by the strength and conditioning professionals and sports coaches who would like to focus on improving the jump ability and agility performance of the athletes. The results of this study highlight the potential of using both plyometric training methods to improve the vertical and horizontal power as well as the agility performance of related components volleyball thought to be necessary for success. Besides, the training programs of present study require no specific equipment (only benches are needed), it is very convenient for coaches to implement the programs to a large group of athletes in a school setting. A limitation of the study is that it was difficult to determine the accurate intensity of the training without quantitative measurement. Different from strength training that percentage of 1 repetition maximum can be applied, the subjects in present study used the body weight for the plyometric training, therefore the researcher could not manipulate the exact percentage of intensity for each subject. During the intervention, the researcher did ask the subjects to perform each jump with maximal effort in order to minimize this limitation. The probable inconsistent intensity applied among subjects may affect the degree of effect on the performance. For recommendation for further study, in addition to the jump height and distance measured in the present study, rate of force development (RFD) would be another useful measurement for assessing muscular power of the athletes. Laffaye and Wagner (2013) found that besides peak RFD and concentric RFD, eccentric RFD was also a strong predictor of jumping performance by summarizing the ability of the muscletendons system to store efficiently elastic energy and to release elastic energy as well as activating the stretch reflex. Therefore the further study would be more comprehensive and in measurement is included. Depth if the RFD Apart from RFD, Electromyography (EMG) can also be used to measure the muscle activation in different parts of muscles. Rodacki, Fowler, and Bennett (2002) examined the segmental coordination of vertical jumps under fatigue of the knee extensor and flexor muscles by using EMG assessment. The researchers found that fatiguing the knee flexor muscles did not reduce the height of the jumps while knee extensor fatigue caused the subjects to adjust several variables of the movement in which the performance was reduced. The researchers suggested that the neural input under the fatigued condition did not form an optimal solution and may lead to the decrease in maximal jump height achievement. Therefore adding EMG to assessment may better help understand the effects of training on muscle activation and coordination. Researchers should also consider the gender of the subjects. Female subjects were included in the present study; however, gender differences may be a factor affecting the results. De Villarreal *et al.* (2009) stated that men showed higher gains in vertical jump height compared to women because of the higher power output and better coordination. According to Ceroni, Martin, Delhumeau, and Farpour Lambert (2012), the highly significant difference in vertical jump performance between male and female teenagers appears to start at age 14. Much greater increase in leg length and muscle volume in male than in female were suggested to be the explanation of the differences. Laffaye, Wagner, and Tombleson 38 (2014) pointed out that the relative eccentric rate of force development was 11.6% higher in males than in females, indicating males have a higher capacity to accelerate their body when performing a countermovement vertical jump. The researchers suggested that the lower rate of force development observed in females may be the result of structural differences in the muscles elastic properties, the higher pennation angles in males than in females of the vastus lateralis (15.8° vs. 14.1°) and the gastrocnemius medialis (26° vs. 24.5°), and longer fascicles in the vastus lateralis in men and gastrocnemii in women, which were concluded to affect the jumping performance. Furthermore, Walsh, Böhm, Butterfield, and Santhosam (2007) found that the arm swing plays an important role in jumping performance in men than in women. The study showed that the arm swing allowed an increase of 7 cm (23%) for men and 4 cm (17%) for women. The researchers suggested that the greater upper body strength and coordination of men contributed to the arm swing and therefore resulted in a more significant increase in jump height. Therefore, researchers conducting future studies should include gender as a variable of interest. Another recommendation for the research design is the combination of the training modes. In reality, both unilateral and bilateral training would usually be adopted by the coaches. Therefore, researchers could attempt to compare combined training to unilateral and bilateral training in order to find out the better program for improving the performance outcomes. According to the findings of current study, CVJ performance increase from pre-test to post-test L, CVJR, RBJ, SLJ, and T agility test t for both UP and BP, but there are no significant differences between groups. Significant interaction effects are observed for the CVJ and T agility test, indicating that from pre-test to post-- R, RBJ, test the UP has greater improvement than the CON, acco or from prerding to the line graphs. The CVJ and SJ do not differ among types of training test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is no better than the other in improving the jump ability and agility t significantly performance. The results from the current study indicate the effectiveness of unilateral and bilateral plyometric training on lower body power. Increase in lower body power may potentially improve overall volleyball performance by enhancing the jump ability and agility performance.

Summary

The purpose of this study was to examine the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players. Secondary school female volleyball players (N = 62, age = 14.56 ± 1.45 years, height = 159.14 ± 6.57 cm, weight = 53.55 ± 9.03 kg) were randomized and divided into three groups: the unilateral plyometric training group (UP), the bilateral plyometric training group (BP), and the control group (CON). For the UP and BP, the subjects completed 15 unilateral or bilateral plyometric training sessions over 8 weeks in addition to the regular volleyball training. For the CON, the subjects performed the regular volleyball training only. Pre-test and post-test were performed by all subjects before and after the intervention. The jump ability and agility performance were assessed by

countermovement vertical jump (CVJ: double legs, right leg, and left leg), squat jump (SJ), 5 repeated block jumps (RBJ), standing long jump (SLJ), and T agility test. 2-way ANOVAs with repeated measures (3 groups x 2 times) were used to analyse the data. The results indicated that CVJ (right leg and left leg), RBJ, SLJ, and T agility test performance significantly increased ($p < .05$) after 8 weeks for both unilateral and bilateral training, but there were no differences ($p > .05$) between groups. Interaction effects ($p < .05$) existed for the CVJ (right leg), RBJ, and T agility test, indicating that from pre-test to post-test the UP had greater improvement than the CON. The CVJ (double legs) and SJ did not differ ($p > .05$) among types of training or from pre-test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is not significantly better than the other in improving the jump ability and agility performance. Plyometric training, such as the depth jump, have been shown to increase vertical jump height (Bobbert, 1990; Jensen & Russell, 1985; McClenton *et al.*, 2008; Sheppard *et al.*, 2008; Verkhoshansky, 1968; de Villarreal *et al.*, 2009; Voelzke *et al.*, 2012). Plyometric exercises that utilized the SSC increased the power output of the athlete in the concentric phase (Arabatzi *et al.*, 2010; Hori *et al.*, 2005) [1]. The majority of the literature has focused on how plyometrics affect jump ability. However, few studies investigated the performance outcome differences between unilateral and bilateral plyometric training. Additional research is needed to compare the unilateral and bilateral plyometric training protocols on jump ability as well as agility performance.

Conclusion

The result of existing learning, CVJ-L, CVJ-R, RBJ, SLJ, and T agility test performance increase from pre-test to post-test for both UP and BP, but there are no significant differences between groups. Significant interaction effects are observed for the CVJ-R, RBJ, and T agility test, indicating that from pre-test to post-test the UP has greater improvement than the CON, according to the line graphs. The CVJ and SJ do not differ among types of training or from pre-test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is not significantly better than the other in improving the jump ability and agility performance. The results from the current study indicate the effectiveness of unilateral and bilateral plyometric training on lower body power. Increase in lower body power may potentially improve overall volleyball performance by enhancing the jump ability and agility performance.

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