Original article

Effect of short duration plyometric training on vertical jump and sprint speed in volleyball players

Efeito do treinamento pliométrico de curta duração no salto vertical e velocidade de sprint em jogadores de vôlei

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ABSTRACT | INTRODUCTION: Volleyball is a fast-paced sport that involves vertical and horizontal projections of the ball by the player. The use of plyometric training is a popular method to enhance performance in players. **OBJECTIVE:** The present study aims to see the effect of short-duration plyometric training on vertical jump and sprint speed in volleyball players. **METHOD:** This study is a parallel group randomized controlled trial. Thirty-nine participants were screened for participation in the study, of which 30 were selected following the inclusion and exclusion criteria for the study. The inclusion criteria for the study comprised of volleyball players of age group 18 to 24 years, both males and females, with playing experience of at least one year, and willing to participate. The exclusion criteria for the study included players with a history of injury in the last six months, any reported neurological or musculoskeletal disorder, and any psychological condition. The selected participants were randomly allocated to Group A and Group B using the lottery method. Group A was given plyometric training for three days a week and Group B was asked to continue their regular routine exercises and playing schedule. The total duration of the intervention was four weeks. The outcome measure for the study was sprint speed and vertical jump height. Sprint speed was measured by the 20 m sprint test, and the vertical jump height was measured by the Sargent jump test. The assessment was done at the baseline and at the end of four weeks. An unpaired t-test was used to analyze between-group differences, and paired t-test was used to analyze the within-group differences in the outcome variables. The significance level was set as $p<0.05$. **RESULTS:** The result of the study showed a significant improvement in vertical jump height (MD= -7.133, 95% CI-12.657, -1.609) and no significant improvement in sprint speed when between-group comparisons were made (MD=0.084, 95%CI -0.177,-.345) with an effect size of 0.75 for vertical jump height. The within-group comparison was found significant only for vertical jump height in Group A, and there was no significant improvement was found in sprint speed for both Group A and B. FINAL CONSIDERATIONS: The short-duration plyometric training is effective in improving the vertical jump height and not the sprint speed in volleyball players. The specificity of plyometric training is important for optimal improvement in sports performance.

KEYWORDS: Plyometric exercise. Volleyball. Physical fitness. Athletes.

RESUMO | INTRODUÇÃO: O voleibol é um esporte de ritmo acelerado que envolve projeções verticais e horizontais da bola por parte do jogador. O uso de treinamento pliométrico é um método popular para melhorar o desempenho dos jogadores. **OBJETIVO:** O presente estudo visa verificar o efeito de quatro semanas de treinamento pliométrico em jogadores de voleibol. **MÉTODO:** Estudo randomizado, controlado, de grupos paralelos. Foram triados 39 participantes para participação no estudo, dos quais 30 foram selecionados seguindo os critérios de inclusão e exclusão da pesquisa. Os critérios de inclusão foram: jogadores de voleibol na faixa etária de 18 a 24 anos, de ambos os sexos, experiência de jogo de no mínimo um ano e disponibilidade para participar. Os critérios de exclusão compreendiam jogadores com histórico de lesão nos últimos seis meses, qualquer distúrbio neurológico ou musculoesquelético e qualquer condição psicológica. Os participantes selecionados foram alocados aleatoriamente no Grupo A e Grupo B usando o método de sorteio. O Grupo A recebeu treinamento pliométrico por três dias em uma semana, e o Grupo B foi solicitado a continuar seus exercícios regulares de rotina. A duração total da intervenção foi de quatro semanas. A medida de resultado para o estudo foi a velocidade do *sprint* e a altura do salto vertical. A velocidade de *sprint* foi medida pelo teste de *sprint* de 20 m e a altura do salto vertical foi medida pelo teste *sargent jump*. A avaliação foi feita no início e no final de quatro semanas. O teste t não pareado foi usado para analisar as diferenças entre os grupos e o teste t pareado foi usado para analisar as diferenças dentro do grupo nas variáveis de resultado. **RESULTADOS:** O resultado do estudo mostrou uma melhora significativa na altura do salto vertical (MD= -7,133, IC 95% (-12,657,-1,609) e nenhuma melhora significativa na velocidade do *sprint* quando comparações entre grupos foram feitas (MD=0,084, 95% IC (-0,177,-,345) com um tamanho de efeito de 0,75 para a altura do salto vertical. A comparação dentro do grupo foi considerada significativa apenas para a altura do salto vertical no Grupo A, e não houve melhora significativa na velocidade de *sprint* para ambos Grupo A e B. **CONCLUSÃO:** Quatro semanas de programa pliométrico é eficaz em melhorar a altura do salto vertical e não a velocidade de *sprint* em jogadores de voleibol.

PALAVRAS-CHAVE: Exercício pliométrico. Voleibol. Aptidão física. Atletas.

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Introduction

Volleyball is a dynamic and fast-paced game. It is an intense anaerobic sport that involves swift recovery times between explosive horizontal and vertical motion. In the game, a player performs approximately 250-300 powerful explosive leg movements that mainly incorporate jumps, in which about 50-60% are high-speed movements, 30% are changes of direction, and 15% are the fall.[1] The nature of the volleyball game requires the use of explosive power of the upper and lower extremity for jumping and propelling the ball in the opponent's court. Explosive power is a function of strength and speed of muscular contraction, which demands a high amount of neuromuscular coordination. The vertical jump is a particularly challenging activity that calls for the coordinated use of numerous arms, legs, and trunk.[2] Developing the jumping skills of the players allows them to perform higher and quicker in order to take better shots and block the opponent's shots. Thus, the jumping ability is considered one of the determining factors to assess the high performance in volleyball players.[3] Sprint speed is another important component that allows a player to excel in the game, as it allows them to rapidly reach the ball and change directions to throw it into the opponent's court in the game of volleyball.

Plyometric training is a popular form of exercise that is used to enhance physical performance. Plyometrics are exercises that involve jumping, hopping, and bounding that resemble the nature of many sports activities.[4] The plyometric involves the contraction of muscle eccentrically followed by the concentric contraction known as the stretch-shortening cycle (SSC). The SSC causes the shifts in a muscle from a quick deceleration to rapid acceleration, and a vigorous eccentric muscular action is produced by the quick eccentric movements, which also include a stretch reflex. The force produced increases with the speed of muscle stretching and increase the strength of the muscle movement.[5,6] The use of plyometrics in volleyball endeavors to strength and speed of movement to produce power. The plyometric improves the power of the subsequent movement by using the natural component of muscle and tendon as well as the stretch reflex. Along with this, the plyometric contributes to the optimization of the landing mechanism and improvement in eccentric muscle control, increase in knee flexion, and activity of hamstring muscle.[7] Thus, plyometrics involves muscles performing more work in a short period of time, which is used to increase explosiveness. The standard plyometric exercises consist of hopping, bounding, and jumping drills such as drop jump, countermovement jump, and squat jump, which resemble the movements involved in many sports.[8]

These exercises can be given independently or in combination with other training programs and are performed at various intensity levels. Various studies have explored the role of plyometric training in combination with other training methods as well as alone in volleyball players.[9-12] The combination of bodyweight plyometric training, which includes depth jumps, countermovement jumps, and squat jumps, reported a 4.7 percent to 15 percent improvement in vertical jump height.[13] It was also suggested that the use of plyometric training increases neuromuscular coordination through training the nervous system[14] as a result of SSC[15], in which there is muscle lengthening followed by the concentric action of the muscle, which stimulates more muscle units and increases the amount of elastic energy in the muscles, resulting in improved joint proprioception, higher firing frequency, and improved flexibility of the muscle.[16] The improved flexibility of the muscles can contribute to increasing the explosive power of the muscles of the lower limb and can improve the sportsperson's performance. Numerous studies have explored the role of plyometrics on explosive power, strength, speed, and vertical jump height, but only a few have explored the role of short-term plyometric training on vertical jump performance and speed, which is an important component of this sport. Thus, the present study was undertaken to explore the effect of short-duration plyometric training on vertical jump performance and sprint speed in volleyball players.

Materials and methods

Study design

The study was performed as a parallel group randomized controlled trial, approved by the Institutional ethical committee, number PTY/2022/155 dated 20/04/2022, Department of Physiotherapy, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, and was performed in accordance with the Declaration of Helsinki, 2013. The study was also registered in the Clinical Trial Registry of India, number CTRI/2022/07/044279. Written informed consent was obtained prior to participation in the study.

Participants

Volleyball players from various sports academies in Hisar and nearby areas were screened for participation in the study using convenience sampling. The inclusion criteria for the study comprised volleyball players of age group 18 to 24 years, both males and females, with playing experience of at least one year, and willing to participate. The exclusion criteria for the study included players with a history of injury in the last six months, any reported neurological or musculoskeletal disorder, and any psychological condition.

The sample size estimation was done based on the findings of a previous study that suggested a minimum of eight participants per group to estimate the effect of plyometric training on volleyball players.[10]

Procedure

A total of 39 participants were screened for participation in the study. Out of these, 30 were selected following the inclusion and exclusion criteria. The selected participants were randomly allocated to the experimental (Group A) and the control group (Group B) by simple random sampling using the lottery method. Group A was given plyometric training for three days a week, and Group B was asked to continue their regular routine exercises. The total duration of the intervention was four weeks.

The participants in Group A were given plyometric training, which included vertical jumping, bounding, broad jumping, and depth jumping for three days a week for four weeks. Each exercise was done 10 times per session with a rest period of 15-30 seconds. Table 1 shows the protocol of exercise used in the study.

Table 1. Plyometric training program protocol

Experimental group					Control group
Exercises	Week 1	Week 2	Week 3	Week 4	Warm-up and stretching, aerobic training, and regular playing schedules
Vertical Jumping	15sets (10reps)	20sets (10reps)	25sets (10reps)	25sets (10reps)	
Bounding	3sets (30m)	5sets (30m)	7sets (30m)	8 sets (30m)	
BroadJumping	5sets (15m)	5sets (30m)	7sets (30m)	8sets (30m)	
DepthJumping	3sets(5reps)	5sets(9reps)	6sets(15reps)	6sets(15reps)	

Source: the authors (2023).

Outcome measures

The outcome measure for the study includes sprint speed and vertical jump height. The outcome measures were taken at the baseline and at the end of four weeks. The speed was measured by the 20 m sprint test, and the vertical jump height was measured by the Sargentjumptest.

20 m sprint test: the participants performed two submaximal 20 m sprints after a warm-up session, followed by three timed sprints on an outdoor track. The time to complete the sprint was noted by a handheld stopwatch nearest to 0.1 seconds.[10]

Sargent jump test: the participants were asked to perform the test after a warm-up of five minutes. The participants were instructed to stand on the side of the wall with both feet on the ground and were then asked to reach as high as possible and mark the wall with chalk. This was marked as M1. Then the participants were asked to jump as high as possible and mark the wall with the chalk again. This distance was marked as M2. The distance between M1 and M2 was calculated and was reported in centimeters. The Sargent jump test is a valid and reliable tool for measuring the vertical jump height for estimating the explosive power of the lower extremity.[17] The readings of outcome measures were assessed three times, and the average of the readings was taken for analysis.

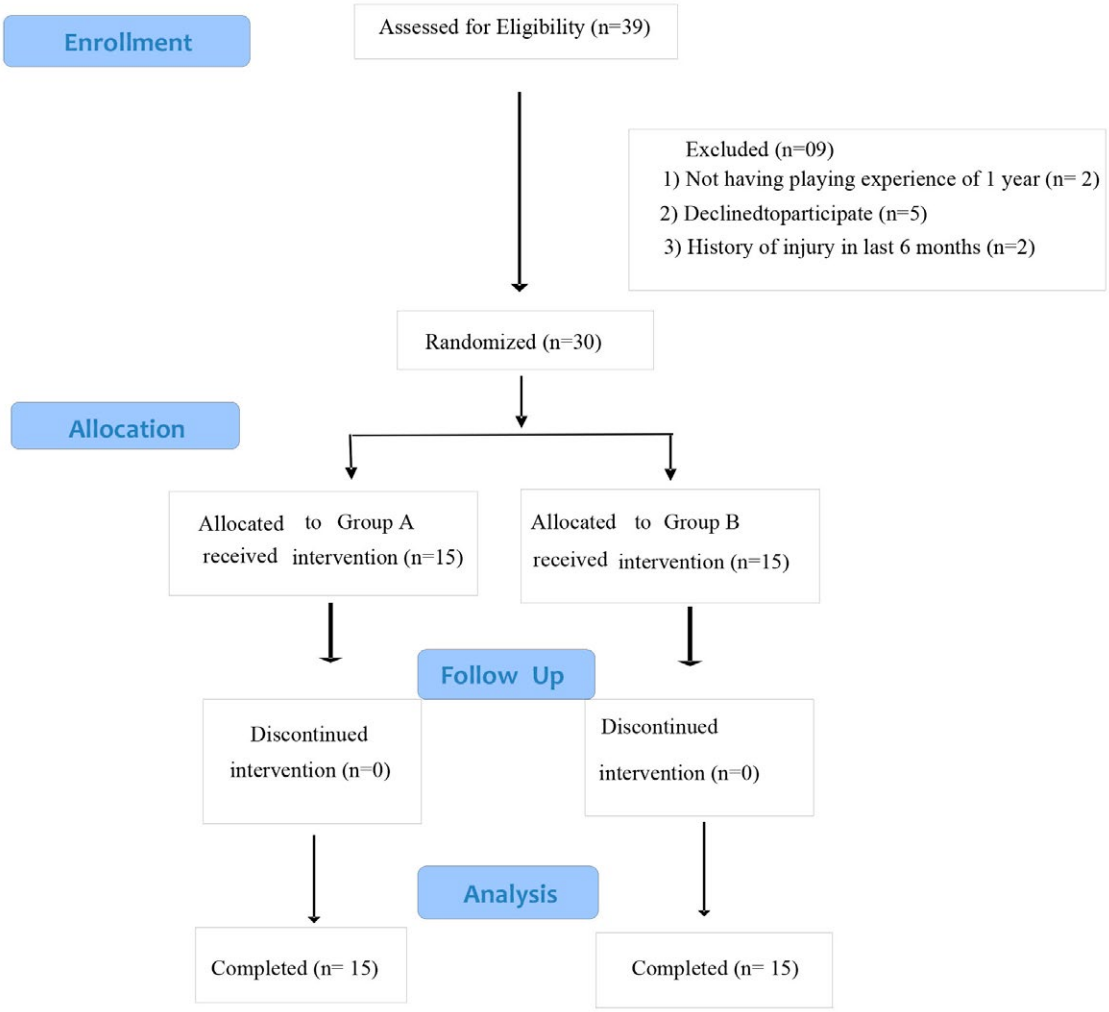
Data Analysis

The data were analyzed in SPSS (version 21.0) and presented as mean, standard deviation, and frequency. The normality of data was assessed by Skewness and Kurtosis. The between-group comparison for the outcome variables was done using an unpaired t-test. Paired t-test was used to analyze the within-group comparisons of the outcome variables. The chi-square test was also used for variables not distributed normally. The level of significance was set as $p<0.05$.

Result

A total of 30 participants were selected for participation in the study and were divided into two groups. Figure 1 shows the flow chart of the study.

Figure 1. CONSORT 2010 FlowDiagram



Source: the authors (2023).

The demographic characteristics of the participants are mentioned in Table 2. The mean age of the participants in group A was 21.60±2.20, height was 167.87±4.91, weight was 60.60±8.62, Body Mass Index (BMI) was 21.43±2.11 and the mean training hours were 16.80±3.55 weeks. The mean age of the participants in group B was 20.93±1.03, height was 171.87±6.82, weight was 63.60±10.76, BMI was 21.48±3.15 and the mean training hours was 19.13±3.20 weeks.

Table 2. Descriptive characteristics of the study participants

	Variables	Group A (Plyometric Group)		Group B (Control Group)		t-value	p-value
		Mean	SD	Mean	SD		
1.	Age	21.60	2.20	20.93	1.03	1.063	0.297
2.	Height (cm)	167.87	4.91	171.87	6.82	1.843	0.076
3.	Weight (kg)	60.60	8.62	63.60	10.76	0.843	0.406
4.	BMI	21.43	2.11	21.48	3.15	0.048	0.962
5.	Weektraining Hours	16.80	3.55	19.13	3.20	1.890	0.069

Source: the authors (2023).

The result of the study showed a significant improvement in vertical jump height when between-group comparisons were made (t = 2.645, p = 0.013*). The within-group comparison of the vertical jump height was also significant in the experimental group t= 6.627, p= 0.0001**. However, no improvement was observed in the sprint speed when between-group comparisons were done t= 0.660, p= 0.515. Table 3 shows the between-group comparisons of the outcome variables, Table 4 shows the mean differences in the outcome variables, and Table 5 shows the within-group comparisons of the outcome variables.

Table 3. Between group comparisons of the outcome variables

	Group A (Plyometric group)		Group B (Control group)	t- value*	p value
		Mean and SD	Mean and SD		
Vertical jump height	Pre	43.87± 7.78	41.00 ± 7.10	1.054	0.301
	Post	47.87± 7.87	40.73 ±6.86	2.645	0.013*
	Gain	4.00 ±2.34	-0.27 ± 0.96	6.538	0.0001**
Speed	Pre	3.49± 0.29	3.62±0.43	1.010	0.321
	Post	3.55±0.33	3.64±0.37	0.660	0.515
	Gain	0.07±0.13	0.02±0.11	1.153	0.259

* unpaired t test, p<0.001**

Source: the authors (2023).

Table 4. Mean difference in the outcome variables

	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		t-value	p-value
			Lower	Upper		
Sprint Speed (PRE) Fastest time	.135	.134	-.139	.410	1.010	.321
Sprint Speed (POST) Fastest time	.084	.127	-.177	.345	.660	.515
Average time-Pre	.086	.121	-.162	.334	.710	.484
Average time-Post	.100	.114	-.134	.334	.875	.389
Vertical Jump Height (PRE) in cm	-2.867	2.720	-8.438	2.704	1.054	.301
Vertical Jump Height (POST) in cm	-7.133	2.697	-12.657	-1.609	2.645	.013*

Source: the authors (2023).

Table 5. Within group comparisons of the outcome variables

	Variable		Mean	SD	t-value**	p-value	Effect size
Group A (Plyometric Group)	Speed	Pre	3.487	0.285	1.996	.066	0.22
		Post	3.554	0.330			
	Vertical jump height	Pre	43.867	7.777	6.627	.0001**	0.76
		Post	47.867	7.873			
Group B (ControlGroup)	Speed	Pre	3.622	0.434	.550	.591	0.02
		Post	3.638	0.367			
	Vertical jump height	Pre	41.00	7.104	1.075	.301	0.07
		Post	40.733	6.863			

**** paired t test, p<0.001****

Source: the authors (2023).

Discussion

The aim of the current study was to investigate the effect of plyometric exercise on vertical jump height and speed in volleyball players. This study reveals that there was a significant improvement in vertical jump height when between-group comparisons were done. However, there was no significant difference in sprint speed. The result of the within-group comparison also showed a significant improvement in the vertical jump height and no significant improvement in speed in Group A, while Group B showed no significant improvement in speed and vertical jump height.

The result of the present study was found to be consistent with the finding of a study that also showed that plyometric training provides greater benefits to vertical jump than sprint speed with eight weeks of plyometric training.[10] Whereas there are studies that showed that the plyometric training that involved repeated horizontal jumps and rebound jumping improved leg muscle power in undergraduates[9] and improvement in explosive power and speed values in female volleyball players.[18] The possible reason for the improvement in vertical jump height is the nature of training that involves bounds, hops, and jumps in horizontal and vertical directions that might have increased the motor efficiency and the neural stimulation of the muscle. A similar mechanism was also demonstrated by a study showing that plyometric exercises increase the neural stimulation of muscle and subsequently improve the production of power.[18]

Plyometric exercises involve various jump activities that produce a stretching force that gives rise to eccentric muscle contraction that stores elastic energy and contributes to an increase in strength in the subsequent concentric contraction.[5,6] The use of plyometric exercises improves the explosiveness by training the muscles to do more work in a short amount of time followed by optimizing the SSC, with the goal of increasing power. The only goal of this exercise is to rapidly transition a muscle from extension to contraction, as in repeatedly jumping. In volleyball, the vertical jump is a common movement performed by the players that call for the coordinated use of the upper and lower extremity. The ability of a volleyball player to project higher in vertical jumping is an indicator of explosive power. A review suggested that using different types of plyometrics, such as squat jumps, countermovement jumps, and drop jump, optimizes the jumping performance rather than using one form of plyometric exercise. It was also suggested that the plyometric training of more than 10 weeks and more than 20 sessions that use a high intensity-program produces greater improvements in vertical jump heights.[19]

The present research also showed no significant improvement in sprint speed. A similar finding was seen in a study that also showed no significant improvement in speed with plyometric training.[12] The possible reason for the insignificant improvement in the speed in the present study could be that the duration of the four-week plyometric training program and the intensity of the training program used were not sufficient enough to improve the sprint speed. Another possible reason for the no improvement in sprint performance is that the training adopted used more of the vertical training component and less of the horizontal component. Similar recommendations were given by a study that suggested that the sprint performance could be improved by using a combination of different types of plyometric programs with training programs involving sprint-specific plyometric exercises and jumps with horizontal displacement.[20]

The principle of specificity is also an important element in plyometric exercises. Studies have also shown that the plyometric exercises that only involved the jumping component of the exercises, and not the running component, showed no increase in the running speed, and when the exercises were specific to running performance, the plyometric training showed a positive effect.[21] The volume and intensity of training are important components in plyometric training to achieve greater improvement in vertical jump height and speed. The present study only included a total of 12 sessions of training, which only improved the vertical jump height and not the sprint speed. It was also advocated in a study that plyometric training of higher intensity produces greater improvement in the sprint speed, and the optimization of a training program that involves greater horizontal acceleration such as skipping, bounding, short distance sprints, and jumps with more horizontal displacement would produce greater benefits in the sprint performance.[20]

This study has similar demographic characteristics and training levels and adequate muscle strength to estimate the effect of the intervention used. Regarding the generalization, applicability, and external validity of the study, no dropout of the participants was addressed and the short duration of plyometric training that focused more on the horizontal component of displacement in the training, which is required in the game of volleyball, improved the vertical jump height.

Thus, it can be interpreted that the short duration of plyometric training can significantly improve the vertical jump height but is insufficient to improve the speed of volleyball players in this study. This research encountered some limitations related to the small sample size and low statistical power used. Therefore, future studies can be conducted on large sample sizes, and the use of a training program that focuses on both the vertical as well as horizontal components of plyometric training, and a combination of different types of plyometric training programs rather than one form can be explored in volleyball players.

Final considerations

It can be concluded that the short-duration plyometric program was effective in improving the vertical jump height and not the sprint speed of volleyball players. The specificity of plyometric training is important for optimal improvement in sports performance.

Authors' contributions

Chaturvedi R and Muwal M participated in conception, design, and in data collection. Chaturvedi R and Rani V participated in data analysis. Chaturvedi R, Joshi S and Bagri M participated in drafting the article. Chaturvedi R, Rani V, Joshi S and Bagri M contributed to the critical revision and final approval of the article.

Conflicts of interest

No financial, legal or political conflicts involving third parties (government, companies and private foundations, etc.) were declared for any aspect of the submitted work (including, but not limited to grants and funding, participation in an advisory board, study design, preparation manuscript, statistical analysis, etc.).

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