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RESEARCH ARTICLE

EFFECT OF PLYOMETRIC TRAINING ON PERFORMANCE AND INCIDENCE OF INJURY IN VOLLEYBALL PLAYERS

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ABSTRACT

Objective: to determine the effect of Plyometric Training on Performance and Incidence of Injury in Volleyball Players. **Material and Methods:** Thirty male volleyball players participated in this study, their ages ranges from 15-30 years old. They were divided into two groups, (Group A) which included 15 players who received traditional training program which included four practical trainings per week (running for 20 minutes, hopping for 15 minutes, jogging for 15 minutes and specific volley ball activates for 30 minutes) plus two gymnastics workout trainings sessions a week plus plyometric exercises program practiced twice a week for six weeks, and (Group B) which included 15 players who followed a program consisted of traditional training program which included four practical trainings per week (running for 20 minutes, hopping for 15 minutes, jogging for 15 minutes and specific volley ball activates for 30 minutes) plus two gymnastics workout trainings sessions a week. Both groups were assessed pre and post-treatment by using Backward overhead medicine ball throw test, 1-RM Leg press test, Vertical jump test and Rate of incidence of injury. **Results:** There was a significance increase in the mean values of the Backward over head medicine ball throw test (P=0.02), Vertical jump test (p=0.01) and 1-RM Leg press test (P=0.01) of the Group A post training compared with that of Group B. While there was a significance decrease in incidence of injury in Group A compared with that of Group B (p=0.0001). There was no significance increase in the mean values of the Backward over head medicine ball throw test (P=0.45), Vertical jump test (p=0.63) and 1-RM Leg press test (P=0.48) of the Group A pre training compared with that of Group B. **Conclusion:** It was concluded that plyometric exercises have a significant effect on Backward overhead medicine ball throw test, 1-RM Leg press test, Vertical jump test and Rate of incidence of injury in comparison to traditional training program in volleyball players.

INTRODUCTION

Volleyball is one of the most popular sports in the world, with more than 200 member countries in the Federation International de Volleyball (FIVB) and about 150 million players, However, injury is a potential outcome of participation and since volleyball is a non-contact game, where players from the opposing teams are separated by the net, it may be expected that the incidence of injuries is low. However, studies have indicated that injuries in volleyball are quite frequent (Verhagen *et al*., 2004). According to 4-year data from the FIVB Injury Surveillance System the incidence of time-loss injuries of volleyball was 3.8/1000 playing hours (Bere *et al*., 2015). The injury incidence is between 1.7 and 4.2 per 1000 hours of play and it is the fourth most common source of sports injuries (Solgard *et al*., 1995). Ciesla *et al*. (2015) reported that over 87% of the respondents suffered from at least one sport-related injury. In total, 362 injuries occurred, on average 4.02 injuries per one volleyball player. The most common sports injuries involved ankle (46 injuries), knee and lower leg muscles (30), interphalangeal articulations of fingers (30) as well as shoulder joint. More than half of the injuries (57%) occurred twice or three times. Ciesla *et al*. (2015) reported that over 87% of the respondents suffered from at least one sport-related injury. In total, 362 injuries occurred, on average 4.02 injuries per one volleyball player. The most common sports injuries involved ankle (46 injuries), knee and lower leg muscles (30), interphalangeal articulations of fingers (30) as well as shoulder joint. More than half of the injuries (57%) occurred twice or three times. The most frequent acute injury in volleyball, an ankle sprain, is often the result of player contact, that is, when a blocker lands on the foot of an opposing attacker, or a teammate, close to the net (Verhagen *et al*., 2004). Volleyball players are also prone to acute finger sprains, which mainly occur in contact with the ball (Eerkes, 2012). Similar to other throwing athletes, shoulder problems may result from repetitive spiking and serving (Seminati *et al*., 2013). A high volume of jump training may cause knee problems (Visnes *et al*., 2013). Plyometric is a specialized, high intensity training technique that enables an athlete's muscle to deliver as much strength as possible in the shortest period of time so that power will be developed (Chimera *et al*., 2004).

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All types of plyometric movement occur during three consecutive phases: the first phase consists primarily of stretching or eccentric muscle activity, which is marked by a high concentration of elastic muscle energy, the second phase is known as the amortization phase and begins with the end of the first phase, and ends with the beginning of the concentric muscle action, and finally the third phase, the final phase of muscle contraction, which is primarily manifested as the jump, hit or throw. These phases in plyometric movement are known by one name: the stretch-shorten cycle of muscle work (Stojanovic *et al*., 2012). A good volleyball player needs the ability to rapidly switch between forward, backward, lateral and vertical movement, it is understood that the key to success for volleyball game is to become proficient with the more basic training versions and then advance to more difficult one like plyometrics (Saluja *et al*., 2009).

Aim of study: To determine the effect of plyometric Training on Performance and Incidence of Injury in Volleyball Players.

MATERIAL AND METHODS

This study took place at Wadi Degla sporting club. Thirty male volleyball players were allocated randomly into 2 groups. Group A which included 15 players who received traditional training program which included four practical trainings (running for 20 minutes, hopping for 15 minutes, jogging for 15 minutes and specific volley ball activates for 30 minutes) and two gym workout trainings sessions a week plus plyometric exercises program practiced twice a week for six weeks, and Group B which included 15 players who followed only a program consisted of traditional training program.

Assessment procedures

Backward overhead medicine ball throw test: The standing backward overhead medicine ball throw was consisted of starting with the feet shoulder width apart, heels on the zero measurement line, and the medicine ball (3 Kg) was hold with arms straight out front at shoulder height. The countermovement consisted of the subjects flexed the hips and knees. At the same time, they also flexed forward at the trunk, lowering the medicine ball to just below waist or hip height.
After the countermovement, the subjects began to thrust the hips forward and to extend the knees and trunk. They were flexed the shoulders, elevating the ball back up to shoulder height and beyond as they thrown it back over their head. The arms maintained in an extended manner. The finishing point was with the ankles plantar flexed; the knees, hips, and trunk was extended; and the shoulders was flexed to above the head.
At the end of the throw, the subjects' feet were allowed to leave the ground, as what happened with a jumping motion, to minimize any deceleration component of the vertical ground reaction forces. The subjects were asked to keep their arms as straight as possible as they were throw the ball back over their head with a pendulum action. This instruction was mean to force the legs, trunk, and shoulders to generate the power. The distance of the throw was measured in centimeters from the front of the individual's toes to the first point at which the medicine ball made contact with the floor. The measurement was took as a shot, the tape measure was placed at the zero point where the individual was stand and the tape measure was extended to the point at which the ball made its first contact. Figure (1).

Fig. 3. Backward over head throw test

1-RM Leg press test

The 1-RM leg press assessed the maximum muscular strength of the major muscles of the lower extremity. Warm-up was consisted of a set of five repetitions at the loads of ~40% of the perceived maximum. Leg press test was completed using standard leg press machine (Gym Tech). Participants assumed a sitting position with back on padded supported. On command, the participant performed a concentric extension (as fast as possible) of the leg muscles started from the flexed position to reach the full extension of 180° against the resistance. Tester was alerted the participants when the starting and finishing positions was attained. Each participant was performed 3 maximal trails. Best of three was considered as the maximum weight, it was measured at pre and post 6-week training Figure (2)

Fig. 2. RM Leg press test

Fig. 3. Vertical jump test

Vertical jump test

Vertical jump test was done according to SARGENT Standard Test. First, correct process of measurement was described for participants and they were warmed up completely to perform the test. Participant was stand side on to a wall and reached up with the hand closest to the wall. They were keeping the feet flat on the ground; the point of the fingertips was marked. This called the standing reach height. Then they were stand away from the wall, and jumped vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempted to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height was the score. The best of three attempts was recorded (Fattahi *et al*., 2015). Figure (3).

Rate of incidence of injury

Incidence of non- contact injury was estimated in both groups at the end of the season (10 months).

Athletic trainers were given weekly injury reporting forms to monitor the number of injuries and mechanism of injury was occurred in a specific week along with game and training. It was calculated per 1000 hours of games as well as 1000 hours of training, but in each case using the total number of injuries. Thus the risk per 1000 hours of exposure was calculated as the following: number of new injuries x 1000/total hours of either training or games (Dvork and Junge, 2000).

Statistical analysis

Descriptive statistics and t-test was conducted for comparison of the subject characteristics between both groups. Mixed MANOVA was conducted to compare the effect of time (pre versus post) and the effect of treatment (between groups), as well as the interaction between time and treatment on mean values of backward overhead medicine ball throw test score, vertical jump test score and leg strength. Chi squared test were conducted for comparison of hand dominance between both groups. Statistical measures were performed through the statistical package for social studies (SPSS) version 22 for windows. Comparison of incidence rate of injury between

groups was carried out using MedCalc Software bvba. The level of significance for all statistical tests was set at $p < 0.05$.

RESULTS

Patient characteristics: The study sample consisted of 30 male players divided equally into two groups (A and B).

Group A: fifteen male volleyball players were included in this group. Their mean ± SD age, weight, height and BMI were 23.06 ± 4.41 years, 89 ± 3.92 kg, 189.8 ± 2.85 cm and 24.69 ± 0.75 kg/m² respectively.

Group B: Fifteen male volleyball players were included in this group. Their mean ± SD age, weight, height and BMI were 21.86 ± 3.88 years, 89.33 ± 4.35 kg, 190.93 ± 3.49 cm and 24.58 ± 0.47 kg/m² respectively.

DISCUSSION

The data of present study was conducted to evaluate the effect of Plyometric Training on Performance and Incidence of Injury in Volleyball Players. This study focused on male volley ball players performance and incidence of mainly non contact injuries during training and competition hours through a season.

Table 1. Descriptive statistics and t-test for comparing the mean age, weight, height and BMI of study and control groups

	Group A	Group B	MD	t- value	p-value	Sign
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Age (years)	23.06 ± 4.41	21.86 ± 3.88	1.2	0.79	0.43	NS
Weight (kg)	89 ± 3.92	89.33 ± 4.35	-0.33	-0.22	0.82	NS
Height (cm)	189.8 ± 2.85	190.93 ± 3.49	-1.13	-0.97	0.33	NS
BMI (kg/m²)	24.69 ± 0.75	24.58 ± 0.47	0.11	0.48	0.62	NS

$\bar{x}$: mean SD: Standard deviation MD: mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

Table 2. Mean backward overhead medicine ball throw test score pre and post training of the study and control groups

Distance of throw (cm)	Pre	Post	MD	% of change	P-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Group A	902 ± 168.19	1050.66± 246.56	-148.66	16.48	0.0001	S
Group B	861.66± 120.73	876.33 ± 137.27	-14.67	1.7	0.56	NS
MD	40.34	174.33				
P-value	0.45	0.02				
Sig	NS	S				

$\bar{X}$: Mean, SD: Standard Deviation, MD: Mean difference, p value: Probability value, S: Significant, NS: Non significant

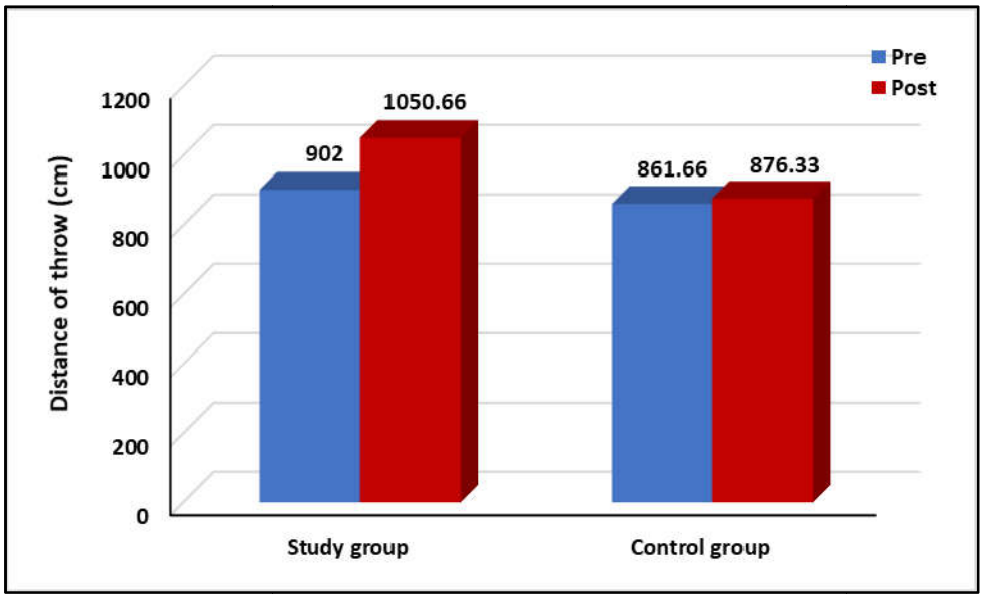

Fig. 4. Mean backward overhead medicine ball throw test score pre and post training of both groups (study and control)

Table 3. Mean vertical jump test score pre and post training of the study and control groups

Jump distance (cm)	Pre	Post	MD	% of change	P-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Group A	60.73 ± 3.69	66.2± 3.76	-5.47	9	0.0001	**S**
Group B	61.4± 3.83	62.86 ± 3.15	-1.46	2.37	0.02	**S**
MD	-0.67	3.34				
P-value	0.63	0.01				
Sig	**NS**	**S**				

$\bar{X}$: Mean, SD: Standard Deviation, MD: Mean difference, p value: Probability value, S: Significant, NS: Non significant

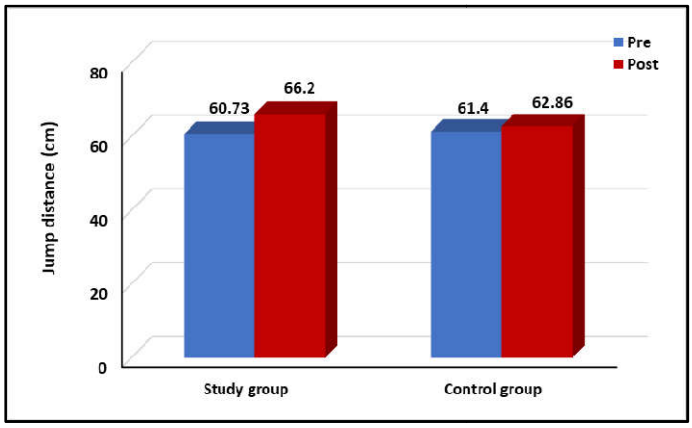

Fig. 5. Mean vertical jump test score pre and post training of both groups (study and control)

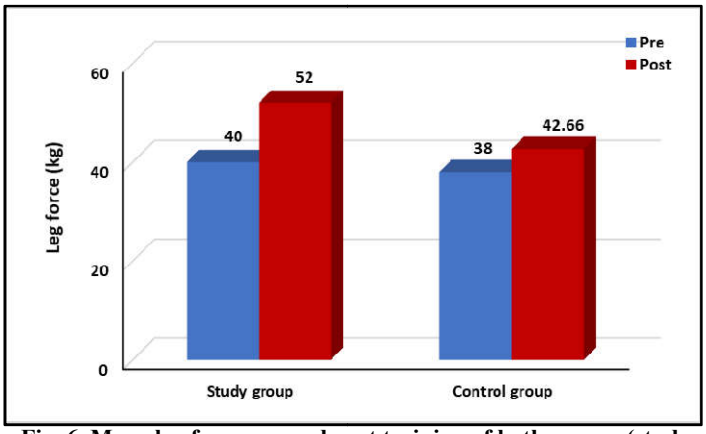

Fig. 6. Mean leg force pre and post training of both groups (study and control)

Table 4. Mean leg force pre and post training of the study and control groups

Leg force (kg)	Pre	Post	MD	% of change	P-value	Sig
	$\bar{x}$ ±SD	$\bar{x}$ ±SD				
Group A	40 ± 7.55	52± 12.07	-12	30	0.0001	**S**
Group B	38± 7.74	42.66 ± 10.32	-4.66	12.26	0.01	**S**
MD	2	9.34				
P-value	0.48	0.03				
Sig	**NS**	**S**				

$\bar{x}$: Mean, SD: Standard Deviation, MD: Mean difference, p value: Probability value, S: Significant, NS: Non significant

Table 5. Comparison of the incidence rate of injury between the study and control groups

Incidence rate (injury /1000 hours)	Group A Number (incidence rate)	Group B Number (incidence rate)	Incidence rate difference	p-value	Sig
Supraspinatus tendinitis	6 (7.29)	8 (9.73)	-2.43	0.0001	**S**
Tennis elbow	2 (2.43)	2 (2.43)	0	1	**NS**
Metacarpal fracture	1 (1.21)	2 (2.43)	-1.21	0.0001	**S**
Jumpers' knee	7 (8.51)	9 (10.94)	-2.43	0.0001	**S**
Ankle sprain	2 (2.43)	4 (4.86)	-2.43	0.0001	**S**
Meniscal injury	3 (3.64)	8 (9.73)	-6.08	0.0001	**S**
ACL injury	0 (0)	2 (2.43	-2.43	0.0001	**S**
Total number of injuries	21 (25.54)	35 (42.75)	-17.03	0.0001	**S**

p value: Probability value, S: Significant, NS: Non significant

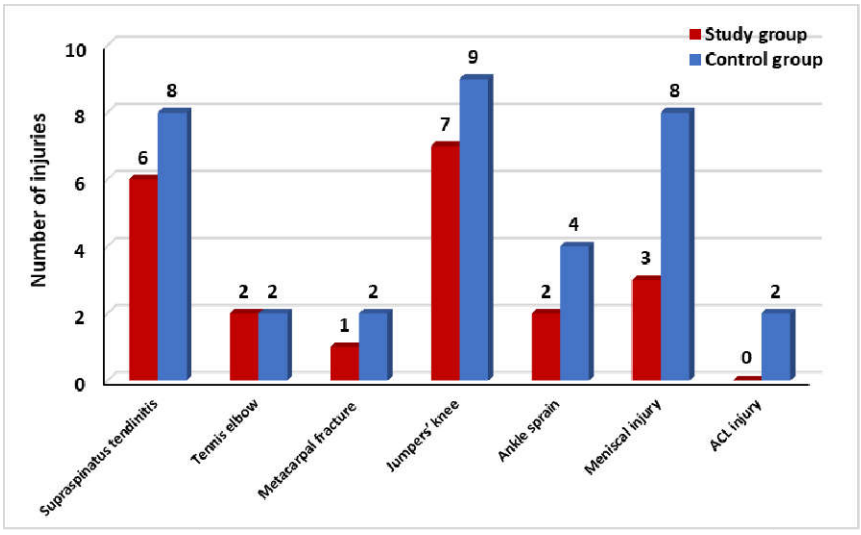

Fig. 7. Number of injuries in study and control groups

This study showed significance improvement in players performance through (Backward overhead medicine ball throw test, 1-RM Leg press test, Vertical jump test) and significance decrease at rate of incidence of injury at study group which applied specific plyometric training for 6 weeks. There was no significance increase in the mean values of the Backward over head medicine ball throw test, Vertical jump test, and 1-RM Leg press test of the Group A pre training compared with that of Group B. Valades *et al*., 2017 found after 8 weeks of upper limb plyometric training during competitive season of female volley ball team a significant improvement at overhead medicine ball throws with 1 kg (+7.19%), 2 kg (+7.69%), and 3 kg (+5.26%) in study group, but The control group did not present differences in these variable. Gjinovci *et al*., 2017at the

end of the 12-week training of plyometric on 41 volley ball player (post-testing). Plyometric group was found to have a significantly improved their performance in 20 m sprint (moderate effect size; 8%), medicine ball throw (very large effect size; 25%), counter movement jump (large effect size; 27%), and standing broad jump (moderate effect size; 8%). But skill-based-conditioning group improved counter movement jump (large effect size; 18%), standing broad jump (small effect size; 3%), and medicine ball throw (large effect size; 9%). plyometric-training is found to be more effective than skill-based conditioning in improvement of conditioning capacities of senior volleyball players. This study results demonstrated a significant increase in the mean values of the vertical jump test score of the study group post treatment compared with that of control group (p = 0.01), But Kerim SOZBIR, 1998 found after 6 weeks of plyometric training on 24 highly physically active physical education students, in addition to the regular academic program, induced significant improvements in EMG activities of lower extremity muscles but no significant increases in vertical jump height. Markovic *et al*., 2007 on the other hand found significance improvement in vertical jump height after plyometric training program. Idrizovic *et al*, 2018. investigated the effect of a 6-week plyometric exercise training program on the development of lower limb explosive power in terms of vertical jumping ability on 9 male volleyball players ,They reported that from a practical standpoint, the improvement, which was noticed after 3 and 6 weeks, seems to optimal period for volleyball players adaptation to significant increased training load. Enginsu *et al*., 2014 studied the effects of plyometric training on prevention of ACL injuries with lower limp kinematics, eccentric hip and knee torques, and functional performance. Plyometric training effects were investigated in 36 female volleyball players. They concluded that Plyometric training alters lower limb kinematics and increases eccentric hip torque and functional performance, suggesting the incorporation of these exercises in preventive programs for ACL injuries.

Conclusion

From the obtained results of this study, it can be concluded that plyometric exercises is important for improvement of performance and decrease incidence of injury of male volley ball players, Plyometric exercises need further investigation and further research.

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