International Journal of Physical Education, Sports and Health 2023; 10(4): 17-24

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2023; 10(4): 17-24

www.kheljournal.com
Received: 25-04-2023
Accepted: 23-05-2023

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A comparative study on effects of strength and plyometric training to improve performance in an open hand volley ball serve and spike

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DOI: https://doi.org/10.22271/kheljournal.2023.v10.i4a.3003

Abstract
Objective: To improve performance of serve and spike velocity through strength and plyometric training. The modern game of volleyball requires to play in all positions during match. At times player become a spikier, blocker, attacker, server and defender. As a consequence a player is expected to work on programme designed to improve strength, agility and flexibility. The two main techniques which are important in play serve and spike. A definite degree of strength of wrist and shoulder muscle is required for serve and spiking.
Materials and Methods: Using randomized sampling experimental study at the college level, 30 students had participated in the study, study has been conducted for 6 weeks – 2 sessions/day. Tools used included an Electronic stop watch were used to measure the time of the ball during service and spiking, steel tape is used to measure the distance of spike and serve, push pull dynamometer used to measure the strength. Multiple Regression Equation To predict the velocity of the service and the velocity of the spiked ball with the help of selected independent variables i.e. selected strength variables and size of the body parts separate regression were drawn. The resulted equations have been presented as follows.
X1 = (Arm Strength) + (Arm Length) + (Leg Strength) – 36.53 Where X1 = Service Velocity of the ball
X2 = (Arm Strength) + (Arm Length) + (Leg Strength) – 14.86 Where X2 = Spiking Velocity of the ball
Results: On comparing the Mean values of Group A & Group B on Shoulder Muscle Strength Measurement in terms of Maximum Isometric Voluntary Contraction (MIVC) Score using Push Pull Dynamometer, it shows significant Increase in the post test Mean values but (Group B - Strength Training) which has the higher Mean value in Shoulder Flexors, Abductors, Internal Rotators & External Rotators Muscle Strength are more effective than (Group A - Plyometric Training) at $p \leq 0.001$. Hence Null Hypothesis is rejected. On comparing the Mean values of Group A & Group B on Vertical Jump Test for anaerobic power, both the groups shows significant increase in the post test Mean values but (Group B - Strength Training) 50.40 centimeters which has the higher Mean value is more effective than (Group A - Plyometric Training) 45.53 centimeters at $p \leq 0.001$. Hence Null Hypothesis is rejected. On comparing the Mean values of Group A & Group B on Serve and Spike Velocity, both the groups shows significant increase in the post test Mean values but (Group B - Strength Training) 83.74mph & 78.55 mph which has the higher Mean value is more effective than (Group A - Plyometric Training) 73.48 mph & 83.74 mph at $p \leq 0.001$. Hence Null Hypothesis is rejected. On comparing Pre-test and Post-test within Group A & Group B on Shoulder Muscle (MIVC), Vertical Jump Test & Serve and Spike Velocity shows highly significant difference in Mean values at $p \leq 0.001$.
Conclusion: There is significant relationship between selected strength variables namely arm strength, grip strength, leg strength, back strength to the velocity of volleyball serve and spike. There is significant relationship between body parts size namely leg length, arm length, upper body length, hand length to the velocity of volleyball serve and spike. Arm strength, arm length and leg strength together contributed significantly to the velocity of service. Arm strength, leg length and leg strength together contributed significantly to the velocity of spike.
The study concludes that strength training shows more improvement then plyometric training to improve spike and service velocity.

Keywords: Strength training, plyometric training, serve, spiking

Introduction

The modern game of volleyball puts a great deal of emphasis on the fact that in this game a player is required to play in all the positions during a match due to the obligation of the rule concerned with rotation.

At one time, a player became spikier, the next movement a blocker attacker builder, server, a deep defender Strength is defined as the maximal amount of force a muscle or muscle group can produce in a specified movement pattern and velocity. Alternatively, power is the ability to exert as much force as possible in a limited amount of time. It is argued that nothing is more critical to athletic success than the capacity to display a high rate of force development. As in most sports, developing a volleyball player's power output is considered an essential component to a successful performance.

Weightlifting, often referred to as Olympic-style lifting, is one of the most accepted methods to enhance power output among athletes. Because the exercises involve rapid acceleration against resistance throughout the movement, power outputs are quite high. Indeed, the snatch and clean and jerk afford the highest power outputs recorded in sport. Given the intent to move the load as quickly as possible, weightlifting exercises stimulate greater motor unit synchronization and therefore improve the ability to generate power. The high levels of force development as well as improved muscle action speed associated with weightlifting can enhance performance in sports that require explosive dynamic movements, including volleyball. The instrument used in this study to measure the strength push pull dynamometer and for velocity multiple regression equation.

Plyometric exercises have been shown to improve jump performance in many sports. These exercises combine strength with speed of movement to produce power. 1996). the plyometric method is ranked among the most frequently used methods for conditioning in volleyball (Lehnert *et al*., 2009) [25]. In this research we include also plyometric training effect for the arms. Previous studies handle mostly explosive power improvement. As a novelty in this research is that in the players testing has used the temporal parameters, which has not been observed in previous studies and what will make possible to investigate plyometric training effect to improve speed force. Jalak has defined speed force subsequently: Speed force represents nerve - muscle machine's ability to move the maximum speed of the whole body, body parts (hands, feet, etc.) or equipment (ball, disc, etc.), (Jalak, 2008) [26]. The purpose of this study was to find out the efficiency of composed plyometric training program on youth volleyball players force capabilities in their usual training period.

Methodology

Study design: Experimental study design.

Study Setting: ACS Medical College Campus Dr. MGR Educational and Research Institute.

Study Type: Comparative study.

Sampling Method: Convenient sampling.

Study Duration: 2 sessions per day – 6weeks/5 days per week.

Sample size: 30 subjects.

Inclusion criteria

- Players were not undergone for strength plyometric training.
- University volleyball players.
- Age group between 18 to 26 years old.

Excusion criteria

- Players with injuries and surgery.
- Recent fractures of athletes, hyper mobility of joint.
- Musculoskeletal problems, any neurovascular and cardio-vascular disease were excluded.

Materials used in the study

1. Electronic stop watch.
2. Steel tape.

Outcome measures

Push-pull dynamometer.

Multiple regression equation to measure velocity of ball.

Procedure

The 30 university volleyball players will be selected for alternate plyometric and strength training for 6 weeks. The players had 2 training sessions per day/6 weeks /5 days per week and two of them included plyometric and strength training. Training duration was 90 minutes. Prior to each training sessions, all subjects should participate in 10 min warm –up period which includes jogging at a comfortable pace. After warm up session follow up plyometric training and strength training in alternate days. The training group will be divided into 2, Group A: 15 players will be undergoing strength training programme Group B: 15 players will be undergoing plyometric training programme. Improve the velocity of serve and spike through the strength and plyometric training.

Multiple Regression Equation To predict the velocity of the service and the velocity of the spiked ball with the help of selected independent variables i.e. selected strength variables and size of the body parts separate regression were drawn. The resulted equations have been presented as follows:

X1 = (Arm Strength) + (Arm Length) + (Leg Strength) – 36.53 Where X1 = Service Velocity of the ball.

X2 = (Arm Strength) + (Arm Length) + (Leg Strength) – 14.86 Where X2 = Spiking Velocity of the ball.

The Push Pull Dynamometer (Hydraulic Ana log), the pressure range is 0-300 Newton (N). The meter is equipped with a maximum indicating pointer with a resetting knob and a curved applicator. For quadriceps muscle strength measurement, Subject Position - High Sitting, Dynamometer placement- just proximal to the ankle joint. For Hamstrings muscle strength measurement, Subject Position - Prone Lying, Dynamometer placement- just proximal to the posterior aspect of ankle joint. For arm flexion and extension – supine lying arm flexed.

Table 1: Show Plyometric training and Strength training

Plyometric training	Number	Strength training	Number
1. Squat jumps	15 rep 3 sets	1. Front squat	10 reps 3 sets
2. Lateral box push up	15 rep 3sets	2. Leg extension	15 reps 3 sets
3. Split squat jump	30 rep 3 sets	3. Incline bench press	15 reps 3 sets
4. Power drop	30 reps 3sets	4. Dumbbell jump squat	15 reps 3 sets
5. Depth jump	30 reps 3sets	5. Dumbbell forward lunge	30 reps 3 sets

Testing procedure

All players undergo three control testing

- Vertical jump test.
- Push pull dynamometer.
- Multiple regression equation for velocity.

Data analysis

The collected data were tabulated and analyzed using both descriptive and inferential statistics. All the parameters were assessed using a statistical package for social science (SPSS) version 24. Paired t-test was adopted to find the statistical difference within the groups & Independent t-test (Student t-Test) was adopted to find the statistical difference between the groups.

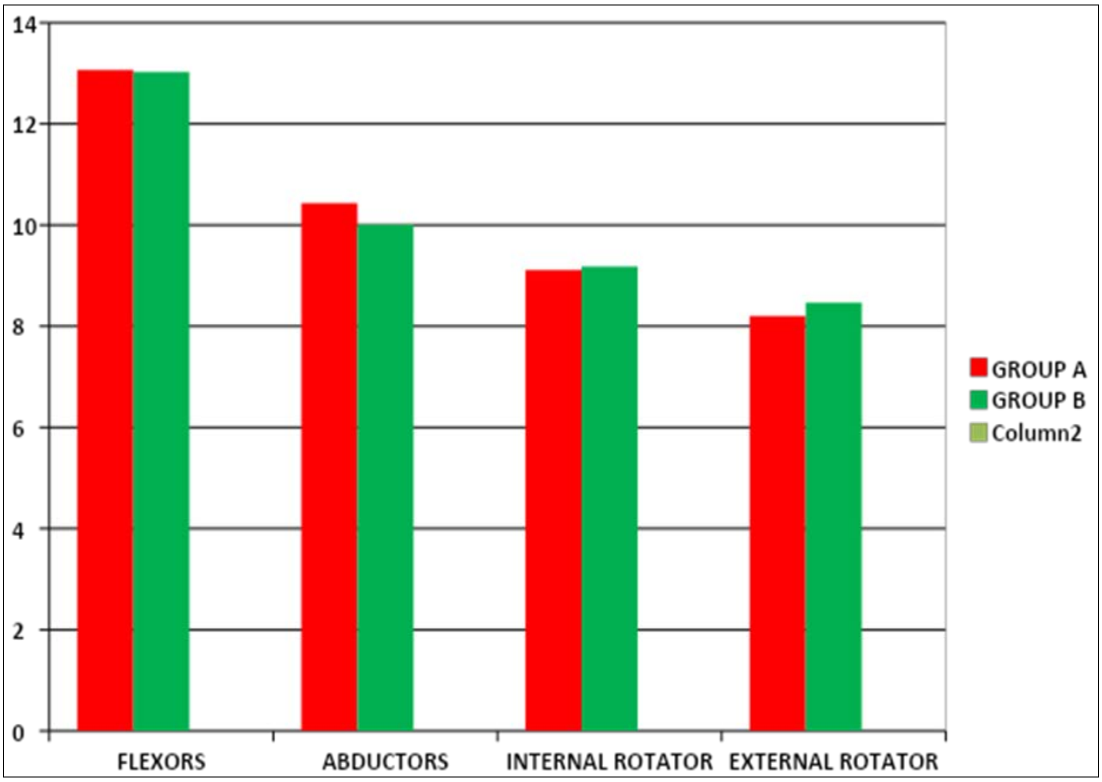
Table 2: Comparison of maximum isometric voluntary contraction (MIVC) of shoulder muscles between group – a and group - b in pre test

# Shoulder Joint (Pounds)	# Group-A		# Group- B		T-Test	DF	Significance
	Mean	SD	Mean	SD			
Felxors	13.06	1.60	13.02	.965	0.97	28	.924*
Abductors	10.43	.938	10.01	.705	1.38	28	.177*
Internal rotators	9.11	.617	22.90	2.16	-3.25	28	.751*
External rotators	8.20	.611	8.46	.530	-1.24	28	.224*

*- $p>0.05$

The above table reveals the Mean, Standard Deviation (SD), t-test, degree of freedom (DF) and p-value of the Maximum Isometric Voluntary Contraction (MIVC) of shoulder muscles between (Group A) & (Group B) in pre-test.

This table shows that there is no significant difference in pre-test values of the Maximum Isometric Voluntary Contraction (MIVC) of Shoulder Muscles between Group A & Group B (*****$p>0.05$).



Graph 1: Comparison of maximum isometric voluntary contraction (MIVC) of shoulder muscles between group-a and group-b in pre-test

Table 3: Comparison of maximum isometric voluntary contraction (MIVC) of shoulder muscles between group – a and group - b in post test

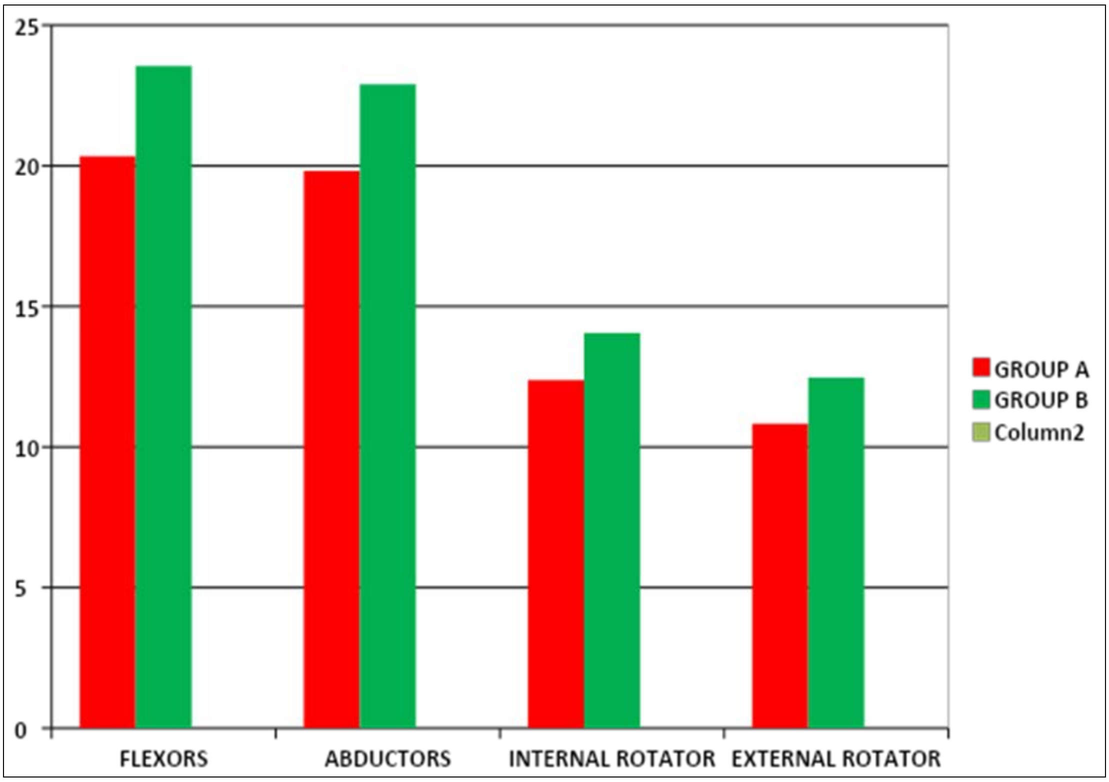
# Shoulder Joint (Pounds)	# Group-A		#Group-B		T-Test	DF	Significance
	Mean	SD	Mean	SD			
Felxors	20.34	2.15	23.54	1.75	-4.45	28	.000***
Abductors	19.81	2.98	22.90	2.16	-3.25	28	.000***
Internal rotators	12.37	1.72	14.06	1.00	-3.16	28	.000***
External rotators	10.82	1.20	12.46	1.09	3.91	28	.000***

***$p\leq0.001$.

The above table reveals the Mean, Standard Deviation (SD), t-test, degree of freedom (DF) and P-Value of the Maximum Isometric Voluntary Contraction (MIVC) of shoulder muscles between (Group A) & (Group B) in post-test.

This table shows that there is highly significant difference in Post Test values of the Maximum Isometric Voluntary Contraction (MIVC) of Shoulder Muscles between Group A & Group B ***$p\leq0.001$.

Both the Groups shows significant increase in the post test Means of MIVC but (Group-B) which has the Higher Mean value is effective than (Group-A), **(**Graph – II).



Graph 2: Comparison of maximum isometric voluntary contraction (MIVC) of shoulder muscles between group – and group-b in pre and post test

Table 4: Comparison of dependent variables within group–a between pre & post-test values

#Group-A	Pre test		Post test		T-Test	Significance
	Mean	SD	Mean	SD		
Mivc shoulder flexors	13.06	1.60	20.34	2.15	-19.35	.000***
Mivc shoulder abductor	10.43	.938	19.81	2.98	-13.22	.000***
Shoulder internal rotator	9.11	.617	12.37	1.72	-9.41	.000***
Shoulder external rotator	8.20	.611	10.82	1.20	-10.56	.000***

***- $p \leq 0.001$

The above table reveals the Mean, Standard Deviation (SD), t-value and P-Value of the Dependent variables between pre-test and post-test within Group–A.

In the above table, Dependent variables shows that there is a statistically highly significant difference between the pre-test and post-test values within Group A (***- $p \leq 0.001$).

Table 5: Comparison of dependent variables within group–b between pre & post-test values

#Group-B	Pre test		Post test		T-Test	Significance
	Mean	SD	Mean	SD		
Mivc shoulder flexors	13.02	.965	23.54	1.75	-27.10	.000***
Mivc shoulder abductor	10.01	.705	22.90	2.16	-25.18	.000***
Shoulder internal rotator	12.37	1.72	14.06	1.00	-25.00	.000***
Shoulder external rotator	8.46	.530	12.46	1.09	-21.19	.000***

***- $p \leq 0.001$

The above table reveals the Mean, Standard Deviation (SD), t-value and p-value of the Dependent variables between pre-test and post-test within Group – B.

In the above table, Dependent variables shows that there is a statistically highly significant difference between the pre-test and post-test values within Group B (***- $p \leq 0.001$).

Table 6: Comparison of vertical jump test between group – a and group-b in pre and post test

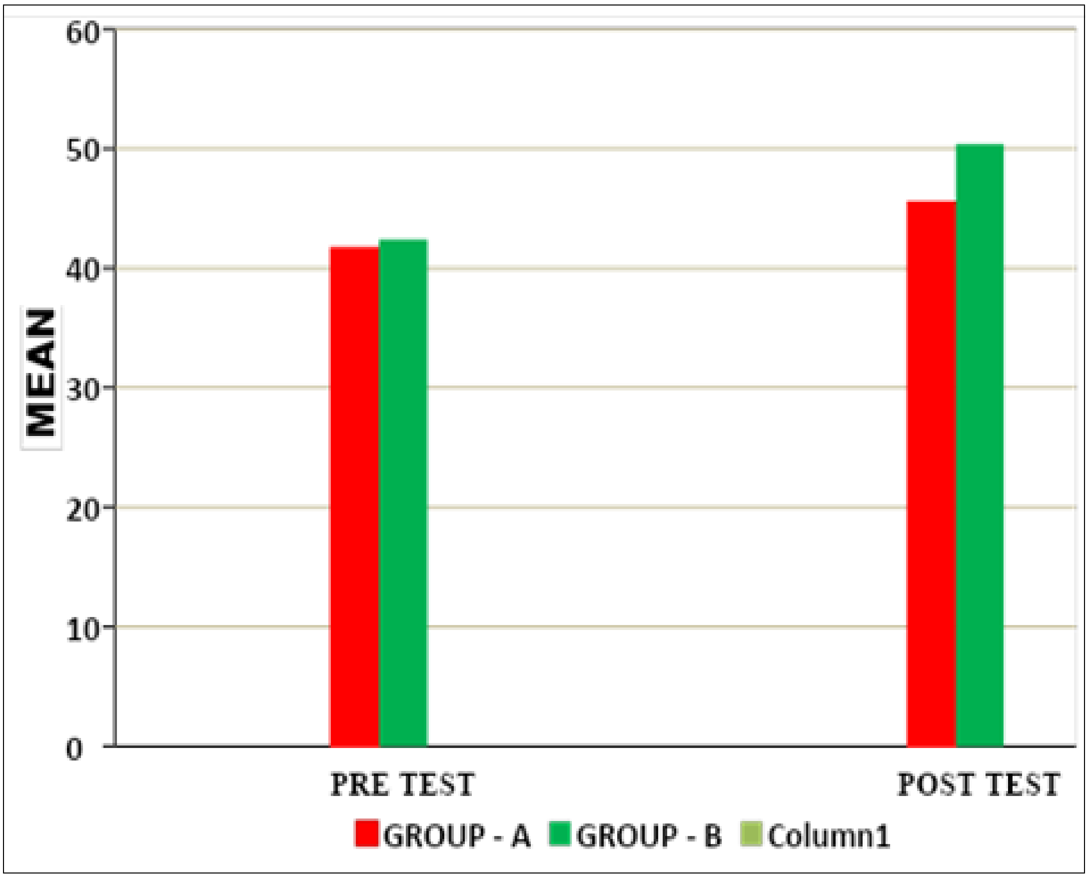
#VJT	# Group-A		# Group-B		T-Test	DF	Significance
	Mean	SD	Mean	SD			
Pre test	41.66	3.61	42.40	3.26	-.582	28	.565*
Post test	45.53	3.09	50.40	3.99	-3.73	28	.000***

*- $p > 0.05$), ***- $p \leq 0.001$

The above table reveals the Mean, Standard Deviation (SD), t-test, degree of freedom (DF) and p-value between (Group A) & (Group B) in pre-test and post-test weeks.

This table shows that there is no significant difference in pre-test values between Group A & Group B (*$p > 0.05$).

This table shows that statistically significant difference in post-test values between Group A & Group B (**- $p \leq 0.05$).



Graph 3: Comparison of vertical jump test score between group–a and group-b in pre and post test

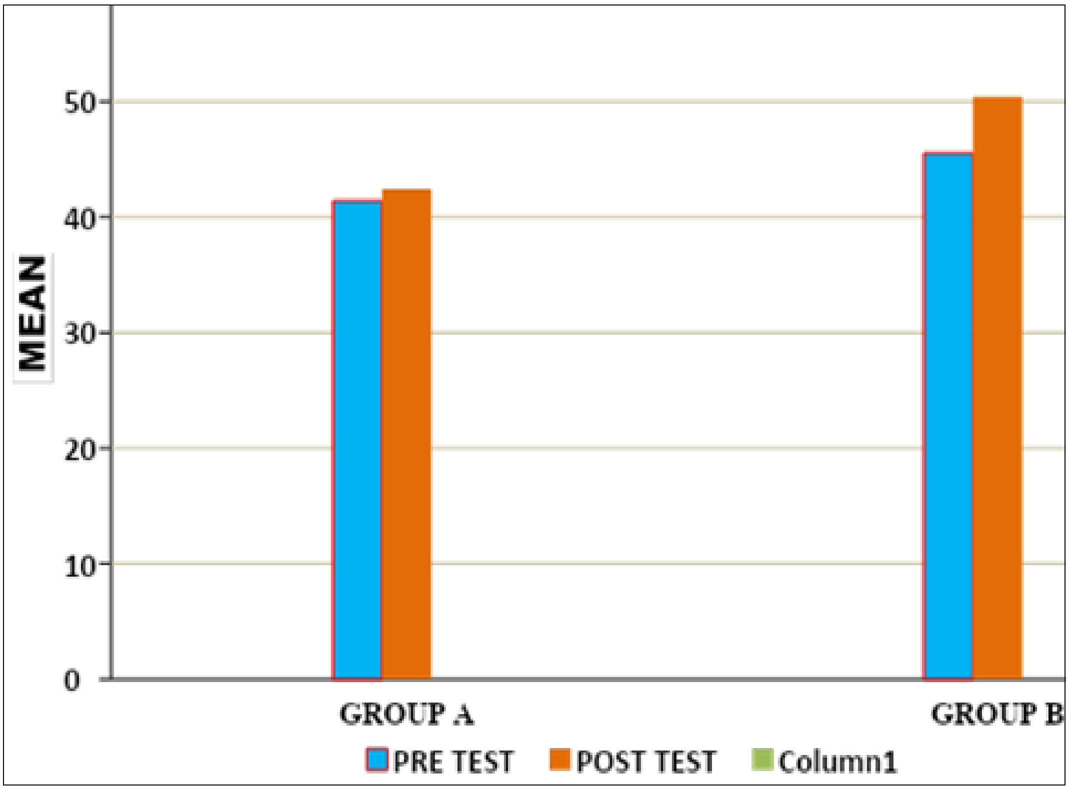
Table 7: Comparison of vertical jump test within group–a & group-b between pre & post-test values

#VJT	Pre-test		Post-test		T-Test	Significance
	Mean	SD	Mean	SD		
GROUP- A	41.66	3.61	45.53	3.09	-30.72	.000***
GROUP- B	42.40	3.09	50.40	3.99	-24.00	.000***

***- $p \leq 0.001$

The above table reveals the Mean, Standard Deviation (SD), t-value and p-value between pre-test and post-test within Group-A & Group–B.

There is a statistically highly significant difference between the pre-test and post-test values within Group A and Group B (***- $p \leq 0.001$).



Graph 4: Comparison of vertical jump test within group–a & group–b between pre & post-test values

Table 8: Comparison of serve velocity score between group–a and group-b in pre and post test

#SV	# Group-A		# Group-B		T-Test	DF	Significance
	Mean	SD	Mean	SD			
Pre-test	61.80	9.65	61.26	9.58	.152	28	.880*
Post-test	73.48	8.41	83.74	7.87	-3.44	28	.000***

*- *p*>0.05), ***- *p*≤0.001

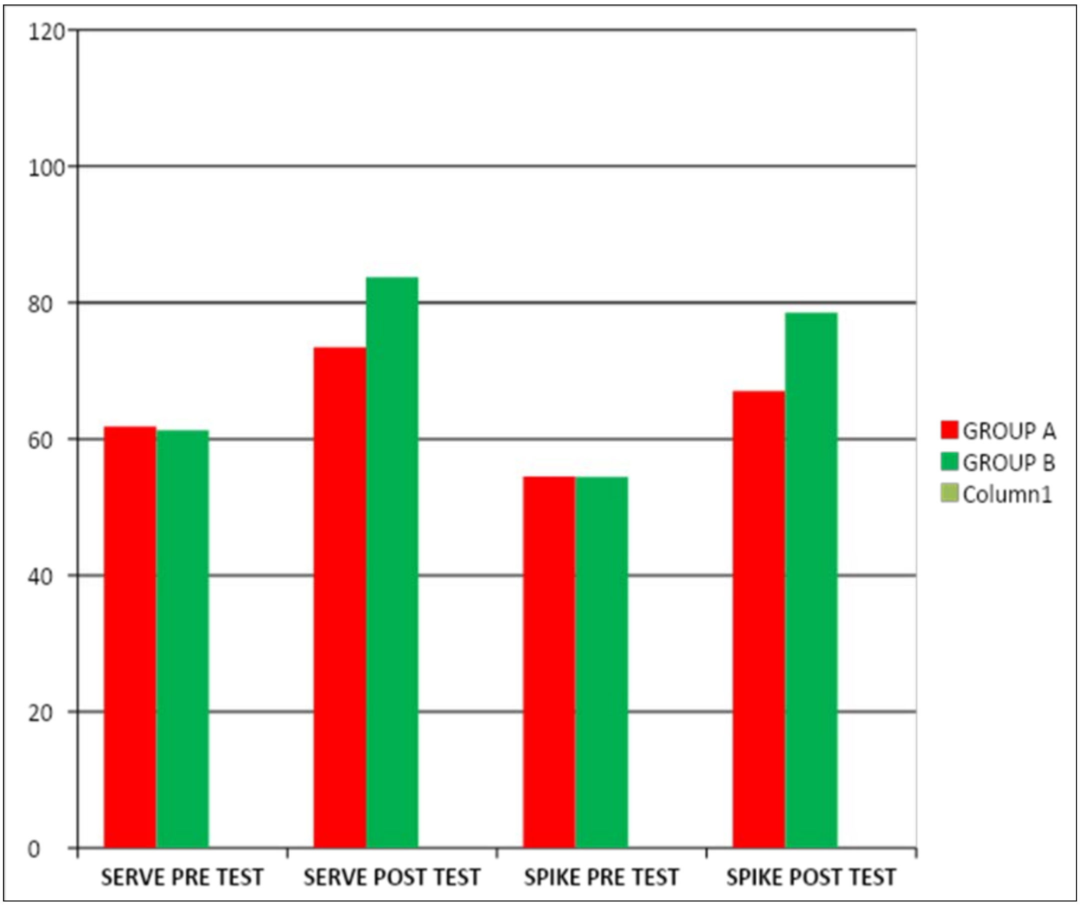
The above table reveals the Mean, Standard Deviation (SD), t-test, degree of freedom (DF) and p-value between (Group A) & (Group B) in pre-test and post-test weeks.
This table shows that there is no significant difference in pre-test values between Group A & Group B (***p*>0.05).
This table shows that statistically significant difference in post-test values between Group A & Group B (***- *p*≤0.001

Table 9: Comparison of spike velocity score between group – a and group - b in pre and post test

#SV	# Group-A		# Group-B		T-Test	DF	Significance
	Mean	SD	Mean	SD			
Pre test	54.53	6.34	54.40	3.75	-.070	28	.945*
Post test	67.02	7.31	78.55	4.52	-5.19	28	.000***

*- *p*>0.05, ***- *p*≤0.001

The above table reveals the Mean, Standard Deviation (SD), t-test, degree of freedom (DF) and p-value between (Group A) & (Group B) in pre-test and post-test weeks.
This table shows that there is no significant difference in pre-test values between Group A & Group B (***p*>0.05).
This table shows that statistically significant difference in post-test values between Group A & Group B (***- *p*≤0.001).



Graph 5: Comparison of serve & spike velocity score between group–a and group-b in pre and post test

Results

On comparing the mean values of Group A & Group B on Shoulder Muscle Strength Measurement in terms of Maximum Isometric Voluntary Contraction (MIVC) Score using Push Pull Dynamometer, it shows significant Increase in the post test Mean values but (Group B - Strength Training) which has the higher Mean value in Shoulder Flexors, Abductors, Internal Rotators & External Rotators Muscle Strength are more effective than (Group A - Plyometric Training) at *p*≤0.001. Hence Null Hypothesis is rejected.
On comparing the Mean values of Group A & Group B on Vertical Jump Test for anaerobic power, both the groups shows significant increase in the post test Mean values but (Group B - Strength Training) 50.40 centimeters which has the higher Mean value is more effective than (Group A - Plyometric Training) 45.53 centimeters at *p*≤0.001. Hence Null Hypothesis is rejected.
On comparing the mean values of Group A & Group B on Serve and Spike Velocity, both the groups shows significant increase in the post test Mean values but (Group B - Strength Training) 83.74mph & 78.55 mph which has the higher Mean value is more effective than (Group A - Plyometric Training) 73.48 mph & 83.74 mph at *p*≤0.001. Hence Null Hypothesis is rejected.
On comparing Pre-test and Post-test within Group A & Group B on Shoulder Muscle (MIVC), Vertical Jump Test & Serve and Spike Velocity shows highly significant difference in Mean values at *p*≤0.001.

Discussion

The velocity of service and spiking in volleyball depend upon many bodily and mechanical factors. The main findings of the study are: There is significant relationship between selected strength variables to the velocity of volleyball service and spike. Investigation of relationship of strength and size of different body parts to velocity of there is significant relationship between body parts size namely leg length, arm length, upper body length and hand length to the velocity of volleyball service and spike. There is no significant relationship between foot length and velocity of volleyball service and spike. Arm strength, arm length and leg strength together contribute to velocity of service bal. Arm strength leg length and leg strength together contribute to the velocity of spiked ball. Result of multiple regression analysis indicates that it is possible to make prediction regarding velocity of volleyball service and spike in volleyball on the basis of strength and body parts size.

From the above mentioned findings we can say that to service and spike with a high velocity a person must have optimum level of strength not only in his arm but in his back to make an arch, and in his leg for jump during spike and to provide affirm ground supporting during service. That is why significance positive relationship between all the four strength variables namely grip strength, arm strength, back strength and leg strength with the velocity of volleyball service and spike was found on the other hand significance relationship between arm length with spiking and service velocity is attributed to the fact that greater the arm length at the time of contact with the ball, greater will be the force, a contributory factor for the velocity of service and spike.

Another important factor that may determine the effectiveness or the amplitude of the benefits of plyometric interventions is the duration of the training period. It was observed that the interventions implemented in the reviewed studies ranged from four to 16 weeks with periods of 6 and 12 being the most common. In the reviewed studies, improvements of 8 and 9.2% [44] in the vertical jump were reported in two of the studies that used six-week plyometric training protocols. Meanwhile, improvements of 16.9% and 27.6% were observed in counter-movement jumps in two of the studies which included 12-week training period protocols.

The purpose of plyometric training is to improve the power of subsequent movements using both the natural elastic components of the muscles and tendons as well as stretch reflex. Considering that jump performance ability is highly influenced by the individual's ability to take advantage of the elastic and neural benefits of the SSC, well-developed strength and the rate of excursion of the activated musculature during the contraction, it is expected that plyometric training may benefit athletes' jumping performance. In fact, the literature is consistent in suggesting that plyometric training contributes to the optimization of landing mechanisms, improvements in eccentric muscle control and an increase in knee flexion and hamstring activity. Improvements in jumping performance (independent of the type of jump analyzed) were observed in all the studies presented in Table 3. Moreover, such benefits were observed in both males and females and independently of age. In theory, it is expected that meaningful improvements on the jumping performance will be observed after the implementation of a plyometric training intervention, with larger increases in counter-movement or drop jumps than in squat jumps. The results of the study indicate that there was significant improvement in serving ability due to the influence of strength training and plyometric training between pre and post - test, between posttest and adjusted post - test. However there was no statistically significant change in serving of control group. The results of the analysis reveal that the strength training group, plyometric training group and control group had differed significantly in serving. Strength training group and plyometric training group produced significant improvement in serving than the control group. There were no significant differences among the experimental groups in improving serving. Who found that service can be beneficially altered with strength and plyometric training.

Conclusion

There is significant relationship between selected strength variables namely arm strength, grip strength, leg strength, back strength to the velocity of volleyball serve and spike. There is significant relationship between body parts size namely leg length, arm length, upper body length, hand length to the velocity of volleyball serve and spike. Arm strength, arm length and leg strength together contributed significantly to the velocity of service. Arm strength, leg length and leg strength together contributed significantly to the velocity of spike.

The study concludes that strength training shows more improvement then plyometric training to improve spike and service velocity

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