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Effect of 4 Weeks Upper Extremity Plyometric Versus Free Weight Exercise On Shoulder Power and Strength in Cricket Players: An Experimental Study

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Abstract

Background: *Bowling action is explosive in nature; whereby a large amount of force must be generated over a very short period of time. Cricket bowlers are at the greatest risk of shoulder injury. The purpose of plyometric training is to increase the excitability of the neurological receptors for improved reactivity of the neuromuscular system. Overhead activities necessitate elastic loading to produce maximal, explosive, concentric contraction. In addition to the neurophysiological stimulus, the positive results of plyometric exercise can also be attribute to the recoil action of elastic tissues.*

Aims & Objectives: *To compare the effects of 4 weeks' upper extremity plyometric and free weight exercise on shoulder power and strength in cricket players.*

Methods: *Total 60 subjects were included in this study and were randomly divided in three groups. Group A performed plyometric exercise 2 days/week, Group B performed exercises with dumbbells and Thera Band for 3 days/week for 4 weeks.*

Result: *Analysis of the present study was done using One-way ANOVA for between the group comparison and Repeated Measures ANOVA for within the group comparison. The results of between the group analysis showed statistically significant improvement in shoulder strength as p=0.03 while no significant difference found for power (p=2.517).*

Conclusion: *This study concludes that 4 weeks of upper extremity plyometric exercise group showed significant improvement in upper extremity strength compared to free weight exercise group and control group while no significant improvement is found for upper extremity power between all the three groups.*

1. Introduction

Cricket is one of the world's major team sports in terms of regular international games. It is a bat-and-ball sport similar to the game of baseball, generally played outdoors on natural grass fields. Throwing is an important aspect of fielding in the sport of cricket. Although the skill of bowling is used to deliver the ball to the batsman, once hit, the fielders commonly use the overhead throw to return the ball back to the wicket keeper or stumps. In this way, the overhead throw is vital for affecting run-outs and to prevent the opposition from scoring runs. Higher velocity throws are particularly valuable as they reduce the time in which the opposition has to complete a run, impacting the decision making of the opposition as to whether or not a run can be completed safely and increasing the likelihood of affecting a runout. (1) Muscular strength and power have been well established as important determinants of throwing velocity in overhead throwing sports such as baseball, water polo, and European handball. Measures of strength and power have been significantly correlated with throwing velocity, whereas interventions involving the development of strength and/or power have been shown to increase throwing velocity across these sports. The influence of strength and power on velocity provides a viable method through which performance of cricket player can be improved cricket. Bowling action is explosive in nature; whereby a large amount of force must be generated over a very short period of time.Orchard et al. discussed that fast bowlers have consistently been identified as the category of cricket players at the greatest risk of injury. Bowling action is a highly skilled activity, which is acquired over years of fine tuning. Bowlers typically bowl in either of two styles, fast (with a long run-up) or spin (with a shorter run-up). Equally from a neuro-muscular perspective, the bowling action is a complex activity and optimal performance is a result of highly tuned inter- muscular and intra-muscular coordination, which is governed by the central nervous system. (1) During bowling in cricket, the internal rotators of the shoulder are involved in the acceleration phase of the arm through concentric contractions, whereas the external rotators are involved during the deceleration phase. During the bowling action's acceleration phase, the external rotators are contracted eccentrically in order to decelerate and control arm and any external shoulder rotation weakness could contribute to impingement syndrome. The presence of an imbalance between the agonist and antagonist groups is one of the major risk factors for developing shoulder injuries such as dislocation and impingement, with a deficiency in the external rotator strength possibly resulting in an injury. In addition to the technical skills required to perform, cricketers also need to possess a high level of fitness, thus making them susceptible to overuse injuries as a result of repetitive training. Shoulder problems, for example, rotator cuff strains and impingement, are common in bowlers. Upper extremity plyometric; Enhances athletic performance by emphasizing on the muscle's ability to exert maximal force output in a minimal amount of time. Exaggerated maximal muscular force develops due to athletic movements producing a repeated series of stretch-shortening cycles. The stretch-shortening cycle occurs when elastic loading, through an eccentric muscular contraction, is followed by a burst of concentric muscular contraction. A form of exercise called plyometric employs a quick, powerful movement involving a pre-stretch of the muscle, followed by a shortening, concentric muscular contraction, thus utilizing the stretch-shortening muscular cycle. (4) Plyometric exercise uses the elastic and reactive properties of a muscle to generate maximal force production. In normal muscle function, the muscle is stretched before it contracts concentrically. This eccentric-concentric coupling, also referred to as the stretch-shortening cycle, employs the stimulation of the body's proprioceptors to facilitate an increase in muscle recruitment over a minimal amount of time.The purpose of this training is to increase the excitability of the neurological receptors for improved reactivity of the neuromuscular system it also referred to as a reactive neuromuscular training. overhead activities such as throwing, necessitate elastic loading to produce maximal, explosive, concentric muscle contraction. In addition to the neuro-physiological stimulus, the positive results of stretchshortening exercise can also be attributed to the recoil action of elastic tissues.(4) Free weight exercise (FW) is the type of resistance training like free weights which includes exercise with dumbbells, barbells, weight machine or by our own body weight. FW are free from exercise which allows for movement in multiple planes and require balance. Free weight exercise tends to more closely match the movement pattern that likely to need for specific sport.(5,8,11) This study aims to compare the effect upper extremity plyometric and free weight exercise on shoulder power and strength in cricket players. The findings could assist physical therapists, coaches, and strength and conditioning professionals in determining the most effective approach to enhance shoulder strength and power through exercise selection.

2. Methodology

Study Type: Pre-post Experimental study.

Study Population: Male cricket player aged between 17-25 years.

Sampling Method: Random sampling method

Sampling Size: Sample size was calculated using G-power version 3.1.9.2. At effect size 0.25 power 0.90, and α 0.05, the required sample size was 54. Assuming 10% as drop out chances, the final sample size was adjusted to 60.

- All 60 players were divided in 3 groups:
- **Group A:** Plyometric Group (n= 20)
- **Group B:** Free weight Exercise Group (n=20)
- **Group C:** Control Group (n=20)

Study Duration:2021-2022

2.1 Eligibility Criteria

2.1.1 Inclusion Criteria

Following players were included in the study:

- Age between 17-25 years
- Participating at inter-school and inter-collage competition
- Male cricket players
- Practice volume of approximately 12-14 hours/week
- Playing cricket more than 3 years

2.1.2 Exclusion Criteria

- Any pathological condition of spine, hip, knee, and pelvis.
- Any history of musculoskeletal injury in past 6 month.
- Any history of neurological condition.
- Uncontrolled metabolic disorder such as Diabetes Mellitus
- Any surgical h/o shoulder or elbow in past 6 months.

2.2 Materials Used

- Consent form
- Data recording sheet
- Digital weighing scale
- Flexible 5-meter measure tape
- Resistance tube
- Resistance band
- Dumbbells
- Medicine ball

2.3 Outcome Measures

2.3.1 Medicine ball Throw Test

Procedure: The athlete set on the floor with his legs fully extended, feet 24 inches (~60 cm) apart and with the back against a wall. The ball was held with the hands on the side and slightly behind the center and back against the center of the chest. The forearms are positioned parallel to the ground. The athlete throws the medicine ball vigorously as far straight forward as he can while maintaining the back against the wall. The distance thrown is recorded.

Scoring: The distance from the wall to where the ball lands is recorded. The measurement is recorded to the nearest centimeter (other protocols have used the nearest 0.5 foot or 10 cm). The best result of three throws is used.

Variations: 1-2 kg medicine balls are sometimes used too, depending on the abilities of the subjects being testing. (9,10,11)

2.3.2 Closed Kinetic Chain Upper Extremity Stability Test

Procedure: This test position and procedure was performed according to the original description by Goldbeck and Davies (Goldbeck & Davies, 2000). Two tapelines were placed 36 inches apart. The subject started in a standard push-up position, with one hand on each tapeline. The subject was to touch one tapeline with the opposite hand, and repeat. The score is the number of touches achieved in 15 s. The examiner examined the test procedure and demonstrated if necessary. The score was calculated by tallying the total number of crossreaches with both hands, and in the interest of efficiency, only one trial was performed. (19,20)

Procedure of the Study: After getting approval from ethical committee, players were screened according to inclusion and exclusion criteria. Total 60 players were included in this study and they were equally divided in three groups. Upper extremity plyometric exercise Group, Free weight exercise group and Control Group. All the subjects who fulfilled the inclusion criteria were informed about the purpose of the study and written consent form was taken. Pre-training evaluation was done according to evaluation format. Following this plyometric group received plyometric exercise for 2 days/week while free weight exercise group received free weight exercises for 3 days/week for 4 weeks. The pre-training measurements were taken on a very first day prior to the training and at the end of the 2nd and 4th weeks of the training. Before testing, players were given three practice trials to become familiar with the testing procedures for medicine ball throw test. For CKCUEST, proper explanation was given and they had to perform for 15 second (Table 1 & 2).

Table 1 Illustrates Upper Extremity Plyometric Training

	Exercise	First 2 weeks (rep*kg)	2 – 4 weeks (rep*kg)
Throwing movements	Medicine ball chest pass	8*1 kg	10*2kg
	Medicine ball step and pass	8*1 kg	10*2kg
	Medicine ball side throw	8*1 kg	10*2kg
	Tubing Plyos IR/ER	8	10
	Tubing Plyos Diagonal	8	10
	Tubing Plyos Biceps	8	10
	Plyo Push-ups(boxes)	8	10
	Push-ups(clappers)	8	10
Trunk movements	Medicine ball sit-ups	6*1 kg	10*2
	Medicine ball back extension	6*1 kg	10*2

Table 2 Illustrates Free Weight Exercise Program

Exercise	Sets
Circumduction	2.5kg*10
Abduction	2.5kg*10
Biceps Curls	2.5kg*10
Triceps Extensions	2.5kg*10
Standing "Empty can"	2.5kg*10
Posterior Cuff External Rotation	2.5kg*10
Horizontal Adduction	2.5kg*10
D2-diagonalpatternPNF	Colorcoded,10*10

Statistical Analysis: This study was conducted to find out the comparison of upper extremity plyometric and free weight exercise on shoulder power and strength in cricket players for this purpose data was collected by principle investigator in terms of medicine ball throw test and close kinetic chain upper extremity stability test. Statistical analysis was carried out using SPSS version 20.0 software. Results were tested for normal distribution using a Shapiro-Wilk Test. Repeated measure ANOVA for within the group analysis was used to determine pre- and post-test difference. One-way ANOVA was used for between the group analysis to determine differences in medicine ball throw test Variables and Close kinetic chain upper extremity stability test scores (Refer Graph 1 to 4). Results were considered to be significant at $p \leq 0.05$ and confidence interval set at 95% (Tables 3 to 10).

3. Results

Table 3 **Illustrates Physical Characteristics of Plyometric Group**

	Age(year)	Weight (kg)	Height (cm)	BMI (kg/m^2)
Mean±SD	19.85±2.300	61.4 ± 7.096	166.4± 8.055	22.12± 1.611
Minimum	17	45	154	18.73
Maximum	24	70	179	25.15

Table 4 **Illustrates of Physical Characteristics of Free Weight Exercise Group**

	Age(year)	Weight (kg)	Height (cm)	BMI (kg/m^2)
Mean ± SD	21.15±2.85	62±6.104	164.95±7.14	22.74±1.22
Minimum	17	50	154	20.02
Maximum	25	73	177	25.71

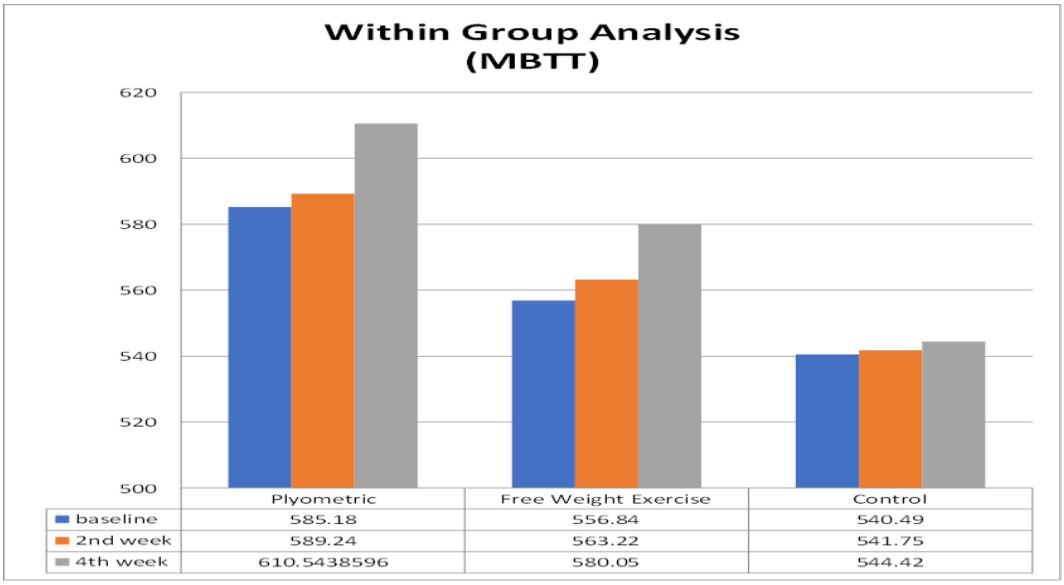
Table 5 **Illustrates of Physical Characteristic of Control Group**

	Age(year)	Weight (kg)	Height (cm)	BMI (kg/m^2)
Mean±SD	19.35±1.92	61±9.22	166.2±10.30	22.04±2.42
Minimum	17	44	145	17.78
Maximum	23	81	183	25.8

Table 6 **Illustrates Between the Group Analysis for MBTT using ANOVA**

		Sum of Squares	Mean Square	F	Sig.
BL MBTT	Between Group	16993.640	8496.820	1.044	.359
	Within Groups	463952.099	8139.511		
	Total	480945.738			
2ndWK MBTT	Between Group	18750.826	9375.413	1.180	.315
	Within Groups	452846.350	7944.673		
	Total	471597.176			
4THWK MBTT	Between Groups	38960.715	19480.357	19480.357	2.517
	Within Groups	441191.167	7740.196	7740.196	
	Total	480151.882			

(Significant Value: ≤0.05, Non-Significant Value: >0.05)

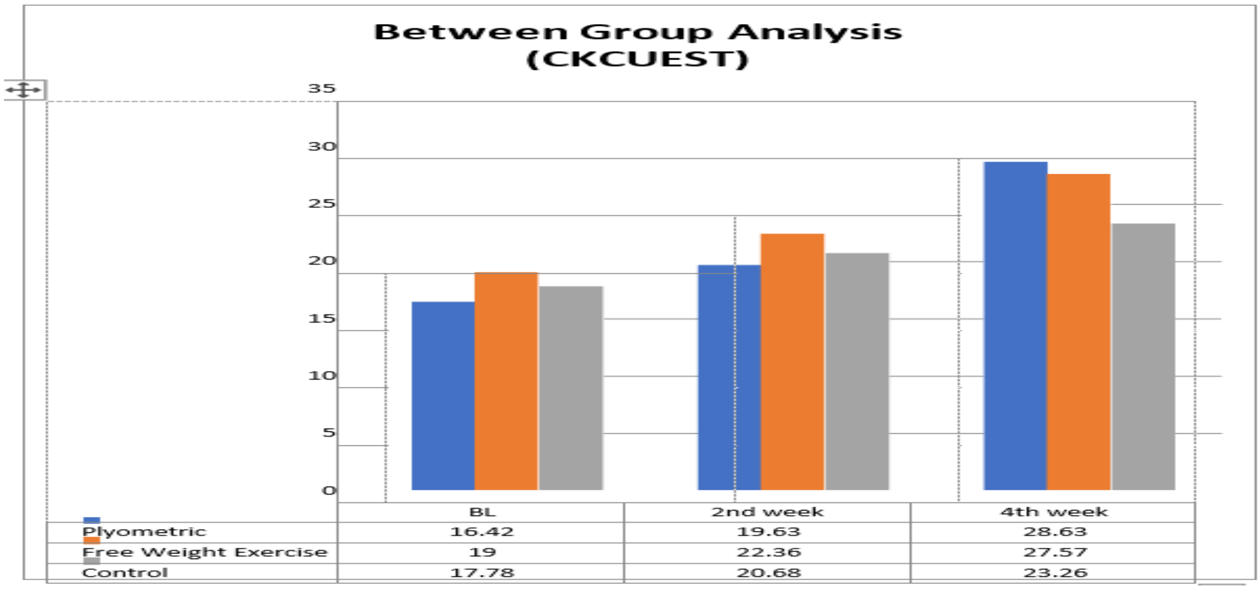


Graph 1 Illustrates Between Group Analysis for MBTT using One-way ANOVA

Table 7 Illustrates Between the Group Analysis for CKCUEST using ANOVA

		Sum of Squares	Mean Square	F	Sig.
BL CKCUEST	Between Groups	38.100	19.050	.835	.439
	Within Groups	1300.750	22.820		
	Total	1338.850			
2ND WK CKCUEST	Between Groups	46.800	23.400	1.045	.358
	Within Groups	1276.850	22.401		
	Total	1323.650			
4TH WK CKCUEST	Between Groups	360.633	180.317	6.607	.003
	Within Groups	1555.700	27.293		
	Total	1916.333			

(Significant Value: ≤0.05, Non-Significant Value:>0.05)



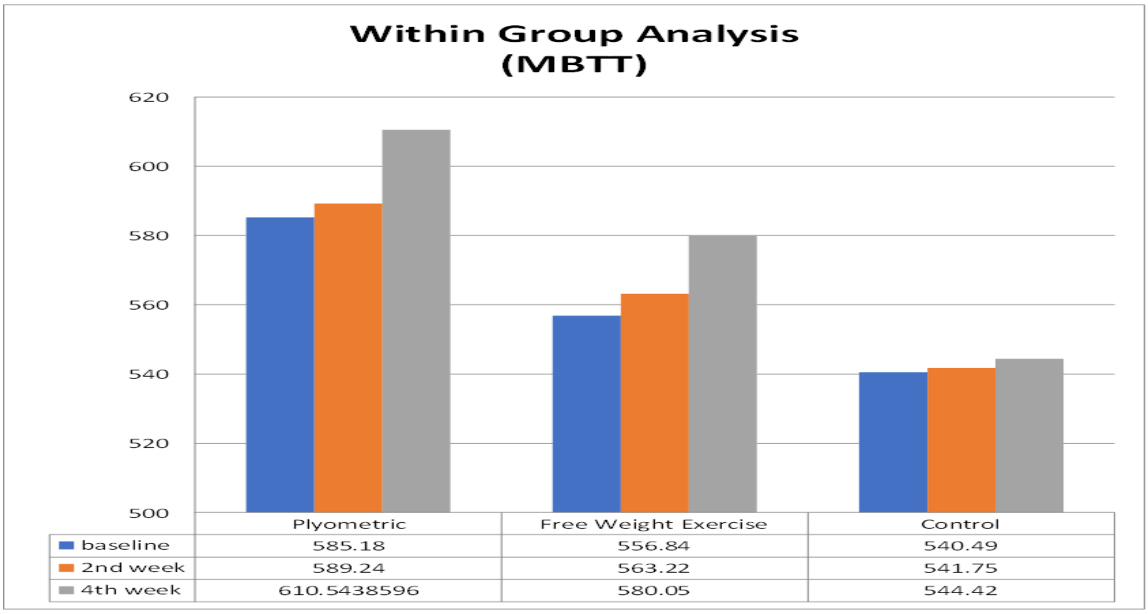
Graph 2 Illustrates Between Group Analysis of CKCUEST using One-way ANOVA

Table 8 Illustrates Post Ho can analysis of CKCUEST at BL, 2wk and 4wk of Between the Group

Dependent Variable	(I) GROUP1	(J) GROUP1	Mean Difference (I-J)	Std. Error	Sig.
CKCBL	PLY	FWE	-1.95000	1.51063	.606
		CON	-.90000	1.51063	1.000
	FWE	PLY	1.95000	1.51063	.606
		CON	1.05000	1.51063	1.000
	CON	PLY	.90000	1.51063	1.000
		FWE	-1.05000	1.51063	1.000
CKC2W	PLY	FWE	-2.10000	1.49669	.498
		CON	-.60000	1.49669	1.000
	FWE	PLY	2.10000	1.49669	.498
		CON	1.50000	1.49669	.961
	CON	PLY	.60000	1.49669	1.000
		FWE	-1.50000	1.49669	.961
CKC4W	PLY	FWE	1.75000	1.65206	.882
		CON	5.85000*	1.65206	.002
	FWE	PLY	-1.75000	1.65206	.882
		CON	4.10000*	1.65206	.048

Table 9 Illustrates Within Group Analysis of MBTT at BL, 2wk and 4wk using Repeated Measures ANOVA

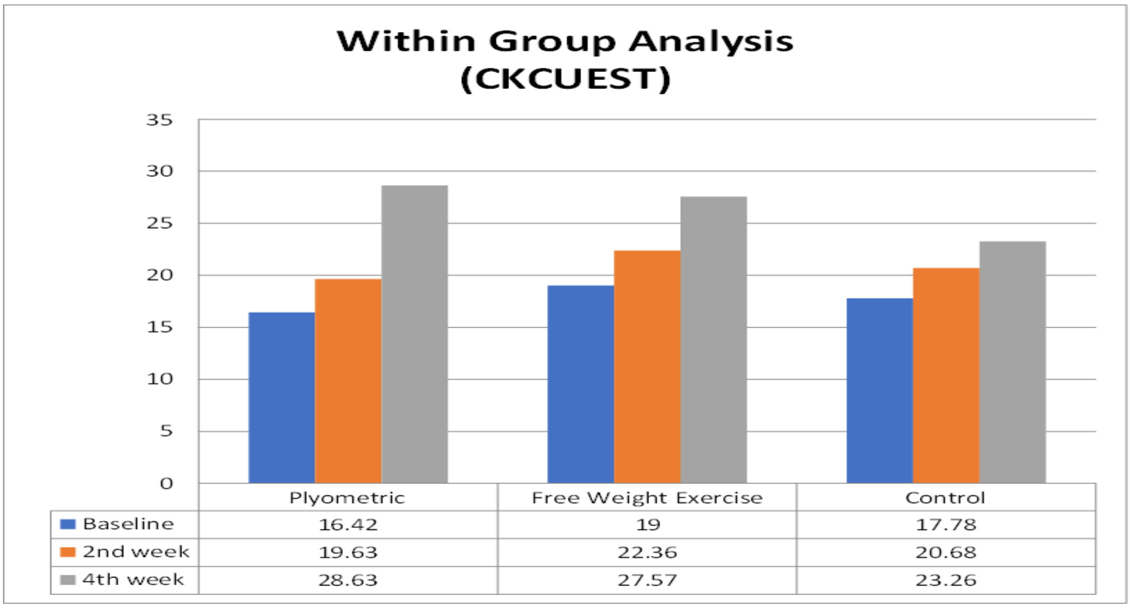
	MBTTBL	MBTT 2NDWK	MBTT 4THWK	F	P VALUE
PLY	585.18±82.47	589.24±82.06	610.54±79.56	172	0.000
FEW	556.84±80.31	563.22±79.27	580.05±78.45	267	0.00
CON	540.49±110.96	541.75±109.15	544.42±108.77	21.6	0.00



Graph 3 Illustrates Within the Group Analysis for MBTT Test Using Repeated Measures ANOVA

Table 10 Illustrates Within Group Analysis of CKCUEST at BL, 2wk and 4wk Using Repeated Measures ANOVA

	CKCUEST BL	CKCUEST 2NDWK	CKCUEST 4THWK	F	P VALUE
PLY	16.42±4.84	19.63±4.57	28.63±4.83	131.47	0.000
FEW	19±4.21	22.36±4.20	27.57±4.48	257	0.00
CON	17.78±4.92	20.684±4.89	23.26±5.55	69.20	0.00



Graph 4 Illustrates Within Group Analysis for CKCUEST using Repeated Measures ANOVA

4. Discussion

The present study was conducted to compare the effects of plyometric exercise and free weight exercise on shoulder power and strength in cricket players aged between 17-25 years. The calculated sample size was 60. The outcome measures used were medicine ball throw test and closed kinetic upper extremity stability test. On the basis of the results of normality, statistical tests used were One-way ANOVA for between the group and Repeated Measures ANOVA for within the group comparison. Result of present study shows that 4 weeks post-intervention there is significant difference found in shoulder strength in upper extremity plyometricgroup and free weight exercise group. The significant value for upper extremity plyometric group and free weight exercise group is p=0.02 and p=0.04 respectively but there was no significant difference found in upper extremity power, i.e. p=2.517 which is greater than the baseline significant value, i.e., p≥0.05. A study done by **Robert U. Newton and Kery P.Mcevoy**on comparison of medicine ball training and weight training in baseball throwing velocity. The results showed that both experimental groups significantly increased their strength while there was no significant difference was seen in throwing velocity in medicine ball group. The present study results also shows improvement in upper extremity strength (p<0.5). The possible reason for improvement in plyometric group can be the movement pattern chosen were the chest pass and overhead throw in order to be comparable with weight training of bench press and pullover.[22] **Andrew B. Carter et al.,** conducted a study on the effect of upper extremity plyometrictraining on the throwing velocity and shoulder rotators in baseball players. The measurement was taken in isokinetic dynamometer at peak torque values

60˚/s,120˚/s,180˚/s,300˚/.The result showed that no statistically significant differences ($p \geq 0.05$) for power while for strength it showed statistically significant improvement in plyometric group. The results of present study also shows significant improvement in strength of the upper extremity and the significant value p=0.03. In the present study alsoresults clearly shows improvement in strength regardless of training program. It is because of eccentric shoulder ER strength might improve as a consequence of repeated bouts of stretch-shortening activation. [18] **Bryan C. Heiderscheit et al.,** did a study on the effect of isokinetic vs plyometric training on shoulder internal rotators. The result showed statistically no significant difference between isokinetic and plyometric group. All the groups demonstrated an increase in throwing distance from their pretest, these differences were statistically not significant (p=.19)**.** The plyometric training group displayed the greatest increase in throwing distance, approximately five times the isokinetic group, but the improvements were statistically neglected by the large standard deviations (±317.0 cm). However, the present study results shows similar result, there was improvement in power at the end of 4 weeks of plyometric training but the improvement was not statistically significant, i.e., p=0.369. Possible reason for this non-significant result can be inability to control throwing motions used by the players in the plyometric group. A**s** with all training, proper technique is needed for effective training**.** During the initial training weeks, the individuals monitoring the training sessions noted that subjects substituted extension of the elbow or trunk rotation accompanied with a sidearmed throw for the desired shoulder internal rotation throwing motion. These substitutions would result in ineffective training of the target (shoulder internal rotators) muscles. [27] **Pankaj Kumar Singh Vishen**et al., did a study on comparison of dynamic push-up training and plyometric push-up training on upper body performance test in cricketPlayers. The result showed insignificant results for between the group comparison while within the group comparison showed significant difference in dynamic push-up group which were p=0.033 and 0.0001 for one arm hop test and medicine ball put test respectively. Similarly within group comparison of plyometric push-up group showed significant difference which was p=0.004 and 0.011 for one arm hop test and medicine ball put test respectively. Similarly the present study results also shows within the group improvement, i.e., p=0.00 for plyometric group. The possible reason for the findings of significant improvement of strength in the plyometric group may be credited to a greater workload experienced in the Plyometric program. This greater workload is attributable to the momentum of the falling trunk, which contributes to the resistance provided by the individual‟s body weight and must be overcome by the upper extremities during the plyometric push-up. Because the kinetic energy the participant must overcome is a function of mass and velocity, the greater velocity of the falling trunk results in greater work to decelerate and then accelerate the body during the plyometric push-up. As per SAID principle imposed demand leads to adaptation against to training stimulus, thereby improvement in performance.[28] A study on posterior rotator cuff strengthening using theraband in a functional diagonal pattern in collegiate baseball pitchers was carried out by **Phillip A.Page,et al**., and they concluded that theraband group was significantly stronger following the training than the control group at p=0.00. Similarly, the present study result also shows similar result in free weight exercise group for improvement in strength as p=0.048. Possible reason for increase in eccentric strength of the experimental group could be the strengthening repetitions were slow and controlled to emphasize the eccentric contraction. The concentric phase of the strengthening pattern may have also contributed to an increase in eccentric strength. In order to facilitate the eccentric contraction using Theraband in the diagonal pattern, the subjects had to concentrically contract the posterior rotator cuff to the starting position concentric contractions may be sufficient to provide gains in eccentric strength. [23] In this study, the possible reason for not getting statistically significant improvement in power can be because of the training duration which was selected. Previous studies which showed improvement in power were of minimum of 6-8 weeks duration while in present study it was of for 4 weeks.[18]**Kisner C & Colby LA(2007)** stated that maximum training benefits typically occur within 8 to 10 weeks duration while in present study it was only for 4 weeks. So this can be the possible reason for not getting improvement in power. (25)

4.1 Limitations of the Study

- Sample size was small.
- 4-weeks training duration was not adequate enough to produce significant improvements in Power.
- The exercise design would have to be re-examined according to the players level of achieved fitness.
- It is unclear, if elite players with already a high level of technical ability would have comparable results to young players [26-30].

4.2 Future Recommendations

- Study can be done on other sports like badminton and tennis.
- Study can also be done separately on girls participants.
- Upper extremity strength of players can be assessed for 10 RM and accordingly free weight exercise can be implemented for each player.

Conclusion

This study concludes that 4 weeks of upper extremity plyometric exercise group showed significant improvement in upper extremity strength compared to free weight exercise group and control group while no significant improvement is found for upper extremity power between all the three groups.

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