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Effect of Plyometric Exercise on Upper Limb Strength and Speed Performance Among Professional Cricket Bowlers - Quasi Experimental Study

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ABSTRACT

Aim: To study the effect of Plyometric exercises on upper limb strength & speed performance among professional cricket bowlers.
Relevance of study: The study reflects the need and importance of plyometric exercise to improve performance in sport. The principal neurophysiological adaptation states that the stretch-shortening cycle activation is similar in both upper and lower extremities.
Methodology: In this experimental study, 30 patients were selected based on inclusion and exclusion criteria. Pre- and post-analysis was conducted using the Plate Tapping Test and Closed Kinetic Chain Upper Extremity Stability Test. The plyometric exercises were prescribed to the patient for 4 weeks, five days per week. A minimum sample size of 30 was obtained through purposive sampling.
Result: On intragroup comparison using paired t test the pre intervention mean of plate tapping test was 17.430±3.42. Obtained p value after the intervention is <0.0001 with post mean 13.533±2.75 which implies that there is significant difference between pre post comparison for closed kinetic chain upper extremity stability test was 81.530±18.68 Obtained p value after the intervention is <0.0001 with post mean 93.714±17.06 which implies that there is significant difference between pre post comparison.
Conclusion: Plyometric exercises are effective for increase in bowling speed and strength Performance among professional cricket bowlers.

KEYWORDS: Plyometric exercises, Strength and Speed of bowlers.

INTRODUCTION

Cricket is an outdoor game, and its popularity has grown immensely. At present, it is treated as the most popular game in India and all over the world. Cricket is a team game, and cricketers have to perform different roles as a bowler, fielder, or batsman in a single game. This involves intermittent activities during which players are required to repeatedly perform striding, sprinting, turning, and jumping, placing considerable demands on the physiological and neuromuscular system. [1,2] (Davies et al., 2008; Noakes et al., 2000; Bartlett, 2003). In the game of cricket, physical fitness is crucial for players, especially when it comes to fast

bowling. The speed at which the ball is released is a key factor in the success of bowling [3]. Fast bowling in cricket is explosive and requires effective training to improve both power and speed [4,5]. Unfortunately, many training programs do not adequately address explosive strength parameters. This is important not just in cricket, but also in other sports that involve overhead throwing, as they require maximum explosive power to generate high levels of force in a fraction of a second [4,6]. The speed at which a ball is released is influenced by many factors. Plyometric exercises involve rapid, powerful movements, including an eccentric contraction followed by an explosive concentric contraction. The overall performance of any activity depends on how quickly muscular forces can be generated. Consistent use of plyometric exercises will gradually improve the neuromuscular connections between the brain and muscles.[7] Plyometric training allows athletes to generate more force in a shorter amount of time. This improves their performance during sudden movements required in on-field situations. It is one of the most effective methods for increasing strength in an athlete, which is crucial in modern sports. To be most effective, plyometric training should be preceded by a phase of maximal strength training. The greater the maximal power of an athlete, the more power can be harnessed for their sport.[8] The shoulder joint is the most mobile joint in the body, but it is structurally insecure. The ball-shaped humeral head rotates and glides on a shallow scapular cuff. The glenoid labrum provides a limited amount of passive stability by slightly deepening the scapular cuff, and ligaments reinforce the capsule on its superior and anterior surface. Dynamic stability is primarily provided by the rotator cuff, which is a group of muscles consisting of the subscapularis, supraspinatus, infraspinatus, and teres minor. These muscles not only provide dynamic stability but also help with internal and external rotation when they contract concentrically and eccentrically, along with other extrinsic shoulder muscles. [9,10,11,12] The bowling action involves the rotation of the upper arm, engaging the pectoral and latissimus dorsi muscles, as well as the deltoid muscles. Stuelcken et al., (2007) stated that, the biceps brachii are active during the bowling action stabilising the elbow and glenohumeral joint, along with the rotator cuff muscles. Force production from the upper body is an important aspect of bowling technique, contributing to 36 – 45% of the variance in bowling speed. (Portus et al., 2000, Pyne et al., 2006, Stuelcken et al., 2007). Increased upper body muscularity in performers results from conditioning programs and adaptation to game demands.[13] Plyometric training has been shown to effectively increase shoulder strength and performance. [14,9] Upper extremity plyometric exercises involve quick and powerful movements that require a pre-stretch of the shoulder muscles, activating the stretch-shortening cycle. The cycle consists of three phases: the eccentric phase, the amortization phase, and the concentric phase. During the eccentric phase, rapid eccentric contractions trigger a stretch reflex, where muscle spindles, sensory mechanisms within muscle fibers, are activated by the quick stretch. This activation leads to a more powerful concentric contraction in the opposite direction.[15] The second phase of the stretch-shortening cycle is the amortization phase. This phase refers to the amount of time between the yielding eccentric contraction and the initiation of a concentric force. Amortization represents the electromechanical delay between the eccentric and concentric contractions during which the muscle must transition from overcoming work to generating the necessary acceleration in the required direction. Successful training utilizing the stretch-shortening cycle depends more on the rate of stretch rather than the length of the stretch. The second phase of the stretch-shortening cycle is the amortization phase. This phase refers to the amount of time between the yielding eccentric contraction and the

initiation of a concentric force. Amortization represents the electromechanical delay between the eccentric and concentric contractions during which the muscle must transition from overcoming work to generating the necessary acceleration in the required direction. Successful training utilizing the stretch-shortening cycle depends more on the rate of stretch rather than the length of the stretch.[16] If the amortization phase is slow, elastic energy is wasted, and the stretch reflex is not activated. The more quickly the individual is able to switch from yielding work to overcoming work, the more powerful the response. The final phase of the stretch-shortening cycle is the concentric phase. During this phase, the muscle contracts to produce the desired effect of the exercise and prepares for initiation of the second repetition.[4] The amortization phase is the summation of the eccentric and concentric phases. [15.16,9] It is often referred to as the resultant or payoff phase due to the enhanced concentric contraction. Pyne et al. found that upper body strength was a main predictor of ball release speed in junior fast bowlers. In senior fast bowlers, however, lower body strength played a paramount role in predicting the ball release speed.[17] In cricket, traditional strength training has been used to enhance bowling performance so far.[18] Shoulder performance in activities involving overhead movements, such as throwing, appears to improve with the assistance of plyometric exercises.[9] There have been few studies on the immediate effects of upper limb plyometric exercises on the speed and strength of the upper limb among bowlers. Therefore, the present study aims to investigate the long-term impact of plyometric exercises on the strength and speed performance of professional cricket bowlers.

METHODOLOGY

A quasi-experimental study conducted on 30 subjects at cricket clubs in & around Jalgaon for 6 months. The trial was registered at Clinical Trials Registry- India and the CTRI registration number is CTRI 2024/02/063183. Ethical clearance was obtained from institutional ethical committee of Dr. Ulhas Patil College of physiotherapy, Jalgaon.

Subjects were screened according to the inclusion and exclusion criteria. Subjects included in study were :1) male cricket bowlers, 2) Age (18years-28years), 3) Professional cricket bowlers who are currently playing for more than 1 year. Subjects excluded were 1) any upper limb surgery in previous years ,2) Any upper limb injury in previous year, 3) Joint stiffness, 4)" Previous history of rotator cuff tear,5) Previous history of nerve injury & joint subluxation,6) All rounder cricket players.

The procedure & purpose of study was explained to participants. A written informed consent were obtained from subjects selected for the study. Selected participants demographics details were recorded. Subjects were assessed for speed using Plate tapping test (0.80) and strength using Closed kinetic chain upper extremity stability (≥0.97).

1) Evaluation of Speed using plate tapping Test.

Procedure: The subject was asked to stand comfortably in front of the discs. The two discs were placed with their centers 60 cm apart on the table. Subjects were asked to placed their non-dominant hand in the center. Then subject moves the preferred hand back and forth between the discs over the hand in the middle as quickly as possible. This action was repeated for 25 full cycles (50 taps).

Scoring: The time taken to complete 25 cycles is recorded. Performed the test twice and the best result was recorded.

FIGURE 1) Evaluation of speed using plate tapping test

Intervention

All 30 participants were assessed with plate tapping test and received plyometric exercises.

with 5reps of 30 second rest between start of 3sets for 5days per week for 4weeks.

2) Evaluation of Strength using Closed Kinetic Chain Upper Extremity Stability Test.

Procedure: The starting position was push up with both hands positioned on two pieces of tape affixed to the ground at a distance of 91.4cm apart. The participant alternatively touched the opposite hand for a time frame of 15 seconds while remaining in push up position. Each subject was allowed to perform the test once as a trial in order to familiarize themselves with the task before the actual test. Three (3) repetitions of the 15 second CKCUEST were performed with an interval of 45 seconds between each test. The average touches score was calculated on the basis of the arithmetic mean number of touches recorded during the three attempts. The power score was obtained by the product of the average number of touches and 68% of body weight in kilograms divided by 15. where 68%= Trunk, head, arms

$$Power = \frac{68\%\ Weight \times Average\ number\ of\ touches}{15}$$

Intervention:

Plyometric exercises were given to all 30 participants. There were no dropouts from the study. Exercise Dosage- 5reps of 30 sec rest between start of 3 sets for 5 days per week for 4 weeks.

Table 1: Plyometric Exercises

1) Overhead Soccer throw: Facing a wall, stand along with your feet pointed forward and around shoulder width separate. Hold your chest muscle tissues out and head up. Hold 6lb medicine ball with both hands extended above your head. Throw the ball against the wall when keeping each arms extended out. As the ball bounces back, catch the ball of the wall. And after that get back for start position within controlled manner. Figure 2	5 Reps with 30 sec hold. 3sets
2) 90\90 External rotation side throw: Shoulder and elbow at 90°of abduction and elbow flexion. For Right arm, stand sideways so that your right side is facing a wall. Keep the right elbow tucked against your right side with the elbow at 90°.Throw a ball against a wall. Catch the rebounded ball in the same arm position, allowing the arm comfortably stretch back, and then quickly throw the ball again. Do not pause or stop the ball movement after catching it. Figure 3	5 Reps with 30 sec hold. 3sets
3) Bounce a weighted Ball: Prone on the table with scapula retracted and upper arm supported on the table, position shoulder in 90° abduction and external rotation and elbow in 90° flexion. Have subject bounce a weighted ball on the floor by internally rotating the shoulder. Catch it, moving the shoulder back into external rotation under control. Figure 4	5 Reps with 30 sec hold. 3sets
4)Theraband External Rotation: Attach the theraband at waist level. While standing sideways and looking straight ahead, grasp one end of the band and pull the band all the way through until it is taut. Feet are shoulder width apart. The elbow is placed next to the side with the hand as close to your chest as possible. Taking the band in the hand, move the hand away from the body as far as it feels comfortable. Return to the start position. Figure 5	5 Reps with 30 sec hold. 3sets
5) Elastic 90/90 External Rotation: Stand with the theraband attached in front. Keeping the arm elevated to 90°of shoulder and elbow at 90°angle, Rotate the hand and arm slowly backward and then return slowly to start position. Figure 6	5 Reps with 30 sec hold. 3sets
6)Clap Pushups: While on the floor, have the subject perform a forceful prone push up from knees or feet. Get into an arm supported position with your hands positioned beneath your shoulders and fingers spread slightly, ready to push. Poise on the toes or balls of your feet to maintain balance throughout the movement. Bend the elbows to initiate the first part of the pushup. Keep the elbows close the body and lower your weight. Reverse the motion by pushing hard through the palms. Just as your arms reach full extension, pull your hands up off the floor. Once you've pushed your body up and your hands are off the floor, bring them together in one quick motion in front of chest. Clap hands together catch self with both hands allowing elbows to flex. Quickly perform another pushup. Figure 7	5 Reps with 30 sec hold. 3sets

FIGURE 2) Overhead Soccer throw:

FIGURE 3) 90\90 External rotation side throw:

FIGURE 4) Bounce a weighted Ball:

FIGURE 5) Theraband External Rotation:

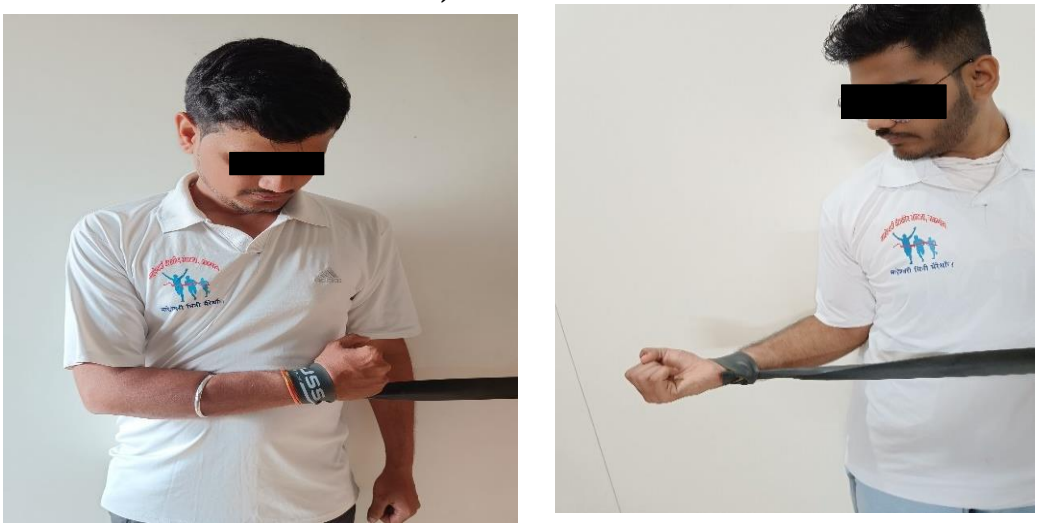

FIGURE 6) Elastic 90/90 External Rotation:

FIGURE 7) Clap Pushups:

STATISTICAL ANALYSIS

The entire data of the study was entered and cleaned in MS Excel before it as statistically analysed in "GraphPad Instat version 3.05". All the results are shown in tabular as well as graphically format to visualized the statistically significant difference more clearly. The data on quantitative characteristics was presented as Mean ± Standard Deviation (SD) across study group. The paired t-test was used for intragroup pre and post comparison of Plate tapping test and closed kinetic chain upper extremity stability test. The entire data was analyzed statistically using "GraphPad Instat version 3.05".

RESULTS

In study 14 participants were between 18-21 years of age, 9 were between 22-25 years of age, 7 were between 26-28 years of age.

Table 2) The age wise distribution of study subjects

Age in years	Number of subjects (n=30)
18-21	14 (47%)
22-25	9 (30%)
26-28	7 (23%)

Table 3: Intragroup Comparison of pre-post plate tapping test (speed)in sec.

Plate tapping test	Mean & SD	t Value	p value	Significance
Pre	17.430±3.42	13.299	<0.0001	Extremely Significant
Post	13.533±2.75			

Table 4: Intragroup Comparison of pre-post closed Kinetic chain upper extremity stability test in touches (strength).

Closed kinetic chain upper extremity stability test	Mean & SD	t value	p value	significance
Pre	81.530±18.68	12.234	<0.0001	Extremely Significant
Post	93.714±17.06			

Results: Statistical analysis was done with paired t test and on intragroup comparison of pre and post of each group the 'P' value of plate tapping test for speed and closed kinetic chain upper extremity stability test for strength was found to be extremely significant (P value <0.0001).

DISCUSSION

Cricket is an outdoor game and physical fitness plays pivotal role for the players. The ball release speed plays a major role in bowling success. Fast bowling in cricket is very explosive and ballistic in nature and requires effective training to improve the explosive power and speed. The main purpose of this study was to investigate the effect of plyometric exercise on upper limb speed and strength performance among professional cricket bowlers. Plyometric exercise refers to activity that enables a muscle to reach maximal force in shortest possible time. plyometric training uses the acceleration and deceleration body weight as the overload in dynamic activity.

Variable 1: Effect of plyometric exercises on speed performance.

On intragroup comparison using paired 't' test the mean pre-treatment value of speed (plate tapping test) was 17.430±3.42 with post treatment mean of plate tapping test was 13.533±2.75 with 'p' value as < 0.0001 respectively. Our study found that there was a significant increase in speed performance among fast cricket bowlers after performing plyometric exercise which includes Overhead soccer throw, 90/90 external rotation side throw, Bounce a weighted ball.

The physiological requirements of bowling reveal that the muscle activity required is fueled mainly by the phosphagen breakdown system[19].However, aerobic energy system is also required as high repetitions of bowling are performed during the game. Lachowetz et al. also reported significant improvements in throwing velocity after 8 weeks of a generalized strength training routine in a group of collegiate baseball players. Earlier studies of plyometric training have speculated that gains were enhanced by motor unit recruitment patters[20]. Usually when an athlete reacts or responds as a result of better coordination between the proprioceptive feedback and the CNS signal the, neural adaptations occur. Another research states that ballistic six programme may have been effective in improving bowling speed due to unique feature of ballistic six programme is that plyometric exercises were performed in a ballistic manner with high velocities and thereby taking advantage of the stretch shortening cycle. It has been shown that the stretch shortening cycle decreasing the amortization phase when transitioning from the eccentric to the concentric contraction. This trains the muscle to generate tension in the shortest time possible. The stretch shortening cycle normally supports to improve the explosiveness of the muscles and strengthen the large muscle which stimulated by the explosive exercise Carter et al [6] conducted a study to examine the effects of ballistic six programme on throwing speed among baseball pitchers. However there are two major differences between the studies. 1)The investigator measured the throwing speed

after an 8 weeks training of ballistic six programme, while their research examined the acute effects of BSP.2) High volume ballistic six programme of 30% and 50% of ballistic six programme. However, despite the differences, BSP can still be considerate an appropriate warm up program to increase throwing speed.

Variable 2: Effect of plyometric exercises on strength performance.

On intragroup comparison using paired 't' test the mean pre-treatment value of strength (closed kinetic chain upper extremity stability test) was 81.530±18.68 with post treatment mean of closed kinetic chain upper extremity stability test was 93.714±17.06 with 'p' value as < 0.0001 respectively. Our study found that there was a significant increase in strength performance among fast cricket bowlers after performing plyometric exercise which includes Theraband external rotation, Theraband 90/90 external rotation, Clap pushups.

Strength training (strengthening exercise) is the systematic practice of using muscle force to raise, lower, or control heavy external loads for a relatively low number of repetitions or over a short period of time [21]. The most common adaptation to strength training is an increase in the maximum force producing capacity of muscle, primarily the result of neural adaptations and increased muscle fiber size. Strength training, muscles adapt to endurance training by increases in their oxidative and metabolic capacities, which allows better delivery and use of oxygen. During concentric muscle contraction, the muscle spindle output is reduced because the muscle fibers are either shortening or attempting to shorten. During eccentric contraction, the muscle stretch reflex generates more tension in the lengthening muscle. Morphological, biomechanical, neurological, metabolic, and biochemical factors all affect the tension-generating capacity of normal skeletal muscle. Each of these factors contributes to the magnitude, duration, and speed of force production and the muscles' susceptibility to fatigue. Properties of muscle and key neural factors and their impact on tension generation during an active muscle contraction. Carter and colleagues[6] carried out a prospective study of the effect of a plyometric program on throwing velocity in a group of intercollegiate baseball players. Following pre-testing of throwing velocity and isokinetic strength of the shoulder rotators, participants were randomly assigned to either the plyometric training group (n = 13) or the control group (n = 11). Both groups participated in an off-season strength and conditioning program that included exercises with elastic resistance for the shoulder rotators, but only the experimental group performed a program of six plyometric exercises with a weighted ball for the upper extremities twice weekly for 8 weeks. At the conclusion of the program, the throwing velocity of the plyometric group increased significantly compared with the control group, but there continued to be no significant differences in shoulder strength between groups. The investigators concluded that a combined program of strengthening exercises and plyometric training is superior for improving throwing velocity than strengthening exercises alone. Schulte-Edelmann et al. 2005 investigated the effects of plyometric training of the posterior shoulder and elbow. The plyometric training group (n = 13) showed significant improvement in the power generated in the elbow extensor muscles. It was concluded that plyometric training of the upper extremity enhances power production of the elbow extensor muscles.

CONCLUSION

The study concluded that there was increase in bowling speed and strength Performance among professional cricket bowlers between the age group of 18-28.

LIMITATIONS

1) Bowling technique, height and built of the bowlers

2) Releasing point of time may impact the bowling speed which was not considered in the present study.

Future Scope:

1) Randomised controlled trial can be conducted
2) Bowling speed can be measured with radar gun

Clinical Implication:

Plyometric exercises can be helpful as an intervention to increase speed and strength performance among professional cricket fast bowlers.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: The authors declare that they have no conflict of interests.

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