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Effect of core-shoulder stability exercises on shoulder performance among throwers with glenohumeral internal rotation deficit

Deepak Manral[1], Jasobanta Sethi[1]*, Ankit Jain[1], Vimal Sharma[2]

[1] Department of Physiotherapy, Amity Institute of Health Allied Sciences, Amity University Uttar Pradesh, Noida, India.

[2] Dr. Vimal's Physiotherapy and Sports Injury Clinic, New Delhi, India.

Corresponding author: Jasobanta Sethi ✉jasobantsethi@yahoo.co.in, **Orcid Id**: https://orcid.org/0000-0002-6628-227X

Department of Physiotherapy, Amity Institute of Health Allied Sciences, Amity University Uttar Pradesh, Noida, India

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ABSTRACT

The study aimed to find out the effect of core-shoulder stability exercises on shoulder performance among throwers with glenohumeral internal rotation deficit (GIRD). Out of Forty-two athletes who participated, 30 subjects were selected who fulfilled the selection criteria and were randomized into 2 groups with 15 subjects in each group. Throwing accuracy (functional throwing performance index), throwing distance (overall medicine throw test), and shoulder range of motion were assessed and recorded at baseline, 3rd week, and 6th week of intervention. The control group received shoulder stability exercises while the study group received core-shoulder stability exercises 4 days per week for 6 consecutive weeks. Repeated measure ANOVA was used to see the difference between groups (groups 1 and 2) and time (baseline,3rd week, and 6th week) Averaged across times statistically significant improvement was found in overhead medicine ball throw in the study group (Group 2) as compared to the control group with $p<0.05$. No significant difference was found in the functional throwing performance index and range of motion when groups were compared across times. However, for all the outcome measures when compared across groups, a significant difference was found between 6th and 3rd-week scores as compared to baseline scores. This indicates improvements were seen in both groups independently. We conclude that core stability and shoulder stability training both improve the range of motion with throwing accuracy and distance. Core stability training improves throwing distance compared to shoulder stability training in subjects with GIRD.

Keywords: Overhead athletes, Shoulder internal range of motion deficit, Throwing accuracy, Throwing distance.

INTRODUCTION

Athletes involved in repetitive overhead activities place unique demands upon the shoulder girdle [1]. The glenohumeral joint is a common site for injury, which accounts for more than 30% of all injuries in overhead athletes [2]. Throwers show greater glenohumeral joint external rotation range of motion (ROM) of the dominant arm as compared to the non-dominant arm. This loss of glenohumeral joint internal rotation ROM in the dominant shoulder is referred to as glenohumeral internal rotation deficit (GIRD)[3]. It is believed as an anatomical maladaptive change and becomes pathological when it is associated with a related loss of the total rotation >5° in the throwing shoulder compared to the non-throwing shoulder [4]. A previous study suggested that the prevalence of GIRD in overhead athletes is 40% in adolescent pitchers and 25-43% in professional players [5]. The value of GIRD for cricket bowlers was found to be more than for badminton players[6]. The prevalence rate of GIRD in India in collegiate overhead athletes was found to be 29.1%[7]. GIRD can lead to an increased risk of pathologic conditions in the dominant shoulder in overhead athletes [4].

Shoulder and trunk musculature become active during glenohumeral movements while doing overhead activities. The core musculature gets active in a feed-forward manner while performing movement of the upper limbs[8]. Core stability exercises help in improving strength, endurance, and neuromuscular control which helps in maintaining dynamic segmental stability[9]. When the extremities start moving, the body prepares for a potential disruption of spinal stability through a feedforward process (10). According to additional studies, isometric, low-amplitude isotonic, and rapid isotonic exercise all cause the trunk muscles to contract (11-13).

Numerous isometric shoulder exercises show the trunk's muscles in action. Standing exercises that involve bilateral shoulder extension and unilateral transverse shoulder abduction have the most active trunk muscles. The external obliques and rectus abdominis muscles were most active during bilateral shoulder extension, whereas the multifidus and longissimus muscles were most active during unilateral horizontal abduction (greatest activation on the contralateral side)(11). Trunk musculature activity is also correlated with rapid isotonic shoulder movement (13,14).

Trunk activation doesn't seem to be influenced by arm movement direction; instead, speed of movement may be the main determinant of core activity. There is evidence in the literature that trunk muscles contract at slower isotonic rates, which suggests a lag in the feedforward process (13). Integrating shoulder and core exercises can address musculoskeletal abnormal functioning while providing a transition between the primary therapeutic exercises and the ultimate return to a specific sports rehabilitation program. It may help bridge the gap between the initial and functional rehabilitation exercises [8].

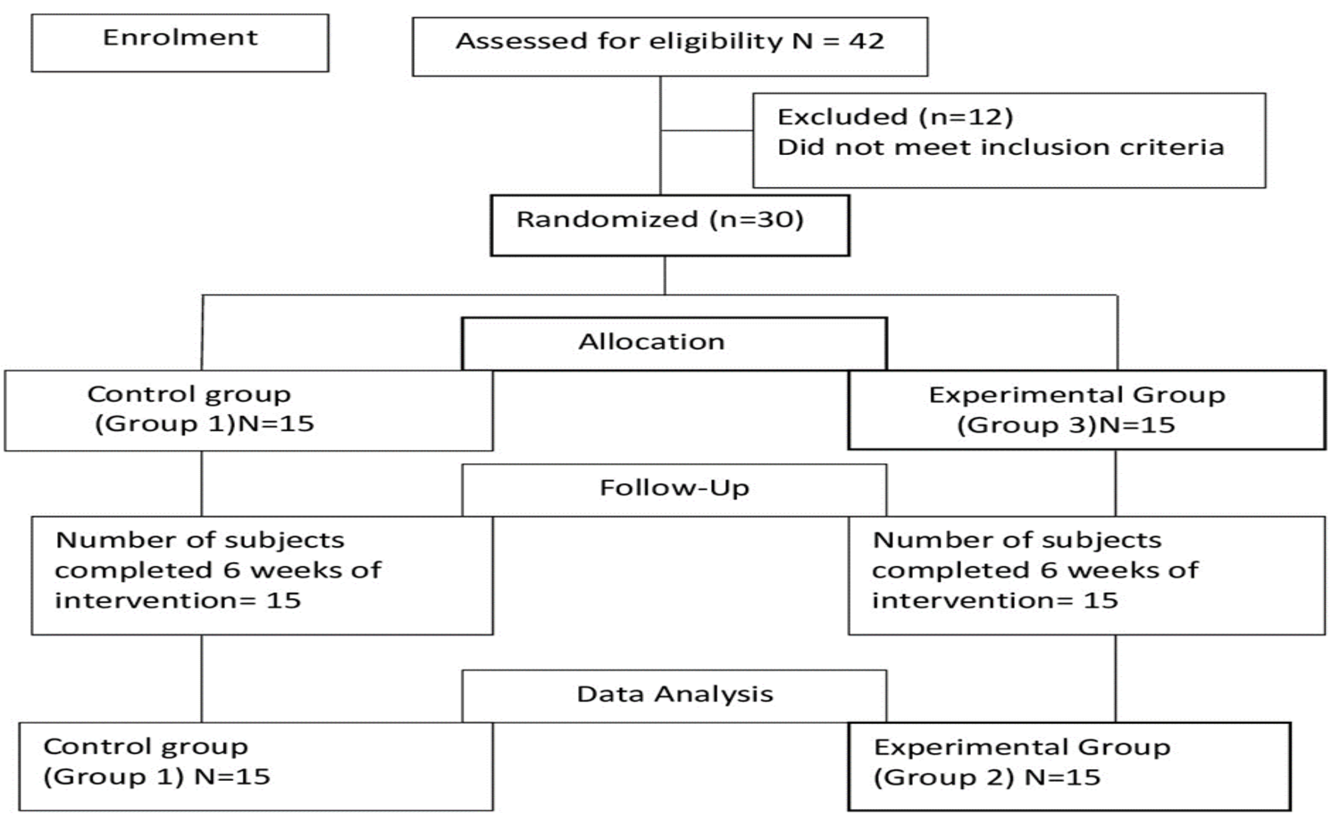
In this study, the throwing performance has been described as the parameter of throwing accuracy, throwing distance, and shoulder internal range of motion. The objective of the study was to find out the effect of core-shoulder stability exercises on shoulder performance among throwers with glenohumeral internal rotation deficits. We hypothesized that there will be a significant improvement with core-shoulder stability exercises in improving shoulder performance among throwers with glenohumeral internal rotation deficit.

MATERIALS AND METHODS

The study is a single-blinded randomized controlled Trial. Forty-two cricket bowlers (age range 16-25 years) with GIRD were recruited and screened for eligibility. Out of those, 12 subjects were excluded from the study as they did not meet the selection criteria, leaving a total sample size of 30 subjects. Informed consent was obtained from all subjects prior to the study.

Our study included male subjects between the age of 16 to 25 years of age who are fast bowlers in cricket at the university/club level. We excluded the subjects with h/o any musculoskeletal injury to the shoulder in the past, any deformity around the shoulder or neck, and any known case of neurological disease which affects shoulder functioning.

Figure 1: Consort flow chart of participants



Procedure

All the details of the subjects were recorded including age, height, weight, and hand dominance. Medical history was asked to scrutinize the subjects who came under exclusion criteria. Before the collection of data, all the subjects have explained the purpose of the study. The investigators have given a detailed orientation to the various test procedures, such as the functional throwing performance index (FTPI) to measure throwing accuracy and the overhead medicine ball throw test to measure throwing distance. The participants were randomized into 2 groups i.e., the study group (n=15) and control group (n=15) and underwent the assigned core stability exercises. All the exercises were demonstrated to the subjects prior to the intervention. A flow chart of the selection process is shown in Figure 1.

Outcome Measures

Throwing Accuracy-

The functional throwing performance index was used to evaluate the throwing accuracy. The participant stands at 4.57 m of distance from a target that is a 30.48 x 30.48 cm square placed on a wall at a height of 1.22 meters from the floor. The objective was to throw a standard leather ball into the target (square) and repeat it as several times as possible over 30 seconds trials three times. Before testing, subjects performed 10 throws for warm-up. As the warm-up was done, the test began immediately and included the participants throwing a leather ball into the target (square), the subject then caught the rebound of the wall and repeated it as several times as possible within 30 seconds of duration.

Then FTPI score was calculated as the number of balls thrown by participants within the target (square) divided by the total number of balls thrown by participants. The throwing accuracy was determined by an investigator to avoid the discrepancy in the judgment. The same examiner determined all throw accuracy to avoid the discrepancy in judgments. The reliability was good with a value of ICC= 0.81-0.89[15].

Throwing Distance

The throwing distance was calculated by the overhead medicine ball throw test. In this test, participants were instructed to throw the ball as far as they can, in a walk-stand position, holding the ball overhead with the dominant hand. The medicine ball was used with a mass of 2 kg and a diameter of 56 cm. Five trials were performed by each subject with 1-minute rest between trials. The distance (in m) was measured with a measuring tape to which the subject threw the medicine ball. The best of five trials were recorded and used for further analysis.

Shoulder Internal Range of Motion

A universal goniometer was used as a reliable (ICC = 0.70–0.93)tool to measure the internal ROM of the glenohumeral joint [16]. The participant was told to relax the shoulder girdle muscles in a supine position. The dominant shoulder was placed at 90° of abduction, and the elbow at 90° of flexion. The universal goniometer axis was aligned with the long axis of the humerus, with the distal tip of the olecranon being the superficial landmark for alignment. The stationary arm of the goniometer was placed in a vertical position with the moving arm aligned with the lateral aspect of the ulna. Then, the examiner moved the shoulder joint passively into internal rotation and placed the other hand on the subject's acromioclavicular joint. Then, as soon as the motion in the acromioclavicular joint was noted, the internal rotation motion was stopped, and the participant's hand was kept constant by the second examiner. The internal rotation around the coronal axis was then calculated.

Intervention

After completion of the pre-test assessment, subjects were reported to their assigned intervention Groups. The exercises were administered 4 days per week for consecutive 6 weeks.

Control Group (Group 1)

The control group received shoulder stability exercises.

1^{st}-2^{nd} Week

Sleeper Stretch and Crossbody Stretch (5reps 30secs hold), Internal and External Rotation at 0° abduction, Full can raise, Seated Rows and Archer pulls with yellow thera-band (3 sets of 10 sets).

2^{nd}-4^{th} Week

Internal and External Rotation at 90° abduction, Empty can raise, PNF pattern, and Prone Rows with red thera-band (3 sets of 10 reps)

4^{th}-6^{th} Week

Prone arm I, Y, T, and W raises with green thera-band (3 sets of 10 reps) and Pushups (3 sets of 10 reps)

Study Group (Group 2

The study group received core-shoulder stability exercises on a Swiss ball.

1^{st}-2^{nd} Week

Sleeper Stretch and Crossbody Stretch (5reps 30secs hold). Internal and External Rotation at 0° abduction, Full can raise, Seated Rows and Archer pulls with yellow TheraBand (3 sets of 10 reps)

2^{nd}-4^{th} Week: Internal and External Rotation at 90° abduction, Empty can raise, PNF pattern, and Prone Rows with red TheraBand (3 sets of 10 reps)

4^{th}-6^{th} Week

Prone arm I, Y, T, and W raises with green TheraBand (3 sets of 10reps), Pushups (3 sets of 10 reps), Plank (2 Reps)

Statistical analyses were performed using the NCSS package version 12.0 (NCSS, Kaysville, UT, USA). The normality of the data was verified using the Shapiro-Wilk test. Standard statistical methods were used for the calculation of means and standard deviation of all dependent variables (Throwing distance, Throwing Accuracy, and Shoulder internal range of motion). Significance was set at $p \leq 0.05$, and repeated measure ANOVA was conducted to find differences across times (pre-test, post-test 3^{rd} week, and 6^{th} week) and groups (core stability and shoulder stability). In case of significant interactions between variables, post-hoc pairwise comparisons were performed using the Tukey-Kramer test for multiple comparisons.

Ethical Approval

All patients gave written informed consent to be enrolled in the study according to the Declaration of Helsinki. The study was approved by the NTCC Review committee of Amity Institute of Physiotherapy, Amity University, Noida India **(Reference No: NTCC/MPT-Sports Med/21-22/Nov2021/14)** and the study has been registered in the Clinical Trial Registry of India **(Registration number: CTRI/2022/01/039536).**

RESULTS AND DISCUSSION

Data were collected on 30 subjects, 15 in each control and experimental group. Demographic information is given in Table 1.

Table 1: Demographic information of Subjects

Parameters	Group 1 (Control) (n=15)Mean (SD)	Group 2 (Experimental) (n=15)Mean (SD)
Age (in years)	17 (2.07)	18.86 (3.58)
Height (in cm)	173.33 (7.41)	174.2 (6.78)
Weight (in kg)	60.73 (10.15)	63.93 (8.37)

Functional Throwing Performance Index (FTPI) Score

Averaged across times, the FTPI score was not significantly improved in the study group as compared to the control group (Mean Difference (MD): 0.032, 95% Confidence Interval (CI): 0.02, 0.09) (p=0.26). Averaged across groups, the FTPI score was significantly improved in 6th week as compared to the 3rd week (MD: 0.068), CI: 0.03, 0.10) (p<0.001), and baseline (MD: 0.187, CI: 0.15, 0.22) (p<0.001). Moreover, there was also a significant improvement in 3rd week as compared to the baseline (MD: 0.119, CI: 0.08, 0.15) (p<0.001). (Table 1.1). There was a significant interaction between times and groups. (F=3.48, P=0.037) (Table 1.2)

Table 1.1: Mean and Standard Deviation of Functional Throwing Performance Index Score across Groups and Times

Side	Baseline	Post-Test 3rd week	Post-Test 6th week	Averaged over time
Shoulder stability exercises	0.65(0.09)	0.75(0.04)	0.80(0.07)	0.73
Core-Shoulder stability exercises	0.64(0.15)	0.78(0.08)	0.87(0.08)	0.77
Averaged over group	0.65^a	0.77^b	0.83^c	

Different letters (‘a’,‘b’,‘c’) are assigned to signify differences across times.
*Indicates differences across sides (p<0.05).

Table 1.2 : Repeated Measure ANOVA results of across groups and times.

Dependent Variable	Factor	DF	F-Ratio	P-value
Functional Throwing Performance Index score	Group	1/28	1.33	0.260
	Time	2/2	76.15	0.000*
	Group x Time	2/56	3.48	0.037*

Overhead medicine ball throw

Averaged across times, the overhead medicine ball throw score significantly improved for the study group as compared to the control group (Mean Difference (MD): 1.766, 95% Confidence Interval (CI): 0.63, 2.89) (p<0.001). Averaged across groups, the overhead medicine ball throw score was significantly improved in 6th week as compared to the 3rd week (MD: 1.486), CI: 1.20, 1.77) (p<0.001), and baseline (MD: 2.842, CI: 2.55, 3.12) (p<0.001). Moreover, there was also a significant improvement in 3rd week as compared to the baseline (MD: 1.356, CI: 1.07, 1.63) (p<0.001). (Table 2.1)

There was a significant interaction between times and groups (F=5.71, P=0.005) (Table 2.2)

Table 2.1: Mean and Standard deviation of Overhead medicine ball throw across groups and times.

Side	Baseline	Post-Test 3rd week	Post-Test 6th week	Averaged over time
Shoulder stability exercises	7.70(1.68)	8.96(1.87)	10.16(2.08)	8.94
Core-Shoulder stability exercises	9.15(1.09)	10.61(1.07)	12.37(1.19)	10.71*
Averaged over group	8.42^a	9.78^b	11.27^c	

Note: Different letters (‘a’, ‘b’, ’c’) are assigned to signify differences across times
*Indicates differences across sides (p<0.05).

Table 2.2 : Repeated Measure ANOVA results of across groups and times.

Dependent Variable	Factor	DF	F-Ratio	P-value
Overhead Medicine Ball Throw	Group	1/28	10.30	0.003*
	Time	2/2	292.81	0.000*
	Group x Time	2/56	5.71	0.005*

Internal rotation range of motion

Averaged across times, the internal rotation ROM was not significantly improved on the study group as compared to the control group (Mean Difference (MD): 0.955, 95% Confidence Interval (CI): 1.71, 3.62) (p=0.46). Averaged across groups, the throwing index score was significantly improved in 6th week as compared to the 3rd week (MD: 1.2), CI: 0.37, 2.02) (p=0.002), and baseline (MD: 18.6, CI: 17.77, 19.42) (p<0.001). Moreover, there was also a significant improvement in 3rd week as compared to the baseline (MD: 17.4, CI: 16.57, 18.22) (p<0.001). (Table 3.1)

There was no significant interaction between times and groups. (Table 3.2)

Table 3.1: Mean and Standard deviation of Internal rotation range of motion across groups and time

Side	Baseline	Post-Test 3rd week	Post-Test 6th week	Averaged over time
Shoulder stability exercises	47.66(4.33)	64.86(3.29)	66.33(2.84)	59.66
Core-Shoulder stability exercises	48.53(4.32)	66.13(3.87)	67.06(3.43)	60.57
Averaged over group	48.1^a	65.5^b	66.7^c	

Different letters (‘a’, ‘b’, ’c’) are assigned to signify differences across times.
*Indicates differences across sides (p<0.05).

Table 3.2 Repeated Measure ANOVA results of across groups and times.

Dependent Variable	Factor	DF	F-Ratio	P-value
Internal Rotation ROM	Group	1/40	0.54	0.470
	Time	2/2	1834.31	0.000*
	Group x Time	2/56	0.33	0.723

This study evaluated the effect of core-shoulder stability exercises on shoulder performance among throwers with glenohumeral internal rotation deficit resulting in an improvement in throwing accuracy, throwing distance, and shoulder internal range of motion scores in both groups. However, there was a significant improvement in overhead throwing ball throw in the experimental group (Group-2) as compared with the control group (Group-1) following the 6-week intervention. However, no significant difference was found between throwing accuracy and shoulder internal rotation range scores between the two groups.

Throwing accuracy

The findings of the functional throwing performance index showed significant improvement in throwing accuracy with pre-test (mean=0.64), post-test 3rd week (mean=0.78), and post-test 6th week(mean=0.87) with $p<0.05$ (Table 1.1). The significant improvements in accuracy may be related to changes in neuromuscular factors. The changes in neuromuscular control are consequent to muscular resistance training. Strength training may cause adaptive changes in the nervous system that allow one to better coordinate the activation of relevant muscles in a specific movement. The changes in muscular response were attributed to greater recruitment of motor units in the trained muscle which increases the activation of prime movers in a specific movement[17]. Similar studies have been found in the past on the effectiveness of exercise programs on throwers' shoulder performance among novice badminton players [18].

Throwing Distance

Overhead medicine ball throw test showed significant improvement in throwing distance with pre-test (mean=9.15), post-test 3rd week (mean=10.61), and post-test 6th week (mean=12.38) with $p<0.05$ (Table 2.1). The core musculature gets active in a feed-forward manner while performing movement of the upper limbs. Integrating the core with shoulder stability exercises generates the force and transfers it through the upper extremity [7]. These exercises seem to affect the length of the muscles and tendons which could produce more force according to the length-tension curve theory in a muscle and improve neuromuscular coordination in agonist and antagonist's muscles. As a result, these changes may increase the strength of the shoulder muscles[19]. Proximal stability determines distal mobility, better improvement in the experimental group in throwing distance can be attributed to core stability training given. Core muscles stabilize the proximal segment which in turn improves the distance for which the ball is thrown. Similar studies have been found in the past on shoulder performance among novice badminton players[18].

Shoulder Internal Rotation Range of Motion

The shoulder internal rotation range of motion was significantly improved with the pre-test (Mean=48.53), post-test 3rd week (Mean=66.13), and post-test 6th week (Mean=67.07) with $p<0.05$ (Table 3.1). Stretching accomplished in this study not only stretched the Musculotendinous structures but indirectly stretched the various portions of the glenohumeral capsule. Also, improved shoulder strength could be another factor contributing to the significant improvement in internal rotation[17]. Similar studies have been found in the past on stretching exercises on shoulder joint range of motion in overhead athletes with glenohumeral internal rotation deficit [20, 21].

Previous studies on upper extremity rehabilitation proposed stabilization training only for isolated shoulder and core muscles [8, 22]. Since trunk musculature also becomes active during glenohumeral movement, they should also receive attention during shoulder rehabilitation. The present study provides insight into the integration of core-shoulder stability exercises.

LIMITATIONS

The results of the study cannot be generalized due to small sample size. We took subjects of age group 16-25years, and gave only 6-week training. Future studies can be planned on larger sample sizes, wider age groups, and longer interventions.

CONCLUSION

The study concluded that 6 weeks of core-shoulder stability exercises significantly improved the throwing distance among throwers with glenohumeral internal rotation deficit.

Conflict of Interest

The authors declare that there is no conflict of interest.

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