

**EFFECTS OF KINETIC CHAIN TRAINING ON
GLENOHUMERAL INTERNAL ROTATION DEFICIT
AMONG ASYMPTOMATIC RECREATIONAL OVERHEAD
ATHLETES: RANDOMISED CONTROLLED TRIAL**

by

PINAK PRASHANT DHOMNE

**Dissertation Submitted to the
Odisha University of Health Sciences, Bhubaneswar, Odisha**

**In Partial Fulfilment
Of the requirements for the degree of**

**MASTERS OF PHYSIOTHERAPY (MPT)
In
SPORTS SCIENCES**

Under the Guidance of

**Dr. Deepak Kumar Pradhan (PT)
Associate Professor, ABSMARI**



**Abhinav Bindra Sports Medicine and Research Institute
Department of Physiotherapy
Bhubaneswar, Odisha
2023-2025**

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I hereby declare that this dissertation/thesis entitled “**Effects of Kinetic chain training on Glenohumeral Internal Rotation Deficit Among Asymptomatic Recreational Overhead Athletes: Randomised Controlled Trial**” is a bonafide and genuine research work carried out by me under the guidance of Dr. Deepak Kumar Pradhan (PT), Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha and there are no conflict of interest associated with this dissertation work.

Date:

Signature of the candidate

Place:

Name: Pinak Prashant Dhomne

University Registration No.: 23MP435028

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Date:

Place:

Seal & Signature of the Guide

Dr. Deepak Kumar Pradhan (PT)

Department of Movement Science

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Date:

Seal & Signature of the HOD

Place:

Dr. Asifuzzaman Shahriyar Ahmed (PT)

Associate Professor, HOD,

Musculoskeletal and Sports, ABSMARI

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This is to certify that the dissertation entitled “**Effects of Kinetic chain training on Glenohumeral Internal Rotation Deficit Among Asymptomatic Recreational Overhead Athletes: Randomised Controlled Trial**” is a bonafide and research work carried out by **Pinak Prashant Dhomne** under the guidance of **Dr. Deepak Kumar Pradhan (PT)**, Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha.

Date:

Seal & Signature of the Principal

Place:

Dr. Chinmaya Kumar Patra (PT)

PRINCIPAL, ABSMARI



ODISHA UNIVERSITY OF HEALTH SCIENCES

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This is to certify that the dissertation entitled “**Effects of Kinetic chain training on Glenohumeral Internal Rotation Deficit Among Asymptomatic Recreational Overhead Athletes: Randomised Controlled Trial**” carried out by **Mr. Pinak Prashant Dhomne**, bearing University Registration Number 23MP435028, has been **evaluated and accepted** by me as an **Examiner /Evaluator**, appointed by the **Odisha University of Health Sciences, Bhubaneswar**, in partial fulfilment of the requirements for the award of the degree of **Master of Physiotherapy (MPT) in Sports Sciences**.

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Date:

Name:

Institution:

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Thank you.

Date:

Place:

Signature of the candidate

Pinak Prashant Dhomne

LIST OF ABBREVIATIONS USED

Abbreviation	Full Form
AHD	Acromiohumeral Distance
BSET	Bilateral Shoulder Elevation Test
CBS	Cross Body Stretch
CKC	Close Kinetic Chain
EMG	Electromyography
ER	External Rotation
FTPI	Functional Throwing Performance Index
GIRD	Glenohumeral Internal Rotation Deficit
IR	Internal Rotation
KC	Kinetic Chain
MWM	Mulligan With Movement
OKC	Open Kinetic Chain
ROM	Range Of Motion
SLAP	Superior Labrum Anterior to Posterior
SRRT	Standing Rotation Reach Test
SS	Sleeper Stretch
TROM	Total Range of Motion
WBP	Weight Bearing Position

ABSTRACT

Background: The overhead throwing motion is complex, and restrictions in range of motion (ROM) at the hip may place additional demands on the shoulder that lead to injury. However, the effect on glenohumeral internal rotation deficit (GIRD) of adding contralateral hip in kinetic chain training is unknown.

Objective: Primary objective was to investigate added effects of contralateral hip exercises on GIRD of the dominant shoulder using a smartphone inclinometer application. Secondary objective was to investigate added effects of contralateral hip exercises on GIRD of the dominant shoulder using Functional throwing performance index, Bilateral shoulder elevation test, and Standing rotation reach test.

Methods: 175 asymptomatic recreational overhead athletes were screened for GIRD >18 degrees and hip rotational deficit >10 degrees. 48 eligible athletes were randomly allocated into 2 groups. Controlled group were given shoulder focused exercises whereas Experimental group were focused on ipsilateral shoulder and contralateral hip. Functional parameters such as bilateral shoulder elevation test, functional throwing performance index, and standing rotation reach test were and Both groups were assessed through pre-test and post-test evaluations to measure improvements in GIRD and Functional parameters.

Results: Paired t test showed no significant difference between the groups for BSET (p value >0.05, d = 0.2). Mann Whitney U test showed significant difference between the groups for ROM (P value < 0.05, d =

2.205) and no significant difference for FTPI (p value >0.05 , $d = 0.237$) and SRRT (p value >0.05 , $d = 0.487$). In between-group analysis showed statistically significant improvement in ROM in the experimental group, whereas functional parameters showed no significant improvement. For within- group analysis there was significant improvement in ROM, BSET, SRRT, and FTPI (experimental group).

Interpretation & Conclusion: Overall, the findings confirm that integrating contralateral hip exercises with conventional shoulder-focused rehabilitation yields superior improvements in GIRD among asymptomatic recreational overhead athletes.

Keywords: “Range of Motion”, “Smartphone”, “Shoulder”, “Athletes”.

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INTRODUCTION

INTRODUCTION

Overhead throwing refers to the act of propelling an object into space using internal rotators while keeping the arm separated from the body, with extension at the elbow being a key movement of the upper limb. The stages of throwing consist of wind-up, initial cocking, final cocking, acceleration, deceleration, and follow-through phases¹. The extensive Range of Motion (ROM) at the shoulder joint allows the athlete to engage in a multitude of sporting activities. This is especially evident in sports involving overhead movements, such as cricket, badminton, tennis, baseball, basketball, volleyball, and shot put¹. The overhead movement trajectories of badminton smashes, tennis and volleyball serve, and baseball pitchers are alike, leading to very similar kinematic mechanisms for the shoulder². Over time, with increased overhead activity, throwers demonstrate posterior capsule contracture, leading to a decrease in internal rotation in the throwing hand known as Glenohumeral Internal Rotation Deficit (GIRD)¹.

GIRD is defined as $>18^\circ$ difference in internal rotation (IR) range of motion (ROM) between the dominant and non-dominant shoulder¹⁰. GIRD is a frequent finding among overhead athletes, though prevalence varies depending on sport, level of play, and diagnostic threshold used. In professional and youth baseball pitchers, prevalence is reported between 20 and 30%, with younger athletes often showing even greater IR loss when compared to older groups^{3,4}. In tennis players, both professionals and youth athletes frequently display internal rotation deficits with compensatory external rotation gains, with a high prevalence of altered rotational profiles across competitive levels⁵. In volleyball players, recent evidence demonstrates a very high prevalence of both anatomical and pathological GIRD, emphasizing the magnitude of shoulder adaptations in

this sport⁶. In cricket fast bowlers, mean GIRD was found to be relatively small ($\sim 5.7^\circ \pm 4.4^\circ$) with no bowlers meeting pathological cut-off criteria, suggesting lower prevalence than in baseball or volleyball⁷. Similarly, in badminton players, internal rotation loss is observed in some cohorts but rarely meets pathological thresholds⁷. Importantly, while anatomical GIRD (IR loss with ER gain and preserved total rotational motion) may represent a benign adaptation, pathological GIRD (IR loss with total rotational motion deficit) has been more strongly associated with increased risk of shoulder injury across overhead sports^{8,9}.

Clinical symptoms include Internal Rotation (IR) Deficit –a reduction in IR, typically greater than 10–20°, is frequently observed in the dominant shoulder compared with the non-dominant side, even in the absence of reported pain⁹. External Rotation (ER) Adaptation – Athletes often compensate with increased ER in the dominant arm, which helps preserve overall total rotational motion (TROM) symmetry. This adaptation is generally regarded as a physiological adjustment¹¹. Posterior Shoulder Tightness –restriction or stiffness involving the posterior capsule or muscles such as the infraspinatus, teres minor, and posterior deltoid can be identified on clinical evaluation¹². Scapular Dyskinesis –although sometimes subtle, alterations in scapular kinematics may occur, including winging or early elevation, but these changes are not always symptomatic¹³. Muscular Imbalance – testing may reveal diminished eccentric strength of the external rotators or reduced endurance of the rotator cuff¹⁴. Absence of Pain – athletes with these adaptations typically do not experience the hallmark symptoms (e.g., pain at rest, night discomfort, or weakness), even though structural changes are present.

Potential consequences include even if asymptomatic now, pathological GIRD –internal rotation deficit becomes clinically concerning when it is accompanied by a loss of total rotational motion (TROM), as this state is linked to a higher likelihood of shoulder injuries⁸. Elevated Risk of Overuse Injuries – Prospective research indicates that athletes with significant but initially asymptomatic GIRD are predisposed to future shoulder issues such as pain, rotator cuff tendinopathy, or labral pathology¹⁵. Biomechanical Alterations in Throwing/Serving – persistent IR restriction can elevate anterior shoulder loading and posterior shear forces, predisposing athletes to internal impingement or superior labral (SLAP) lesions¹⁶. Posterior Shoulder Tightness Leading to Microtrauma –long-standing stiffness of the posterior capsule may result in repetitive stress on the posterosuperior labrum, even before clinical symptoms emerge¹⁷. Subclinical Performance Impairments –subtle declines in performance, such as reduced throwing velocity, accuracy, or endurance, may be present, often going unnoticed in recreational athletes until activity demands intensify¹⁸.

Studies done so far on relating the outcomes across various populations are A comparative study was done between Kinesiotaping and kinetic chain-based rehabilitation of shoulder on downward rotated scapula in young elite fast bowlers. 1) Group A involved Open Kinetic chain (OKC) and Closed Kinetic Chain (CKC) exercises, and Group B involved kinesiotaping to serratus anterior and upper trapezius. The study concluded that kinesiotaping was not as effective as kinetic chain exercises¹⁹. 2) A randomized crossover trial was done comparing kinetic chain Vs isolated shoulder exercise for people with and without shoulder pain, where the study showed adding lower-body/trunk contribution altered muscle activation and offered benefits for shoulder

rehabilitation²⁰. 3) A systematic review of EMG studies was done on role of Kinetic chain (KC) in shoulder rehabilitation, study concluded that adding a trunk and lower limb (KC) element to shoulder exercises tends to increase recruitment of axioscapular stabilizers and reduce relative demand on the rotator cuff compared with isolated (non-KC) shoulder exercises²¹. 4) A review was done on throwing injury prevention strategies for overhead throwing athletes with a whole KC focused approach. The authors conclude that comprehensive knowledge of throwing mechanics, combined with phase-specific exercise interventions, has the potential to reduce injury risk across all athletes, irrespective of age or experience²².

Several investigations and reviews have examined the influence of the kinetic chain—including the thorax, trunk, pelvis, and hips—on shoulder mechanics. Interventions targeting thoracic mobility or trunk integration have been shown to produce short-term gains in internal rotation (IR) and related measures. However, there is still a lack of robust, adequately powered randomized controlled trials that specifically isolate kinetic-chain-focused training and demonstrate lasting improvements in pathological GIRD, throwing biomechanics, or injury prevention^{23,24}.

In baseball pitching and in similar sports such as cricket, when a bowler is about to deliver a ball, in badminton when a player is playing an overhead whip stroke, in tennis, when a player is serving or in shotput when a player is throwing a ball, the stride leg is generating force distally and transferring it up to the delivering upper extremity. Stability of the back and stride leg allows rotation of the trunk which is directly proportional to the amount of arm motion that will occur²⁵.

About half of the energy in a throw comes from the stride legs, and if those forces are diminished by 20%, the shoulder takes on an additional 34% of the load. Reduced range of motion in the hips and shoulders, immobility in the spine, and weakening in the muscles all contribute to increased mechanical stress of tissues further along the kinetic chain²⁶. Restricted IR ROM of contralateral hip in the follow-through phase reduces the ability of lower extremities to absorb and transmit forces that are generated in the acceleration phase which places greater forces on the rotator cuff to act as a brake to decelerate arm during the follow-through phase ultimately leading to posterior shoulder dysfunction and rotator cuff injury²⁷.

Hence, hip mobility should be routinely screened in overhead athletes with GIRD, as this approach targets both symptoms (IR loss) and causes (proximal chain inefficiency). Studies have been done that are targeting only the shoulder to treat GIRD but haven't focused on the oblique kinetic chain. Hence, we hypothesized that adding hip component in athletes with GIRD will improve shoulder ROM better than just targeting the shoulder alone.

AIM & OBJECTIVE OF THE STUDY

AIM OF THE STUDY

- Primary -To investigate added effects of contralateral hip exercises on GIRD of dominant shoulder.
- Secondary -To investigate added effects of contralateral hip exercises on functional parameters of throwing.

OBJECTIVES OF THE STUDY

- Primary -To investigate added effects of contralateral hip exercises on GIRD of the dominant shoulder using a smartphone inclinometer application.
- Secondary- To investigate added effects of contralateral hip exercises on GIRD of the dominant shoulder using Functional throwing performance index, Bilateral shoulder elevation test, and Standing rotation reach test.

HYPOTHESIS OF THE STUDY

HYPOTHESIS OF THE STUDY

Null Hypothesis:

1. There will be no significant effect of added hip exercises on GIRD.
2. There will be no significant effect of added hip exercises on Functional Parameters.
3. There will be no significant effect of shoulder mobilization on Functional Parameters.
4. There will be no significant effect of shoulder mobilization on GIRD of the dominant shoulder.

Alternate Hypothesis:

1. There will be significant effect of added hip exercises on GIRD.
2. There will be significant effect of added hip exercises on Functional Parameters.
3. There will be significant effect of shoulder mobilization on Functional Parameters.
4. There will be significant effect of shoulder mobilization on GIRD of the dominant shoulder.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Section 1: Prevalence of GIRD in Recreational overhead athletes

1. Michele Forgiarini Saccol et al. (2015) conducted a study aiming to compare the bilateral ROM and rotation strength in the shoulders of young beach volleyball players. External and internal ROM, total rotation motion, glenohumeral internal rotation deficit (GIRD), external rotation and internal rotation strength, bilateral deficits, and external rotation to internal rotation ratio were measured. 33 volleyball players were included, out of which 6 athletes (18.2%) reported as having pathological GIRD, having GIRD more than 18 degree.
2. Kazutomo Miura, MD, et al. (2018) conducted a study aiming to determine the prevalence of pathological GIRD and suprascapular neuropathy in male collegiate volleyball players. The study evaluated 22 male collegiate volleyball players for range of motion, and results showed pathological GIRD ($\geq 20^\circ$) was found in four players (18.2%).

Section 2: Measurement of Shoulder and Hip ROM Using Smartphone Inclinometer App Vs Goniometer

3. Smith, Allison B, et al. (2016), conducted a study to determine the validity of the smartphone application “Clinometer” for measuring shoulder internal and external rotation range of motion using intra-rater reliability. Participants’ shoulder ROM was measured using both a standard goniometer and the smartphone application. Measurements were repeated to assess intra-rater reliability, and statistical analyses were performed to compare the agreement between the two methods. The findings were that smartphone validation was statistically significant for shoulder internal and external range of motion with values of 0.959 and 0.940, respectively. Intra-rater reliability was statistically significant for external rotation with the goniometer and internal and external rotations with the application (0.804, 0.800, and 0.838)
4. P.C. Charlton et al. (2015), conducted a study that aimed to assess the reliability and validity of a custom smartphone application for assessing hip joint ROM. Passive hip joint range of motion was recorded for seven different movements in 20 males on two separate occasions. The study concluded smartphones are portable and widely available tools that are mostly reliable and valid for assessing passive hip range of motion.

Section 3: Treatment for Glenohumeral Internal Rotation Deficit

5. Annelies Maenhout et al. (2012), conducted a study aiming to quantify acromiohumeral distance (AHD) and to investigate the effect of a sleeper stretch program on ROM and AHD. The method involved randomly allocating the athletes to the stretch (n = 30) or control group (n = 32). The stretch group performed a 6-week sleeper stretch program on the dominant side. Change of range of motion and AHD were measured and analyzed in both groups after 6 weeks. The findings revealed AHD was found to be smaller on the dominant side in athletes with GIRD and was found to increase after a 6-week sleeper stretch program, which further provided an association between GIRD and subacromial impingement.

6. F. Kamali et al. (2021) conducted a study aiming to assess the immediate effect of combining glenohumeral and scapulothoracic mobilization with stretching on improving internal rotation range of motion (ROM) in overhead athletes with GIRD. 30 asymptomatic male volleyball players who had a loss of dominant shoulder IR ROM of 15 degrees or more were randomly assigned to 1 of 2 groups: stretching only (n = 15) or stretching plus joint mobilization (n = 15). Both groups received the intervention every other day for 1 week. The study concluded that both interventions (stretching and stretching plus mobilization) can have the same beneficial effect in decreasing GIRD in asymptomatic overhead athletes.

7. Cools et al. (2011) conducted a study aiming to determine if stretching of the posterior shoulder improves ROM and reduces symptoms, 60 overhead athletes with GIRD were grouped into 30 asymptomatic and 30 symptomatic. The outcome was to improve glenohumeral IR in symptomatic and asymptomatic overhead athletes using angular (stretching) and nonangular stretching (joint mobilizations). Results showed asymptomatic groups had significant internal-rotation improvement of 20.5° and 19.3° in angular- and non-angular-stretching groups, respectively, and concluded stretching, angular as well as non-angular techniques, increases internal rotation ROM in overhead athletes and may decrease sport specific shoulder pain in overhead athletes with impingement symptoms.

8. Naoya Iida et al. (2025) conducted a study aiming to critically assess the efficacy of sleeper stretch (SS) and crossbody (CB) stretch in the ROM of the internal rotation (IR) among overhead athletes with GIRD. Six eligible studies involving 255 athletes with GIRD were included. The meta-analysis demonstrated statistically significant differences between stretching and control groups in terms of enhancing the ROM of IR. The study concluded that SS or a combination of SS and CS interventions significantly enhanced the ROM of IR in overhead athletes diagnosed with GIRD.

Section 4: Article on Kinetic Chain-Influence of Hip and Trunk Motion on GIRD

9. Aaron Sciascia et al. (2012) reviewed an article, “Kinetic Chain Rehabilitation: A Theoretical Framework” aim was to propose a theoretical framework for kinetic chain–based rehabilitation in overhead athletes and recommended incorporating stretching program in overhead athletes with GIRD in which cross body stretch, sleeper’s stretch and corner stretch have been found to be effective.

10. Steve Scher et.al (2010) conducted a study in which the objective was to (1) determine if differences exist in hip and shoulder ROM between professional baseball players with a history of shoulder injury and those with no history of shoulder injury and (2) assess relationships between hip and shoulder ROM in these players. A total of 57 professional baseball players (average age, 26.3 years; range, 21–36 years) volunteered for this study, all ROM testing of the dominant and nondominant hips and shoulders was conducted. Study suggest that (1) bilateral differences in shoulder IR and non-dominant hip IR were detected only in non-pitchers. (2) GIRD was greater in both pitchers and non-pitchers with a history of shoulder injury but not significant.

11. Hye-Min Ko et.al (2022) conducted a study examining the effects of various interventions for improving the hip joint range of motion on elite badminton players, including body balance ability, jumping power, smash speed, and joint range of motion. 21 elite badminton players were selected and assigned randomly to Experimental Group 1 and Experimental Group 2. In Experimental Group 1, hip joint manual mobilization was applied by a physical therapist, and hip self-exercise performed by the athletes was applied in Experimental Group 2. The study showed although not significant but there was increase in Internal and external ROM in experimental group 1.

12. Daniel Torres et al. (2021) conducted a study to determine if hip mobilization with movement (MWM) is superior to passive stretching for increasing hip ROM. 48 participants with impaired hip ROM were randomized to a control group or received a single bout of either a hip MWM or hip passive stretch. Study concluded that although not significant but improvements in ROM were achieved in both the stretching and MWM groups, indicating comparable efficacy.

Section 5: Prevalence of Hip rotation deficit among overhead athletes

13. Ellenbecker et al. (2007) conducted a study on 64 male and 83 female elite tennis players and 101 male professional baseball pitchers participated in this study. Measurement of hip IR and ER were taken to find out side-to-side differences in hip joint ROM. Findings were that a

bilateral difference in hip rotation greater than 10° identified 17% of the professional baseball pitchers with IR differences and 42% with ER differences. Differences in the elite male tennis players occurred in only 15% of the players for IR and 9% in ER. Study concluded that asymmetric hip joint rotational active range of motion encountered during clinical examination and screening may indicate abnormalities and would indicate the application of flexibility training, rehabilitation, and further evaluation.

Section 6: Article on Assessing Performance of Overhead Throwing Athletes

14. S. L. Boudreau et al. (2022), in their review article, aim to assess performance in throwing athletes using the Functional Throwing Performance Index (FTPI) which measures the accuracy of overhand-throwing athletes. The study concluded that FTPI is a useful tool for assessing overhand-throwing accuracy in overhead athletes and can help guide rehabilitation and return to sport. It provides normative values and helps discriminate performance deficits.

15. L. Howe et al. (2015) gave a guideline to screen or assess thoracic extension/rotation and self-management techniques in athletes in which the Bilateral Shoulder Elevation Test (BSET) assess trunk extension and Standing Rotation Reach Test (SRRT) assesses trunk and pelvis rotation. The guideline concluded that thoracic spine screening should be an

essential part of athlete assessment, particularly in overhead and rotational sports.

Section 7: Treatment to Improve Hip Rotational Range

16. Sreenivasu Kotagiri et al. (2018) conducted a study aiming to determine the effectiveness of mobilization with exercise in patients with glenohumeral internal rotation deficit and, secondly to determine whether Mulligan internal rotation MWM with stretching is effective in patients with glenohumeral internal rotation deficit. 60 patients were included in the study, which was divided into two groups: Group A and Group B, with 30 patients in each group. Subjects in Group-A were given mobilizations with stabilization exercises and subjects in Group-B were given Mulligan mobilization with posterior capsule stretching. This study concluded that combining Mulligan's MWM with targeted stretching provides a superior clinical benefit for restoring internal rotation and reducing deficits in shoulder mobility.

17. Do-young Jung (2023) conducted a study aiming to compare the immediate effects of mobilization with movement (MWM) in a non-weight bearing position and a weight bearing position (WBP) and for increasing hip internal range (IR). Fifteen subjects with limited hip IR participated in two interventions: MWM in WBP and in non-WBP. A study showed that both MWM in non-WBP and WBP immediately improved hip IR range of motion.

Section 8: Active Treatment Option for Shoulder

18. Ozge Gokalp et al. (2020), conducted a study aiming to investigate the effects of the Thrower's Ten exercises on the upper extremity performance. 36 healthy sedentary individuals completed this study conducted with a randomized controlled design. The subjects were divided into 2 groups: exercise and control. The exercise group received training on the Thrower's Ten exercises of 50-minute sessions 3 times a week for a duration of 8 weeks. The study concluded that the Thrower's Ten exercises represent an effective method to improve the balance of the upper extremity, explosive power, and isokinetic strength.

19. Hazal Genç et al. (2022) conducted a study to investigate the effects of stability and mobility exercises on range of motion, posture, and body awareness in resistance-trained males with shoulder immobility. 32 resistance-trained males with shoulder immobility, divided into adult and young adult groups. Participants underwent a structured stability and mobility exercise program, and outcomes such as shoulder range of motion, posture, and body awareness were assessed before and after the intervention. The study found positive effects on the range of motion of the joint, body awareness, and posture.

TABLE 1: Review Of Literatures

Sr. no	AUTHORS (year)	AIM	METHOD	FINDINGS	INSIGHTS
1.	Michele Forgiarini Saccol et al. (2015)	To compare the bilateral ROM and rotation strength in the shoulders of young beach volleyball players.	External and internal ROM, total rotation motion, glenohumeral internal rotation deficit (GIRD), external rotation and internal rotation strength, bilateral deficits, and external rotation to internal rotation ratio were measured	33 volleyball players were included, out of which 6 athletes (18.2%) reported as having pathological GIRD, having GIRD more than 18 degree.	Prevalence of glenohumeral internal rotation deficits in overhead athletes and the importance of early screening.
2.	Kazutomo Miura, MD, et al. (2018)	To determine the prevalence of pathological GIRD and suprascapular neuropathy in male collegiate volleyball players.	Study evaluated 22 male collegiate volleyball players for range of motion	Study showed pathological GIRD ($\geq 20^\circ$) was found in four players (18.2%).	Risk of shoulder dysfunction in population with pathological GIRD
3.	Smith, Allison B. et al. (2016)	To determine the validity of the smartphone application, "Clinometer" for measuring shoulder internal and external rotation range of motion using intra-rater reliability.	Participants' shoulder ROM was measured using both a standard goniometer and the smartphone application. Measurements were repeated to assess intra-rater reliability, and statistical analyses were performed to compare the agreement between the two methods.	Smartphone validation was statistically significant for shoulder internal and external range of motion with values of 0.959 and 0.940 respectively. Intra-rater reliability was statistically significant for external rotation with the goniometer and internal and external rotations with the application (0.804, 0.800, and 0.838)	App demonstrated strong validity and good intra-rater reliability, supporting its use as a practical clinical tool for ROM assessment.
4.	P.C. Charlton et al. (2015)	To assesses the reliability and validity of a custom Smartphone application for assessing hip joint ROM.	Passive hip joint range of motion was recorded for seven different movements in 20 males on two separate occasions.	Study concluded smartphones are portable and widely available tools that are mostly reliable and valid for assessing passive hip range of motion.	App demonstrated strong validity and good intra-rater reliability, supporting its use as a

					practical clinical tool for ROM assessment.
5.	Annelies Maenhout et al. (2012)	To quantify acromiohumeral distance (AHD) and to investigate the effect of a sleeper stretch program on ROM and AHD.	Method involved randomly allocating the athletes to the stretch (n = 30) or control group (n = 32). The stretch group performed a 6-week sleeper stretch program on the dominant side. Change of range of motion and AHD were measured and analyzed in both groups after 6 weeks.	The finding's revealed AHD was found to be smaller on the dominant side in athletes with GIRD and was found to increase after a 6-weeks sleeper stretch program, which further provided association between GIRD and subacromial impingement.	Link between GIRD and subacromial impingement and supporting the role of stretching in rehabilitation.
6.	F. Kamali et al. (2021)	To assess immediate effect of combining glenohumeral and scapulothoracic mobilization with stretching on improving internal rotation range of motion (ROM) in overhead athletes with GIRD.	30 asymptomatic male volleyball players who had a loss of dominant shoulder IR ROM of 15 degrees or more were randomly assigned to 1 of 2 group: stretching only (n = 15) or stretching plus joint mobilization (n = 15). Both groups received the intervention every other day for 1 week.	Study concluded that both interventions (stretching and stretching plus mobilization) can have the same beneficial effect in decreasing GIRD in asymptomatic overhead athletes.	Supporting the role of stretching and mobilization in overhead athletes with GIRD.
7.	Cools et al. (2011)	To determine if stretching of the posterior shoulder improves ROM and reduces symptoms.	60 overhead athletes with GIRD were grouped into 30 asymptomatic and 30 symptomatic. Outcome was to improve GH IR in symptomatic and asymptomatic overhead athletes using angular (stretching) and nonangular stretching (joint mobilizations).	Result showed asymptomatic groups had significant internal-rotation improvement of 20.5° and 19.3° in angular- and non-angular-stretching groups, respectively and concluded stretching, angular as well as non-angular techniques, increases internal rotation ROM in	stretching enhances ROM and may reduce sport-specific shoulder pain.

				overhead athletes, and may decrease sport specific shoulder pain in overhead athletes with impingement symptoms.	
8.	Naoya Iida et al. (2025)	To critically assess the efficacy of sleeper stretch (SS) and crossbody (CB) stretch in the ROM of the internal rotation (IR) among overhead athletes with GIRD.	six eligible studies involving 255 athletes with GIRD were included. The meta-analysis demonstrated statistically significant differences between stretching and control groups in terms of enhancing the ROM of IR.	Study concluded that SS or combination of SS and CS interventions significantly enhanced the ROM of IR in overhead athletes diagnosed with GIRD.	Sleeper and crossbody stretches effectively target posterior shoulder tightness and improve glenohumeral internal rotation in overhead athletes, supporting the use of targeted stretching interventions to manage GIRD.
9.	Aaron Sciascia et al. (2012)	To propose a theoretical framework for kinetic chain-based rehabilitation in overhead athletes.	Narrative review / theoretical framework.	Rehabilitation for overhead athletes should not be limited to isolated glenohumeral interventions but instead incorporate the entire kinetic chain. Specifically, addressing GIRD with targeted stretching is recommended as an effective strategy to restore motion, reduce posterior shoulder tightness, and improve overall shoulder function.	Rehabilitation for overhead athletes is more effective when it targets the entire kinetic chain, not just the glenohumeral joint; incorporating GIRD-specific stretches can restore motion, reduce posterior shoulder tightness, and enhance overall shoulder function.

10.	Steve Scher et al. (2010)	To (1) determine if differences exist in hip and shoulder ROM between professional baseball players with a history of shoulder injury and those with no history of shoulder injury and (2) assess relationships between hip and shoulder ROM in these players.	A total of 57 professional baseball players (average age, 26.3 years; range, 21–36 years) volunteered for this study, all ROM testing of the dominant and nondominant hips and shoulders was conducted.	Study suggest that (1) bilateral differences in shoulder IR and non-dominant hip IR were detected only in non-pitchers. (2) GIRD was greater in both pitchers and non-pitchers with a history of shoulder injury but not significant.	GIRD can be associated with a history of shoulder injury in overhead athletes, and bilateral differences in shoulder and hip ROM suggest the importance of assessing the kinetic chain when addressing shoulder mobility deficits.
11.	Hye-Min Ko et al. (2022)	The effects of various interventions for improving the hip joint range of motion on elite badminton players, including body balance ability, jumping power, smash speed, and joint range of motion.	21 elite badminton players were selected and assigned randomly to Experimental Group 1 and Experimental Group 2. In Experimental Group 1, hip joint manual mobilization was applied by a physical therapist, and hip self-exercise performed by the athletes was applied in Experimental Group 2.	Study showed although not Significant but there was increase in Internal and external ROM in experimental group 1.	Hip joint mobilization can contribute to improvements in internal and external hip ROM in overhead athletes, highlighting the potential role of proximal joint mobility in enhancing overall upper-limb function and performance.
12.	Daniel Torres et al. (2021)	To determine if hip mobilization with movement (MWM) is superior to passive stretching for increasing hip ROM.	48 participants with impaired hip ROM were randomized to a control group or received a single bout of either a hip MWM or hip passive stretch.	Study concluded that although not significant but improvements in ROM were achieved in both stretching and MWM groups indicating comparable efficacy.	Both hip mobilization with movement (MWM) and passive stretching can improve hip ROM, suggesting that active joint mobilization techniques

					may be as effective as stretching in enhancing proximal joint mobility, which can influence shoulder function through the kinetic chain.
13.	Ellenbecker et al. (2007)	To find out side-to-side differences in hip joint ROM	64 male and 83 female elite tennis players and 101 male professional baseball pitchers participated in this study; measurement of hip IR and ER were taken to find out side-to-side differences in hip joint ROM.	Bilateral difference in hip rotation greater than 10° identified 17% of the professional baseball pitchers with IR differences and 42% with ER differences. Differences in the elite male tennis players occurred in only 15% of the players for IR and 9% in ER.	Significant side-to-side differences in hip rotation, particularly in internal and external rotation, are common in overhead athletes, especially baseball pitchers, highlighting the need to assess and address proximal joint mobility when managing shoulder ROM deficits and GIRD.
14.	S. L. Boudreau et al. (2022)	To assess performance in throwing athlete using Functional throwing performance index (FTPI) which measures the accuracy of overhand-throwing athletes.	narrative/expert commentary / literature review design	FTPI is a useful tool for assessing overhand-throwing accuracy in overhead athletes and can help guide rehabilitation and return to sport. It provides normative values and helps discriminate performance deficits.	FTPI effectively evaluates throwing accuracy in overhead athletes, offering a practical outcome measure to track rehabilitation progress and functional performance after interventions

					targeting shoulder or kinetic chain deficits.
15.	L. Howe et al. (2015)	To screen or assess thoracic extension/rotation and self-management techniques in athletes in which bilateral shoulder elevation test (BSET) assesses trunk extension and standing rotation reach test (SRRT) assess trunk and pelvis rotation.	Clinical guideline/ expert commentary	The guideline concluded that thoracic spine screening should be an essential part of athlete assessment, particularly in overhead and rotational sports.	Thoracic spine mobility is crucial for overhead athletes, and assessments like BSET and SRRT can identify trunk and pelvic restrictions, supporting the inclusion of thoracic mobility evaluation in shoulder rehabilitation programs.
16.	Sreenivasu Kotagiri et al. (2018)	To determine the effectiveness of mobilization with exercise in patients with glenohumeral internal rotation deficit and secondly to determine whether mulligan internal rotation MWM with stretching in patients with glenohumeral internal rotation deficit.	60 patients were included in the study which was divided into two groups; Group A and Group B, 30 patients in each group. Subjects in Group-A were given mobilizations with stabilization exercise and Group-B were given mulligan mobilization with Posterior Capsule Stretching.	Study concluded that combining Mulligan's MWM with targeted stretching provides a superior clinical benefit for restoring internal rotation and reducing deficits in shoulder mobility.	Combining Mulligan's mobilization with targeted posterior capsule stretching is more effective than mobilization alone in restoring glenohumeral internal rotation, highlighting the benefit of integrated joint mobilization and stretching interventions for managing GIRD in overhead athletes.
17.	Do-young Jung (2023)	To compare the immediate effects of mobilization with movement (MWM) in non-weight bearing position and weight	Fifteen subjects with limited hip IR participated in two interventions: MWM in WBP and in non-WBP.	Study showed both MWM in non-WBP and WBP improved immediately hip IR range of motion.	Mobilization with movement (MWM), whether in weight-

		bearing position (WBP) and for increasing hip internal range (IR).			bearing or non-weight-bearing positions, can immediately improve hip internal rotation, supporting the use of proximal joint mobilization to enhance kinetic chain function in overhead athletes.
18.	Ozge Gokalp et al. (2020)	To investigate the effects of the Thrower's Ten exercises on the upper extremity performance.	36 healthy sedentary individuals completed this study conducted with a randomized controlled design. The subjects were divided into 2 groups: exercise and control. The exercise group received a training of the Thrower's Ten exercises of 50-minute sessions 3 times a week for a duration of 8 weeks.	Study concluded that The Thrower's Ten exercises represent an effective method to improve the balance on the upper extremity, explosive power and isokinetic strength.	The Thrower's Ten exercise program improves upper extremity balance, explosive power, and isokinetic strength, supporting the inclusion of structured shoulder and scapular strengthening programs to enhance functional performance in overhead athletes.
19.	Hazal Genç et al. (2022)	To investigate the effects of stability and mobility exercises on range of motion, posture and body awareness in resistance-trained males with shoulder immobility.	32 resistance-trained males with shoulder immobility, divided into adult and young adult groups. Participants underwent a structured stability and mobility exercise program, and outcomes such as shoulder rom,	Study found positive effects on the range of motion of the joint, body awareness and posture.	Findings support the integration of targeted mobility and stability training into exercise routines for individuals with shoulder restrictions, particularly those engaged

			posture, and body awareness were assessed before and after the intervention.		in resistance training.
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METHODOLOGY & PROCEDURE

METHODOLOGY & PROCEDURE

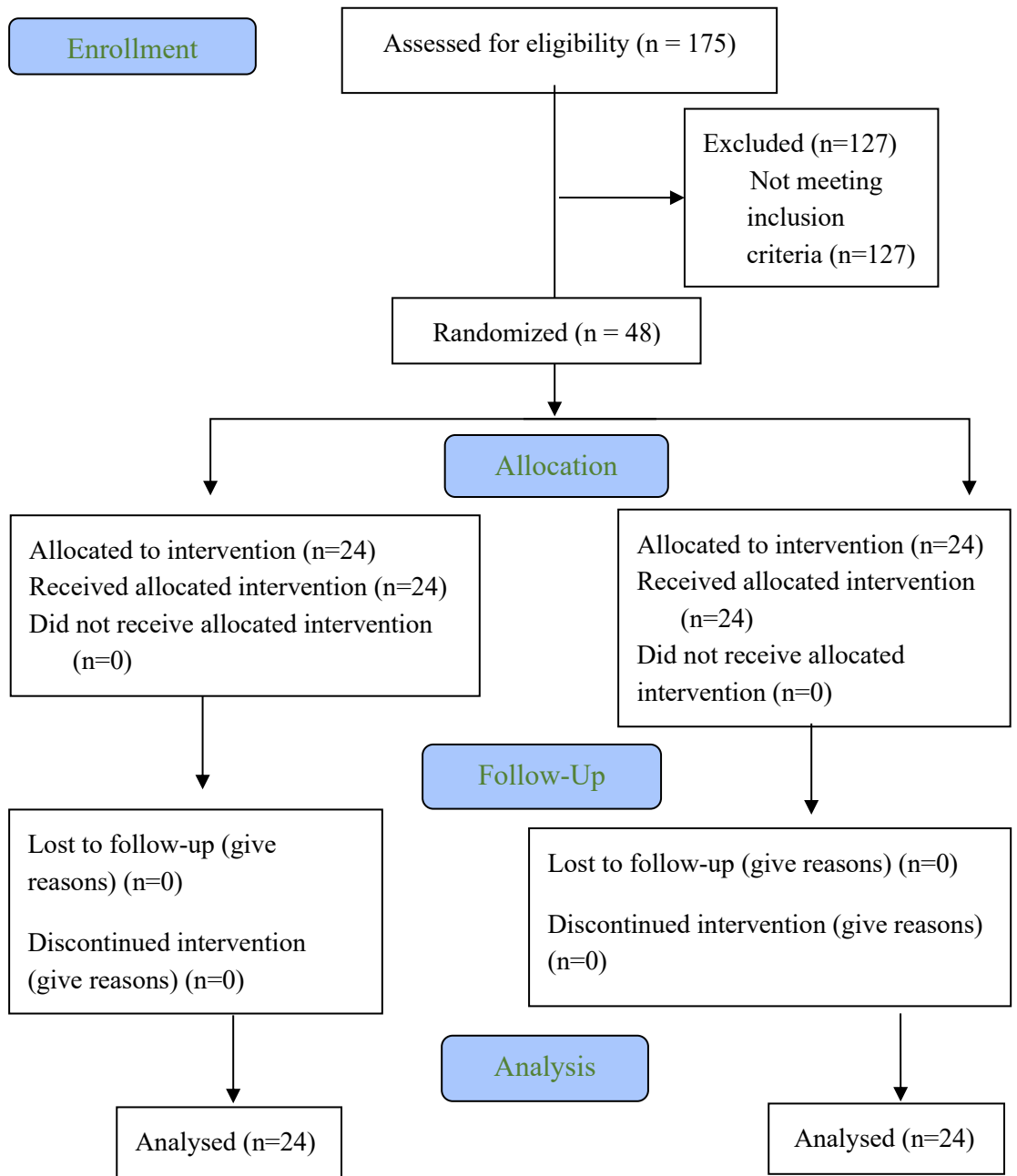
- **STUDY DESIGN:** Randomized Controlled Trial
- **STUDY POPULATION:** Recreational overhead athletes
- **SAMPLE SIZE:** 48
- **SAMPLING TECHNIQUE:** Purposive sampling
- **STUDY SETTING:** Sports clubs and academies in Nagpur
- **STUDY DURATION:** 1 year
 - Ethical clearance: 4 months
 - Sample selection, data collection: 4 months
 - Statistical analysis, results analysis, discussion: 4 months
- **MATERIALS USED:**
 1. Smartphone clinometer application
 2. 21 cm circumference ball
 3. Visible adhesive tape
- **INCLUSION CRITERIA:**
 1. Players with GIRD >18 degrees
 2. Age: 18-28 years

3. Gender: Male
4. Players with hip rotational deficit >10 degrees
5. Athletes with no current musculoskeletal pain and injury.

➤ **EXCLUSION CRITERIA:**

1. Players with GIRD < 18 degrees
2. Past or recent history of trauma to the shoulder in 6 months.
3. Players with hip rotational deficit <10 degrees.
4. History of shoulder surgery.

➤ **CONSORT 2010 Flow Diagram**



➤ **PROCEDURE**

Ethical clearance was obtained from the Institutional Ethics Committee (IEC) to ensure all protocols comply with ethical standards (ABSMARI/IEC/2025/174). Following this, the screening of subjects was carried out at various sports clubs and academies in Nagpur, Maharashtra. 48 overhead athletes were selected based on the selection criteria after screening 175 asymptomatic recreational overhead athletes.

Brief demographic data of all the participants were obtained, written consent was taken from all the participants prior to voluntary participation in the study, and the protocol was explained with its benefits and precautions. The study duration was of 4 weeks, which included 12 sessions of training protocol. 48 participants, who cleared the inclusion criteria, were divided by block randomization into control and experimental group.

Both control and experimental group pre- and post-assessments were taken for shoulder and hip rotational range of motion, functional throwing performance index, bilateral shoulder elevation test, and standing rotation reach test.

➤ **PROTOCOL**

Experimental group

Experimental group intervention focused on the ipsilateral shoulder and contralateral hip.

Shoulder intervention: Ipsilateral Shoulder mobilization involved mobilization with movement (MWM) for internal rotation in which the athlete was in a sitting position, the therapist was standing at the back of the athlete (towards the side of the mobilizing shoulder), the mulligan belt was wrapped around the humeral head and held by therapist with one hand, and other hand was stabilizing the scapula to avoid unwanted movement. The athlete was asked to internally rotate the shoulder while therapist apply posterior and inferior glide to humeral head. Scapular mobilization was performed with the athlete lying on their unaffected side with their arms at 90° flexion. The therapist is standing in front of the athlete and placing his index finger under the medial scapular border, with the inferior angle of the scapula in the webspace. With the other hand, the therapist grasped the superior border of the scapula and moved the scapula superiorly and inferiorly for superior and inferior glide, and medially and laterally for medial and lateral glide. Then the scapula was rotated upward and downward for scapular rotation. Each mobilization was given pain-free for 3 days a week for 4 weeks, having 3 sets with 10 repetitions with 30 seconds rest in between the sets. Cross-body stretch was actively done in a sitting position and the sleeper stretch was actively done in side lying, both stretches were held for 30 seconds and repeated 3 times.

Hip Intervention: Includes MWM of hip rotational range in which the athlete was in supine lying, therapist stood beside the subject while a belt was secured

around the pelvis and looped over the medial side of the upper thigh closest to the joint. The belt was positioned perpendicular to the subject's thigh at all times. With the hip flexed to 90°, the therapist supported the leg and passively moved the hip into internal rotation until the maximum pain-free range was reached. Mobilization was given pain-free 3 days a week for 4 weeks, 3 sets of 10 repetitions were applied with a 1-minute rest interval between each set. Static active and passive stretching included the supine figure of 4 and the prone external rotator stretch respectively. Stretches were held to the point of mild tension or tightness for 30 secs and repeated 3 sets, with 30 secs rest in between.

Control Group

The Control group involved only shoulder intervention, where shoulder MWM, scapular mobilization, crossbody stretch, and sleeper stretch were common for both groups and given in the same way as that of the experimental group. Additionally, active exercises were included, such as 1) Diagonal pattern extension: which was done by pulling a resistance band up and across your body to the opposite side overhead. 2) Internal rotation at waist: was done with a resistance band by standing with elbow at side fixed at 90° and shoulder rotated out, pulling arm across the body keeping elbow at the side, and returning band slowly and controlled. 3) Scapular plane raises with resistance band: This was done by standing with elbow straight and thumb up, raising the arm to shoulder level at a 30° angle in front of the body, and not go above shoulder height, hold for 2 seconds and lower slowly. 4) Wall angles: were done standing with wall support with starting position of 90° arm abducted. In this position, elevate the arm up and then lower it till 90°. All exercises were performed 3 days a week for 4 weeks with 10 repetitions and 2 sets.

➤ **OUTCOME MEASURES:**

Primary Outcome Measures:

1. Range of Motion (ROM) of Shoulder and Hip

Secondary Outcome Measures:

1. Functional Throwing Performance Index (FTPI)
2. Bilateral Shoulder Elevation Test (BSET)
3. Standing Rotation Reach Test (SRRT)

Shoulder range of motion by smartphone clinometer application

The purpose of using the smartphone clinometer application was to find out the shoulder rotational range of motion. Athletes were positioned in supine lying with the shoulder placed at 90° of abduction and the elbow flexed to 90°. An inclinometer was aligned on the radial aspect of the forearm, just distal to the radial styloid process. For assessment of internal rotation, participants actively rotated the arm medially, whereas for external rotation they rotated the arm laterally. During both movements, the therapist provided manual stabilization of the scapula. It has a validity of 0.959 and 0.940 for shoulder internal and external rotation, respectively. Intra-rater reliability of 0.800 and 0.838 for shoulder internal and external rotation.

Hip range of motion by smartphone clinometer application

The purpose of using the smartphone clinometer application was to find out hip rotational range of motion. Participants were positioned in prone lying with the hip maintained in neutral abduction/adduction, and the pelvis stabilized by the therapist. The arms rested comfortably at the sides, and the head was placed in a position of comfort. An inclinometer was positioned along the midline of the medial shaft of the tibia, between the medial malleolus and the medial tibial condyle. For internal rotation, the knee was flexed to 90°, perpendicular to the table, and the shank was moved outward. For external rotation, the knee was flexed to 90°, and the shank was moved toward the midline. The contralateral limb remained extended and slightly abducted to allow full measurement. Throughout the procedure, the therapist stabilized the pelvis to prevent compensatory pelvic motion. It has validity of 0.92 and 0.90 for internal and external range of motion with intra-rater reliability of ICC 0.84 and 0.63 for internal and external rotation.

Functional Throwing Performance Index

The purpose of the test was to measure the accuracy of overhand-throwing athletes. The athlete stands 15' from the target; a 1' × 1' target is placed 4' above floor. Using a 21 cm circumference ball, the athlete performs eight warmup throws starting at 25% submaximal effort, working up to 100% maximal effort. The athlete then has 30 seconds to throw the ball at the target as many times as possible. Measurement is done by recording the number of accurate throws as well as total throws. Test-retest reliability (ICC) of FTPI is reported as 0.91.

Bilateral Shoulder Elevation Test

The purpose of the test was to evaluate thoracic extension. The test was conducted using two inclinometers, one positioned at the junction of T1–T2 and the other at T12–L1. The combined readings of these devices represented the resting thoracic spine angle. To evaluate thoracic extension during bilateral shoulder elevation, thoracic spine position was recorded at end range and compared with the resting value. The technique has reported strong intra-rater reliability (ICC = 0.91-0.97).

Standing rotation reach test

The purpose of the test was to find out trunk and pelvis rotation. The athlete was instructed to stand with feet positioned hip-width apart and, in a single continuous motion, rotate the trunk maximally to one side while reaching with either the ipsilateral or contralateral arm. It had moderate to good test-retest reliability (ICC ~ 0.70-0.90).



Fig 2: Hip Rotation range using Clinometer app



Fig 4: Crossbody stretch



Fig 3: Internal Rotation using resistance band



Fig 5: FTPI

STATISTICAL ANALYSIS

STATISTICAL ANALYSIS

Data was analysed using SPSS 22.0 (SPSS Inc., Chicago, IL), and the level of significance was set at $p < 0.05$.

Finding normality: Normality was measured using the Shapiro-Wilk test

Descriptive statistics: The data were presented using mean and standard deviation values.

Inferential statistics: For normally distributed data, a paired t-test was used to find out the statistical difference within and between groups. For not normally distributed data non parametric test such as Wilcoxon (within group) and Mann-Whitney U test was used to measure between-group (Control and Experimental) differences of the variables.

RESULTS

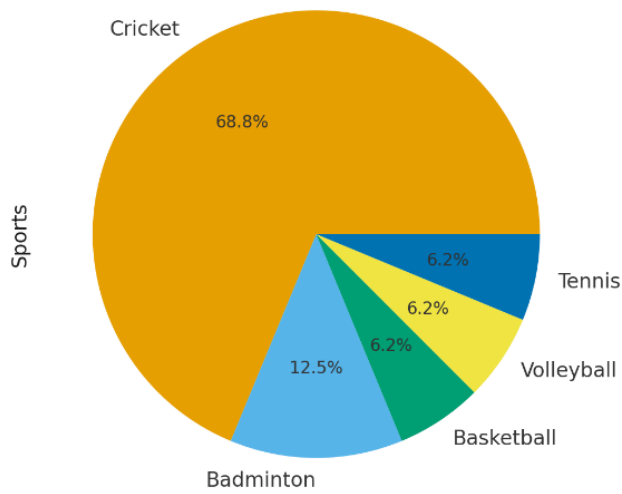
RESULTS

In the present study, 48 asymptomatic recreational overhead athletes with GIRD > 18 degree were recruited. All participants completed the study protocol, and the data were analysed. The analyses were conducted at a significance level of 0.05 (95% confidence level).

BASELINE DATA

Table 2: Sports Distribution across the Sample	
Sport	Combined (n=48)
Cricket	33 (68.8%)
Badminton	6 (12.5%)
Basketball	3 (6.2%)
Volleyball	3 (6.2%)
Tennis	3 (6.2%)

Sports Distribution - Combined (A+B)



GRAPH 1: Sports Distribution combined Group A&B

Interpretation:

- In the combined analysis, cricket accounted for nearly 70% of participants, while the remaining 30% were spread across badminton (12.5%), basketball (6.2%), volleyball (6.2%), and tennis (6.2%). This confirms that cricket was the predominant sport overall, though other disciplines also contributed significantly to the sample.

FINDING THE NORMALITY

Normality of data: Data normality was analysed using Shapiro wilk test as the sample size was less than 50, which implied that data is normally distributed for BSET only and not normal for ROM, FTPI, and SRRT. So, we used paired t-test for normally distributed data and Wilcoxon test (within group) and Mann Whitney test (between group) for not normally distributed data.

VARIABLES		Mean (SD)	p-value
AGE		22.541 ± 2.51	< 0.05
HEIGHT		169.291 ± 5.406	> 0.05
WEIGHT		67.89 ± 4.973	> 0.05
BMI		23.656 ± 1.530	> 0.05
PRE TEST OUTCOMES	ROM	19.3542 ± 0.63546	< 0.05
	FTPI	0.305 ± 0.140	= 0.05
	BSET	14.50 ± 3.672	> 0.05
	SRRT	82.625 ± 4.92	< 0.05

Interpretation:

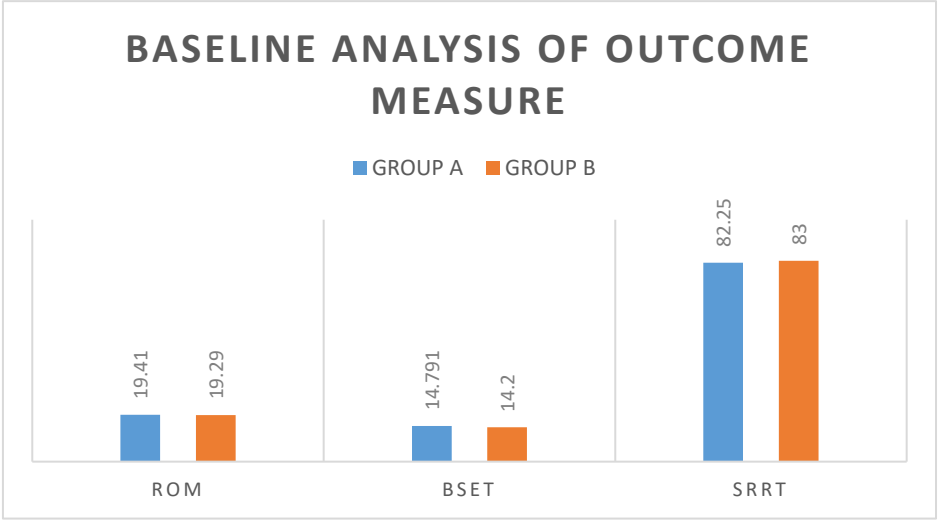
The demographic details of the participants (N = 48) are summarized in Table 3. The mean age of the participants was 22.54 ± 2.51 years, with an average height of 169.29 ± 5.40 cm, weight of 67.89 ± 4.97 kg, and BMI of 23.65 ± 1.53 kg/m². Statistical analysis revealed significant differences among the participants.

DESCRIPTIVE STATISTICS

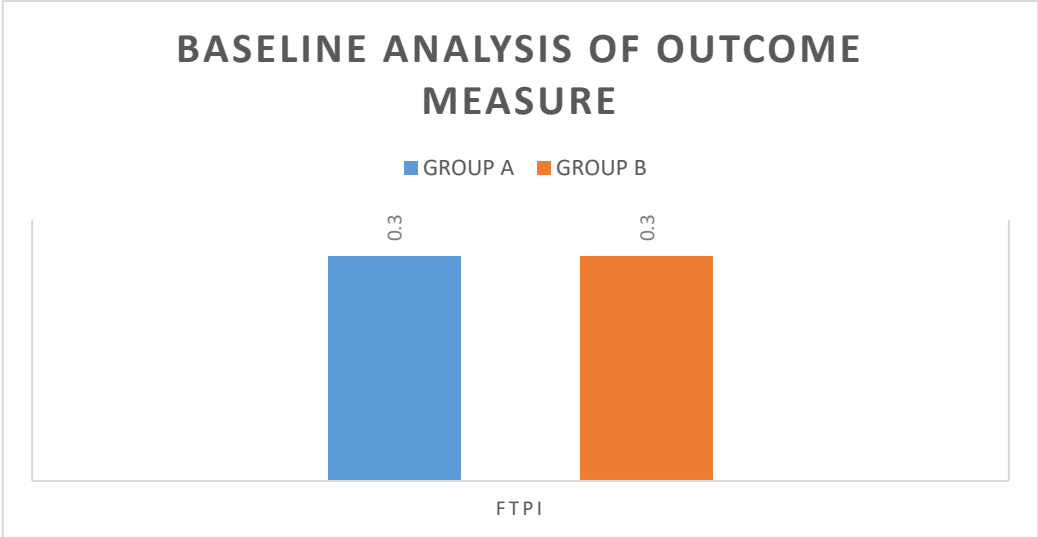
TABLE 4: BASELINE ANALYSIS OF OUTCOME MEASURE BETWEEN GROUP			
VARIABLES	GROUP A	GROUP B	p-Value
ROM	19.41 ± 0.65	19.29 ± 0.624	0.479
FTPI	0.30 ± 0.167	0.30 ± 0.11	0.897
SRRT	82.25 ± 5.76	83.00 ± 4.00	0.632
BSET	14.791 ± 3.77	14.20 ± 3.62	0.554

Interpretation:

Baseline analysis of outcome measures between the two groups (Table 4) showed no statistically significant differences ($p > 0.05$), in ROM ($p = 0.479$), FTPI ($p = 0.897$), SRRT ($p = 0.632$), and BSET ($p = 0.554$). This indicates that both groups were homogenous prior to the intervention.



GRAPH 2: Baseline analysis of ROM, BSET, and SRRT between Group A and



GRAPH 3: Baseline analysis of FTPI between Group A and Group B

INFERENCEAL STATISTICS

TABLE 5: Pre and post values of outcome measures and effect size								
OUTCOME MEASURES	GROUPS	Pre Mean (SD)	Post Mean (SD)	Between-group mean difference	p-value	Cohen's d	95% CI	
ROM	Group-A	19.41 ± 0.65	16.33 ± 1.49	-3.33	0.000	2.205	-3.22	-1.19
	Group-B	19.29 ± 0.624	13 ± 1.53					
BSET	Group-A	14.79 ± 3.77	15.70 ± 3.73	-0.70	0.425	0.2	-1.09	2.510
	Group-B	14.20 ± 3.62	15.00 ± 3.25					
FTPI	Group-A	0.30 ± 0.167	0.35 ± 0.123	0.03	0.486	0.237	-0.56	1.04
	Group-B	0.30 ± 0.11	0.38 ± 0.13					
SRRT	Group-A	82.25 ± 5.76	83.00 ± 5.36	2.12	0.214	0.487	-0.32	1.29
	Group-B	83.00 ± 4.0	85.12 ± 3.04					

Interpretation:

Range of Motion (ROM)

Group A showed a significant reduction in ROM from 19.41 ± 0.65 to 16.33 ± 1.49 post-intervention, while Group B improved from 19.29 ± 0.62 to 13.00 ± 1.53 . The between-group mean difference was -3.33, with a p-value of 0.000 and a large effect size (Cohen's $d = 2.205$). This suggests a statistically significant improvement in ROM, favoring Group B. The large effect size in ROM highlights the clinical relevance of the intervention in improving mobility.

Bilateral shoulder elevation test (BSET)

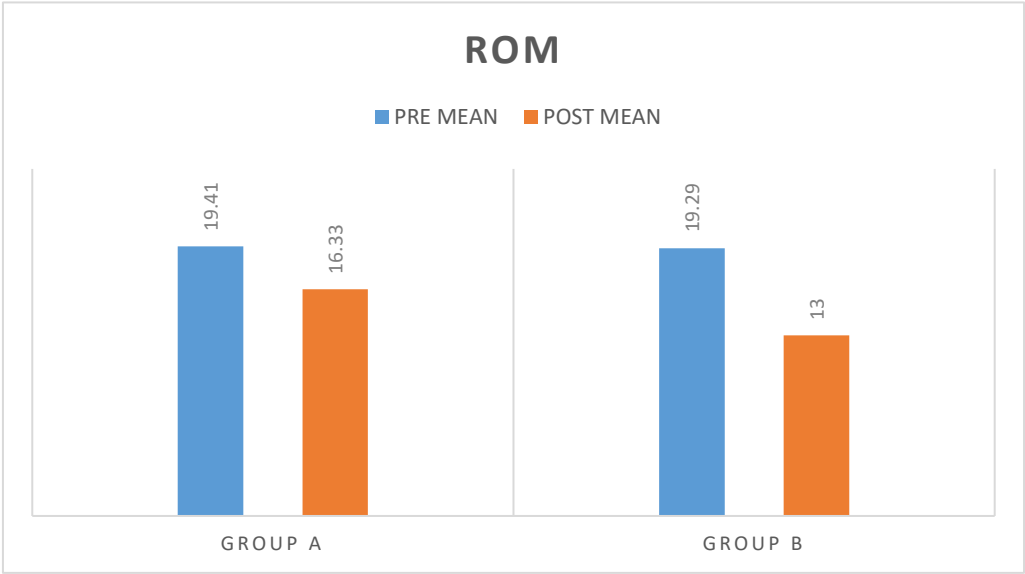
Group A improved slightly from 14.79 ± 3.77 to 15.70 ± 3.73 , whereas Group B improved from 14.20 ± 3.62 to 15.00 ± 3.25 . The between-group difference was not statistically significant ($p = 0.425$, $d = 0.20$), indicating that both groups had comparable improvements.

Functional throwing performance index (FTPI)

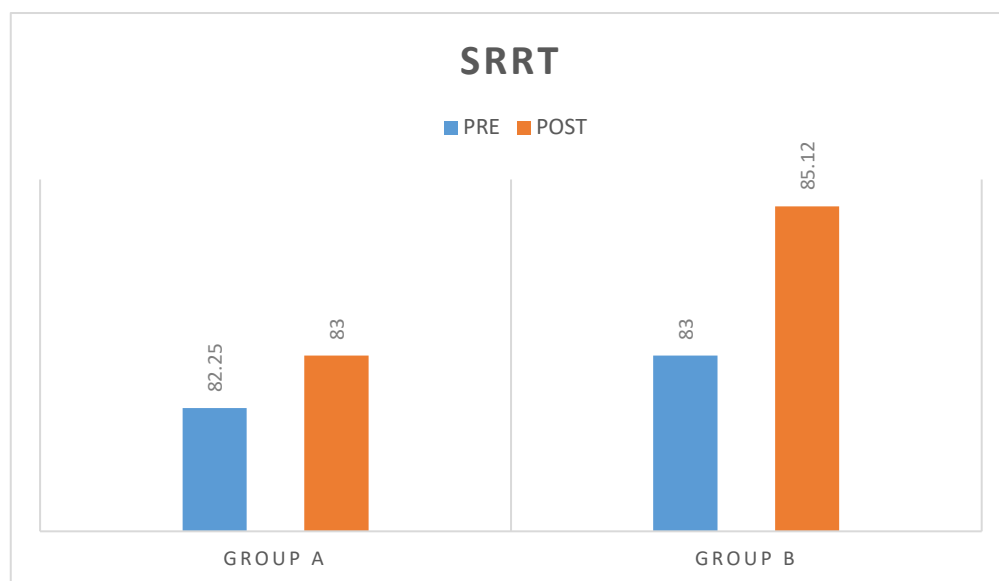
Group A increased from 0.30 ± 0.167 to 0.35 ± 0.123 , while Group B improved from 0.30 ± 0.11 to 0.38 ± 0.13 . The between-group difference was not significant ($p = 0.486$, $d = 0.237$), suggesting both groups improved similarly.

Standing rotation reach test (SRRT)

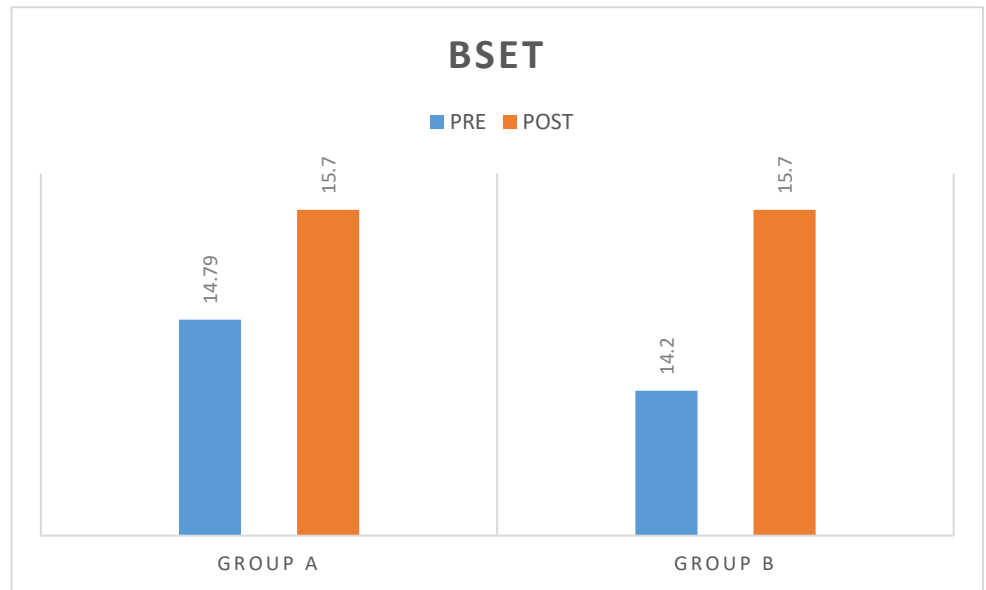
Group A improved marginally from 82.25 ± 5.76 to 83.00 ± 5.36 , whereas Group B improved from 83.00 ± 4.00 to 85.12 ± 3.04 . Although Group B showed greater improvement, the difference was not statistically significant ($p = 0.214$, $d = 0.487$).



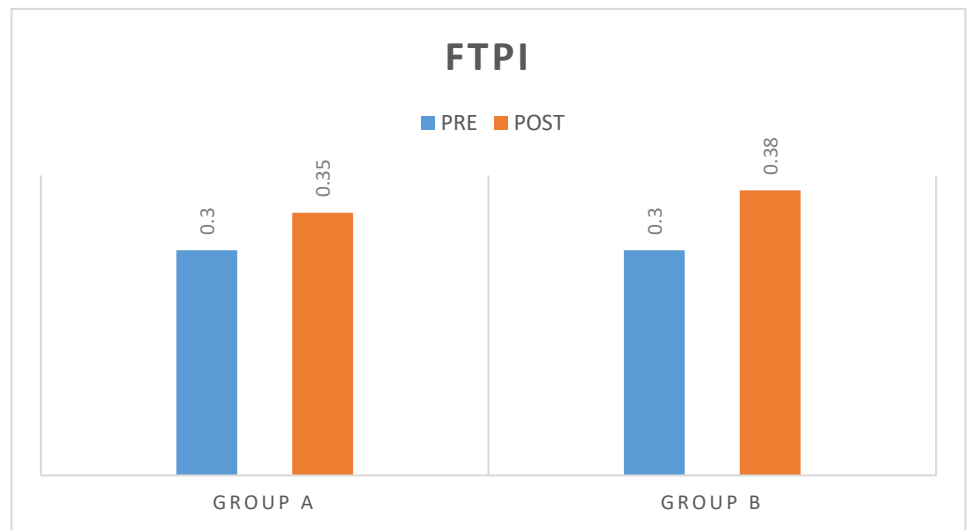
GRAPH 4: ROM Mean comparison within group and between group



GRAPH 5: SRRT Mean comparison within group and between group



GRAPH 6: BSET Mean comparison within group and between group



GRAPH 7: FTPI Mean comparison within group and between group

DISCUSSION

DISCUSSION

The present randomized controlled trial investigated the effect of kinetic chain–based training, specifically incorporating contralateral hip mobilization and strengthening, on glenohumeral internal rotation deficit (GIRD) and functional performance among asymptomatic recreational overhead athletes. To the best of our knowledge, this is one of the first studies to directly compare conventional shoulder-focused intervention with an integrated kinetic chain approach in a non-injured but at-risk athletic population. The novelty of the present study lies in targeting both proximal (hip) and distal (shoulder) contributors to rotational mobility rather than focusing solely on the glenohumeral joint, which is the conventional rehabilitation strategy.

Across four weeks of training, overall, both groups improved after the intervention, but the kinetic-chain group demonstrated superior gains in shoulder internal rotation ROM and meaningful functional improvement on FTPI, whereas improvements in BSET and SRRT were significant within groups but not different between groups.

The primary hypothesis of the study was that adding hip exercises would result in greater improvements in GIRD and functional performance compared to shoulder-focused interventions alone. The findings partly support this hypothesis. Specifically: The null hypothesis for shoulder ROM was rejected, as the experimental group demonstrated significantly greater improvements than the control group. The null hypothesis for functional performance was partially rejected. Within-group improvement in FTPI was observed only in the experimental group, although between-group comparisons did not reach significance.

The findings align with prior studies that have emphasized the role of the kinetic chain in shoulder function. Richardson et al. concluded that incorporating trunk and lower limb movements enhances axio-shoulder recruitment and reduces reliance on the rotator cuff during shoulder tasks.²⁸ Similarly, Werner et al. demonstrated that kinetic chain-based exercises modify muscle activation patterns and yield superior functional outcomes compared with isolated shoulder rehabilitation.²⁹ The current results are also consistent with Scher et al., who reported associations between hip and shoulder ROM in professional baseball players, suggesting that hip deficits may contribute to compensatory shoulder stress.³⁰ Likewise, Muneer and Sibbala showed that lumbo-pelvic-hip complex training improved upper extremity function in collegiate overhead athletes, further validating the interdependence between proximal and distal segments of the kinetic chain.³¹

Regarding GIRD specifically, Kamali et al. and Cools et al. found that shoulder mobilization and stretching interventions alone can restore internal rotation in asymptomatic athletes.^{32,33} However, the magnitude of change in the present study's experimental group exceeded those reported in shoulder-only protocols, suggesting that including contralateral hip mobilization amplifies treatment effects. This supports earlier biomechanical work by Kibler et al., who emphasized that up to 50% of throwing power originates from the legs, and reduced hip mobility can impose excess loads on the shoulder.³⁴

Recent randomized and controlled studies show that interventions explicitly targeting the kinetic chain -i.e., coordinated training of lower limb, trunk/core, and shoulder segments -produce measurable gains in throwing performance and shoulder strength, supporting functional transfer to sport tasks. For example,

Gowda et al. (2024) reported that an 8-week kinetic chain exercise program improved throwing performance and shoulder muscle strength among university shot put athletes compared with conventional training.³⁵ Mechanistically, recent reviews by Barramuño-Medina et al. (2025) emphasize that GIRD is often a multi-segment problem: posteroinferior capsular stiffness and local posterior shoulder tightness interact with altered thoracic, pelvic, and hip mechanics to produce reduced internal rotation and altered throwing kinematics.³⁶ Addressing thoracic and hip mobility as part of a kinetic-chain strategy therefore reduces compensatory glenohumeral loading and allows greater ROM restoration than isolated shoulder stretching alone. Ceballos-Laita et al. (2024) systematically reviewed interventions for GIRD and found that combining stretching with adjunctive strategies such as kinetic-chain or multi-segmental training produced larger internal rotation gains than stretching alone.³⁷ Similarly, Fares et al. (2024) underscored the role of scapular and trunk mechanics in correcting GIRD, demonstrating that multi-segmental exercises enhanced internal rotation and functional throwing metrics.³⁸ Collectively, these studies provide a strong rationale for accepting the alternative hypothesis in ROM and FTPI outcomes. The present finding that the kinetic-chain group improved ROM significantly more than the control group aligns with these recent clinical studies.^{37,38} FTPI is an ecologically valid measure of throwing accuracy and efficiency; the experimental group's significant within-group improvement but absence of a significant between-group difference may reflect both real functional benefit and sample-size limitations. The positive FTPI change supports the hypothesis that kinetic-chain training transfers to sport tasks because functional throwing depends on proximal-to-distal energy transfer (leg drive, pelvic rotation, trunk

twist, and scapular positioning) rather than the shoulder alone. Owens et al. (2024) reported that altering kinetic chain mechanics in throwers improves functional outputs such as throwing velocity and accuracy, reinforcing the FTPI outcomes observed in the present study.³⁹

The rejection of the null hypothesis for ROM can be attributed to the strong biomechanical coupling between hip and shoulder movements. Improvements in contralateral hip internal rotation likely facilitated smoother trunk rotation, thereby relieving posterior shoulder tightness and enhancing glenohumeral motion.^{30,34}

For BSET and SRRT, the null hypothesis could not be fully rejected, as between-group improvements were not significant despite positive within-group changes. The little evidence availability and psychometric evidence for these specific tests (BSET and SRRT) is limited; consequently, measurement error, limited responsiveness, or ceiling effects in this recreational cohort may have obscured between-group differences.⁴⁰ ROM can change quickly with targeted manual techniques and stretching/mobilization, but task-specific functional improvements (throwing accuracy, integrated trunk extension/rotation tasks) typically take longer — they require motor learning, strength/power transfer, and neuromuscular coordination changes that takes place over weeks to months. Several studies mentioned in review of literature (hip MWM vs stretch, hip mobilization studies, kinetic-chain trials) show immediate ROM gains but smaller and slower functional improvements. Thus, short duration favors ROM change but not necessarily functional test divergence between groups.

The partial acceptance of the null hypothesis for functional outcomes may stem from several factors. First, the intervention period (four weeks) may have been

too short to elicit measurable differences in higher-order functional tasks such as SRRT and BSET. Second, the asymptomatic nature of participants meant that baseline functional levels were already high, reducing the sensitivity of these measures to detect significant between-group differences.²⁹ Third, the relatively small sample size, although sufficient for ROM outcomes, may have limited statistical power for functional indices.

Thus, the overall evidence supports acceptance of the alternate hypothesis for shoulder ROM and partial acceptance for functional outcomes.

CONCLUSION

CONCLUSION

This randomized controlled trial provides evidence that integrating contralateral hip exercises with conventional shoulder-focused rehabilitation yields superior improvements in glenohumeral internal rotation deficit among asymptomatic recreational overhead athletes. While both control and experimental groups improved, the kinetic chain approach resulted in significantly greater gains in shoulder ROM and unique improvements in functional throwing performance. These findings support the hypothesis that addressing proximal chain inefficiencies can enhance distal joint function, thereby reinforcing the concept of the shoulder as part of a larger kinetic continuum.

The results underscore the clinical importance of screening and correcting hip mobility deficits in overhead athletes, even when asymptomatic, to reduce mechanical stress on the shoulder and optimize functional outcomes. Although null hypotheses for certain functional measures could not be fully rejected, the overall evidence favors the kinetic chain approach as a more comprehensive and preventive strategy.

In conclusion, incorporating hip-focused training into shoulder rehabilitation protocols should be strongly considered in both preventive and therapeutic settings for overhead athletes. Future studies with longer intervention periods and broader populations are warranted to further substantiate and generalize these findings.

**LIMITATIONS & RECOMMENDATIONS FOR FUTURE
STUDY**

LIMITATIONS & RECOMMENDATIONS FOR FUTURE

STUDY

LIMITATIONS

- The short duration (four weeks) may not capture long-term adaptations or sustained functional changes.
- The exclusive inclusion of male recreational athletes restricts generalizability to female athletes and elite populations.
- While ROM improvements were clear, neuromuscular control and kinetic data were not collected, which could provide further insights into underlying mechanisms.

RECOMMENDATIONS FOR FUTURE STUDY

- Long-term follow-up (e.g., 3-, 6-, or 12-month post-intervention) to evaluate the sustainability of improvements in GIRD and functional parameters.
- Conducting multicentre RCTs with larger and more heterogeneous populations will increase the external validity.
- Biomechanical analyses (e.g., kinematic motion capture, EMG) would clarify the pathways by which hip mobility influences shoulder performance.
- Incorporate hip and trunk mobilization with a progressive kinetic-chain program that builds strength and power, while integrating sport-specific throwing practice. For example, adding resisted hip/oblique power work, medicine-ball rotational throws and graded throwing drills.
- Examining injury incidence following kinetic chain-based preventive programs would help establish clinical relevance in reducing shoulder pathology.

SUMMARY

SUMMARY

This randomized controlled trial explored the impact of adding contralateral hip exercises to conventional shoulder-based rehabilitation for recreational overhead athletes presenting with GIRD. Out of 175 athletes screened, those showing both shoulder and hip rotational limitations were included. Forty-eight eligible participants were randomly assigned to two groups: the control group received only shoulder-focused interventions, while the experimental group underwent the same program supplemented with contralateral hip mobilization and stretching.

Range of motion at the shoulder and hip was evaluated using a smartphone clinometer application, and functional outcomes were assessed through the Functional Throwing Performance Index, Bilateral Shoulder Elevation Test, and Standing Rotation Reach Test.

Findings indicated that both groups benefitted from the interventions. Nonetheless, athletes in the experimental group demonstrated greater improvements in shoulder internal rotation compared with those who received shoulder-focused exercises alone (control group). Functional outcomes improved in both groups, though differences between groups were less pronounced.

STATEMENT OF FUNDING

STATEMENT OF FUNDING

The author(s) reported no funding associated with the work featured in this dissertation. The author(s) further declare that there are no potential conflicts of interest, financial or otherwise, that could have influenced the outcomes, interpretation, or reporting of this work.

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BIBLIOGRAPHIC REFERENCES

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ANNEXURES

ANNEXURE 1: IEC APPROVAL LETTER



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA
CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
ChairpersonMr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/174Date: 12/05/2025

APPROVAL LETTER
APPENDIX- VIII

To,

PINAK DHOMNE
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Effects Of Kinetic Chain Training on Glenohumeral Internal Rotation Deficit Among Asymptomatic Recreational Overhead Athletes.- Randomised Controlled Trial

Protocol ID.: ABS-IEC-2025-PHY-055

Subject: Approval for the conduct of the above referenced study

Dear **Mr./Ms./Dr Pinak Dhomne**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 25/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	25/04/2025
2	Informed Consent Form	25/04/2025
3	Undertaking form PI	25/04/2025
4	CRF	25/04/2025
5	COI from the Investigators	25/04/2025

The following members were present at meeting held on 25-04-2025

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert


Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person




Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani



1

 Utkal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/174

Date: 12/05/2025

MEMBERS	
Dr. Smaraki Mohanty Clinician	
Dr. Satyajit Mohanty Scientific Member	
Mr. Shib Shankar Mohanty Legal Expert	
Ms. Annie Hans Social Scientist	
Ms. Subhashree Samal Lay Person	
Mr. Deepak Ku. Pradhan Scientific Member	
IEC-SECRETARIAT	
Mr. Gouranga Ku. Padhy	
Mr. Susant Ku. Raychudamani	

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Shiba Sankar Mohanty	Junior Counsel-LI, Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ref. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely,

Mr. Chinmaya Kumar Patra
Member Secretary

ABSMARI Ethics Committee

Member Secretary

ABSMARI ETHICS COMMITTEE



2

Utikal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101

+91-63707-03654

lec@absmari.com

ANNEXURE 2: STUDY SETTING APPROVAL

REMEDIC
PHYSIOTHERAPY & RESEARCH CENTER



Ashish Agrawal's
SPORTS HEALTH ACADEMY

Date: 12/05/2019

Dr. Ashish M. Agrawal (Physiotherapist)
B.P.T.H., M.S.P.T., COMT (Australia), DRY NEEDLING (Dubai)
• Ex. Head Physiotherapist, VCA, Nagpur
• Ex. Head Physiotherapist, CSCS, Raipur
• Ex. Asst. Prof. Swami (M), Wardha

TO WHOMSOEVER IT MAY CONCERN

To

DR. PINAK DHOMNE (PT)
PHYSIOTHERAPIST

We are pleased to inform you that your request has been reviewed and approved. You are hereby granted permission to carry out data collection and associated research activities, subject to the following conditions:

1. All participants must provide informed consent prior to participation.
2. Data confidentiality and privacy must be strictly maintained.
3. The research should not disrupt the regular functioning or operations of the club/institution

We appreciate your interest in conducting ethical and meaningful research and wish you success in your work. Should you require further support or clarification, please feel free to contact us.

For AASHA

Yours Sincerely,



Dr. Ashish Agrawal

REMEDIC
PHYSIOTHERAPY & RESEARCH CENTER
Dr. Ashish M. Agrawal (PT)
B.P.T.H., M.S.P.T., C.O.M.T.
Reg. No. - 2010/02/PT/000057

Mob. : +91 932 681 1030 Email : ashu25ashish@gmail.com

2nd Floor- Vignesh Square, Opposite Dinanath High School, Dhantoli, Nagpur, 440012 Timing : Morning 10.30am - 2.30 pm Evening 4.30 pm to 6.30pm	Dalal Nursing Home, Lane In Front of ICICI Bank, Baramji Town, Nagpur - 440 013 Timing : Evening 7 pm to 8.30pm
---	---

ANNEXURE 3: CONSENT FORM

INFORMED CONSENT

Study Title: Effects Of Kinetic Chain Training on Glenohumeral Internal Rotation Deficit Among Asymptomatic Recreational Overhead Athletes - Randomised clinical trial

Study Number: _____

Subject 's Name: _____

Subject 's Initials: _____

Date of Birth / Age: _____

Address of the Subject _____

Qualification _____

Occupation: Student/Self-Employed/ Service/Housewife/Others (Please tick as appropriate)

Please initial box
(Subject)

- (i) I confirm that I have read and understood the information sheet dated _____ [] for the above study and have had the -opportunity to ask questions.
- (ii) I understand that my participation in the study is voluntary and that I am [] free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.
- (iii) I understand that the Sponsor of the clinical trial, others working on the [] Sponsor 's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.
- (iv) I agree not to restrict the use of any data or results that arise from this [] study provided such a use is only for scientific purpose(s)
- (v) I agree to take part in the above study. []

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:

Date: ____/____/____

Signatory 's Name: _____

Signature of the Investigator: _____

Date: Study Investigator 's Name: _____

ANNEXURE 4: CASE REPORT FORM

APPENDIX – XIV

CASE REPORT FORM (CRF)

NAME:

AGE:

DOMINANCE:

OCCUPATION:

ADDRESS:

CONTACT NUMBER:

OUTCOME MEASURE	PRE-INTERVENTION SCORE
SHOULDER ROTATIONAL ROM	
HIP ROTATIONAL ROM	
FUNCTIONAL THROWING PERFORMANCE INDEX	
BILATERAL SHOULDER ELEVATION TEST	
STANDING ROTATION REACH TEST	

OUTCOME MEASURE	POST-INTERVENTION SCORE
SHOULDER ROTATIONAL ROM	
HIP ROTATIONAL ROM	
FUNCTIONAL THROWING PERFORMANCE INDEX	
BILATERAL SHOULDER ELEVATION TEST	
STANDING ROTATION REACH TEST	

ANNEXURE 5: MASTERCHART

Masterchart For Control Group

Sr. No.	Age	Height	Weight	BMI	Sports	Pre ROM	Post ROM	Pre FTPI	Post FTPI	Pre SRRT	Post SRRT	Pre BSET	Post BSET
1	22	168	71	25.2	Cricket	19	15	0.22	0.33	78	83	14	15
2	22	171	64	21.9	Cricket	19	16	0.55	0.4	81	82	17	17
3	21	165	67	24.6	Basketball	20	17	0.1	0.2	86	86	9	10
4	20	170	73	25.3	Cricket	19	14	0.55	0.375	89	88	15	16
5	21	173	80	26.7	Cricket	20	15	0.54	0.55	69	71	15	15
6	21	168	69	24.4	Cricket	19	17	0.11	0.22	88	88	14	16
7	21	162	70	26.7	Cricket	20	15	0.11	0.3	77	76	21	22
8	22	159	60	23.7	Cricket	19	17	0.3	0.3	79	80	15	15
9	22	163	69	26	Cricket	21	17	0.27	0.2	80	82	15	18
10	20	171	76	26	Cricket	19	18	0.5	0.3	88	88	21	21
11	25	179	75	23.4	Volleyball	19	19	0.4	0.5	90	92	22	24
12	26	168	70	24.8	Tennis	21	19	0.11	0.2	87	87	12	13
13	24	168	71	25.2	Cricket	19	15	0.22	0.2	79	81	8	11
14	21	162	71	24.3	Cricket	20	15	0.33	0.375	90	90	10	11
15	26	181	70	21.4	Cricket	19	18	0.5	0.4	76	77	11	11
16	25	168	70	24.8	Cricket	19	14	0.2	0.4	89	88	14	14
17	26	173	64	21.4	Badminton	19	17	0.1	0.22	71	73	16	17
18	25	170	69	23.9	Badminton	19	15	0.25	0.3	83	81	15	15
19	19	168	70	24.8	Badminton	19	15	0.36	0.3	84	86	13	13
20	24	172	72	24.3	Cricket	19	18	0.3	0.55	80	82	10	12
21	20	161	66	25.5	Cricket	19	17	0.45	0.6	81	81	18	19
22	26	170	71	24.6	Cricket	19	15	0.22	0.4	79	78	16	17
23	24	169	66	23.1	Cricket	20	17	0.1	0.33	85	85	14	14
24	26	166	69	25	Cricket	20	17	0.6	0.55	85	87	20	21

Masterchart For Experimental Group

Sr. No.	Age	Height	Weight	BMI	Sports	Pre ROM	Post ROM	Pre FTPI	Post FTPI	Pre SRRT	Post SRRT	Pre BSET	Post BSET
1	23	175	73	23.8	Tennis	19	15	0.33	0.33	85	88	14	14
2	23	161	61	23.5	Cricket	19	12	0.11	0.33	79	82	9	11
3	21	165	59	21.7	Cricket	19	12	0.36	0.3	77	82	11	11
4	21	166	63	22.9	Cricket	19	12	0.27	0.18	79	84	19	19
5	18	171	66	22.6	Cricket	19	11	0.5	0.3	82	87	15	15
6	21	178	76	24	Cricket	20	12	0.4	0.5	80	85	13	13
7	19	166	60	21.8	Cricket	21	17	0.2	0.5	80	83	11	13
8	19	171	66	22.6	Cricket	19	16	0.44	0.4	84	85	19	19
9	22	172	62	21	Badminton	19	15	0.33	0.4	82	84	22	23
10	24	173	70	23.4	Cricket	19	12	0.3	0.6	79	81	13	13
11	25	159	59	23.3	Cricket	19	13	0.36	0.44	87	87	18	19
12	25	163	63	23.7	Cricket	20	12	0.33	0.4	84	85	16	18
13	24	177	68	21.7	Volleyball	19	13	0.2	0.6	86	88	14	15
14	22	168	60	21.3	Cricket	19	13	0.4	0.22	78	80	16	16
15	23	162	63	24	Cricket	19	12	0.27	0.2	77	80	8	10
16	27	172	71	24	Badminton	20	12	0.44	0.6	81	85	11	11
17	24	176	74	23.9	Volleyball	19	13	0.11	0.2	85	85	19	18
18	26	169	65	22.8	Badminton	21	14	0.45	0.5	90	90	15	17
19	18	174	68	22.5	Cricket	19	14	0.3	0.33	83	85	15	16
20	19	169	70	24.5	Basketball	19	12	0.22	0.4	88	90	11	13
21	20	180	64	19.8	Basketball	19	13	0.33	0.2	88	88	17	17
22	19	170	67	23.2	Tennis	19	11	0.11	0.36	88	87	12	13
23	25	168	63	22.3	Cricket	19	14	0.3	0.3	81	82	9	12
24	25	176	75	24.2	Cricket	19	12	0.2	0.54	89	90	14	14

ANNEXURE 6: TURNITIN REPORT FOR PLAGIARISM

Pinak Dhomne

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