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Isokinetic strength testing of shoulder rotators in collegiate throw ball players

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Abstract
Background and Objectives: Throwball involves repetitive shoulder rotations leading to the overuse of shoulder rotators causing several internal risk factors for shoulder problems. Reduction in the range and strength of shoulder rotators is major risk or cause for shoulder injuries. Hence, the primary objective of the study is to determining isokinetic strength of shoulder rotators in collegiate throwball payers. The secondary objectives are to determine the rotator strength on shoulder rotators in non-players and compare the strength between the two groups.
Methods: Sample size was estimated to be 60 females between 18-25years, 30players (20.05+1.39) and 30 nonplayers (19.96+1.33); height (157.36+5.92 players; 158.18+5.38 non-players); weight (59.66+14.60 players; 63.24+12.63 non-players) participated in this cross-sectional study. Concentric and concentric peak torque of internal and external rotator ROM and strength was assessed. Three speeds of 180^0/s, 120^0/s and 60^0/s was used.
Results: The dominant side presented higher mean values for peak torque for IR in players at all three speeds; the non-dominant side presented higher mean peak for in ER in both the groups at all three speeds. In the non-players group, the dominant limb presented higher mean peak torque values in IR at 180^0/s and 60^0/s whereas the non-dominant limb presented higher peak for IR at 120^0/s. However, only the mean peak torque of IR at 60^0/s had significant difference (15.65+3.23 for players; 13.2+3.54 for non-players) with p=0.02 and t-value=2.32.
Interpretation and Conclusion: There was no significant difference between the players and non-players which implies that the players need to be trained for rotator strengthening especially external rotators as muscle strength imbalance between the agonist and antagonist is one of the major risk factors for shoulder injuries. The values obtained for the strength of the players can be used as reference for further studies for population-specific isokinetic data profile for both rehabilitation and prevention.

Keywords: Isokinetic dynamometer, throwball, means peak torque, internal rotators, and external rotators

Introduction

Throwball is a non-contact ball sport played across a net between two teams of seven players on a rectangular court. It is popular in Asia, especially in sub-Asian continents, and was first played in India as a women's sport in Chennai, during the 1940s. At present the game is being played at both indoors and outdoors. Currently throwball is been played in more than 45,000 schools and colleges, apart from a large number of clubs, factories, companies, districts, and state-units from all over Asia at sub-junior, junior and senior levels. Under the classification of sports, throwball fall under non-contact sport. In throwball, the ball should be released from above the shoulder/shoulder-line only. The ball has to be caught with both the hands and thrown back in one hand only. Any ball after catching (during rally) should be released within 3seconds. Shifting the ball from right to left or left to right is not permitted. Pushing the ball deliberately is not permitted. These factors affect the shoulder joint and its surrounding muscles making it more prone to injuries.

The most common shoulder injuries in non-contact sports are–

1. Recurrent anterior dislocation of shoulder
2. Acromio-clavicular dislocation
3. Bicipital tendinitis
4. Supraspinatus tendinitis
5. Rotator cuff syndrome

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Supraspinatus tendinitis and rotator cuff syndrome are due to repetitive movements in abduction or overhead rotation [1].

Shoulder joint is the most freely mobile joint at the cost of its stability. The strength to the shoulder joint is provided by rotator cuff; a fibrous sheath formed by tendons of four muscles namely supraspinatus, infraspinatus, teres minor and subscapularis.

Shoulder injuries are more prevalent in sports involving throwing actions. These high-speed dynamic activities require frequent synchronised action of shoulder stabilisers especially rotator cuff muscles. Since shoulder joint is unstable due to its bony configuration and high degree of freedom of movement, it makes the joint more vulnerable to overuse injuries. These athletes have several internal risk factors for shoulder problem as their daily routine practices add repetitive stress on the shoulder.

When the passive forces are limited by active forces, the moving segment relay on the dynamic muscular control. This provides stability and mobility during normal shoulder function. The dynamic stabilisers are also responsible for the precisely controlled muscular actions which help in the strong and powerful actions in sports. There are studies which show that increased gleno-humeral external rotation and decreased internal rotation in dominant hand among throwing athletes can increase humeral retroversion which can be one of the contributing mechanisms for adaptation of shoulder range of motion. When the humerus is abducted and laterally rotated, the gleno-humeral capsule twists and tightens making it a closed pack position for GHJ, producing the tension which stabilises the GHJ. Supraspinatus is the key structure for dynamic stabilisation. It is under constant tension most of the waking hours of the person. It is more vulnerable to tensile overload and chronic overuse [2].

The overhead throwing motion is a highly skilled movement. It requires extremely high level of muscle activation, velocity, flexibility, muscular strength, coordination, synchronicity and neuromuscular control. Since the throwing motion generates extraordinary demands on the shoulder joint, tremendous forces are placed on the shoulder joint at extremely high angular velocities. The thrower's shoulder often exhibits excessive motion and laxity increasing the chances of shoulder injuries [3].

The superior migration of the humeral head due to the weakness of the rotator cuff muscles contribute to functional shoulder impingement syndrome. Also, deficit in the flexibility or strength of the agonist muscles is compensated by the antagonist muscles leading to scapular dysfunction during overhead throwing motion. Shoulder pathology can manifest as pain, diminished performance, or a decrease in strength or range of motion. Most of the overhead throwing athletes exhibit excessive shoulder external rotation (ER) and limited internal rotation (IR) at 90° of abduction. This loss of IR of the throwing shoulder is referred to as Gleno-humeral Internal Rotation Deficit (GIRD) [3].

The balance between the strength of the agonist and antagonist muscles of the shoulder rotators is important to maintain the stability of GHJ during upper limb activities. The role of external rotators here is to slow down the movement and maintain the stability of the GHJ. It is also known that one of the greatest risks of shoulder injury is the difference in the contralateral limb strength of more than 15%. [4]

Every sport has its own pattern of throwing. But certain similarities can be found in all throwing sports. The most important factor affecting the throwing performance is said to be the biomechanics of throwing. The five phases in throwing are wind up, stride phase, arm cock, acceleration and follow through.

The rotator cuff muscles are responsible in maintaining the external rotation and abduction position of the shoulder during stride phase. The weak rotator cuff muscles lead to improper scapular position causing shoulder impingement or shoulder instability. These muscles are also responsible for maintaining the humeral head in the glenoid fossa during the arm cocking phase. Dysfunction of these muscles may induce additional stress on the anterior stabilisers of the shoulder.

During the acceleration phase, extreme high maximal high velocity is produced by the internal rotators as they contract concentrically. As the arm rotates back, there is increase in the internal rotation range which in turn contributes in generating greater velocity during throwing. Repetitive throwing tends to increase the joint laxity and flexibility leading to instability. This is said to be one of the causes for capsule-labral and rotator cuff injuries. There are many studies which show that the baseball throwers have 10^0-15^0 of more external rotation than the non-throwers [5].

During the deceleration or the follow through phase, the rotator cuff plays the role of resisting the humeral head distraction, horizontal adduction and internal rotation. If the rotator cuff is not strong enough to maintain the tension, it may lead to rotator cuff injury. If there is capsular laxity or muscle weakness, it may lead to labral entrapment followed by labral tear. This is another reason for shoulder instability which increases the chances of shoulder injury as rapid rotation produces large force and torque during throw [5].

Tendonitis is also due to the impingement of rotator cuff tendon. During deceleration, there is abduction, horizontal adduction and internal rotation. Weakness of reduced rotator cuff strength may lead to superior translation of the humeral head causing impingement. The capsular laxity adds on to the increased compressive force of the humeral head on the tendon.

Weakness in any segment may result in a deficiency in the performance. The arm cocking and the deceleration phase is said to be the most common phase for overuse throwing injuries.

An unidentified muscle weakness or imbalance is the reason for assessing the strength of the muscles to prevent or to treat shoulder injuries.

There are various methods to assess the strength of shoulder rotators. One of the gold standard methods to check the maximum strength of the muscles with constant speed is by using isokinetic dynamometer [8]. Isokinetic means accommodating resistance and speed with the change in position. Concentric muscle contraction is the development of muscle tension while the origin and insertion of the muscle approach each other, referred to as positive work. Isokinetic dynamometer limits the difficulty in stabilisation and evaluation of the multi-axial component motions, making it best suitable for scientific research. It provides resistance and a fixed speed i.e., as the torque changes, the machine adjust its resistance to keep the speed same. The speed and torque produced throughout the movement is plotted as a graph in a computer synchronised with the machine [6]. This machine is mostly used in rehabilitation or research settings and is capable of allowing maximum effort throughout the range of motion. This method is said to be the most reliable and consistent way to detect minute strength difference which cannot be picked up by any other strength testing equipment or methods. It also gives specialised information based on the anatomical configurations, muscle length-tension relationships and velocities of muscle action [7].

Since throwball is a sport where there is no specific training followed, these players are more prone for shoulder injuries. Though there are studies concluding that the strength of the dominant side is greater in both internal and external rotators, the need to assess the strength of the rotators on both the side in throwball players is essential as it is a sport where both the sides are used irrespective of the dominance. Since the rotators play major role in stabilisation of the humeral head and provide good stability, the need for assessing the strength of theses muscles is a must. The popularity of this sport is less; hence there is limited data available about the strength of the muscles around the shoulder in throwball players. However, to our knowledge and after a thorough research, there is scarce evidence on throwball players. Hence, the need for this study is to check the strength of the shoulder rotators in collegiate throwball players to identify and minimise the risk of injury. The objectives of this study are to assess the strength of shoulder internal rotators and external rotators in collegiate throwball and non-throwball players and to compare the strength between both the groups.

Materials and Methods

43 female subjects in the age group 18-25 years were included in the study. Study was approved by the institutional ethics and research committee. A cross sectional research study design was chosen to assess the strength of shoulder internal and external rotators. The subjects were recruited based on the convenience sampling. Subjects with any history of shoulder injuries, dislocations, fractures, tendinitis, systemic diseases, bursitis, frozen shoulder in the past 6months, previous shoulder surgeries, any history of shoulder pain and nerve injuries, current cervical or thoracic spine injury and those indulged in any other sports other than throwball were excluded from the study. With a reported standard deviation of 0.09 [9], effect size was calculated as 0.7, 0.05 alpha error and 80%power, sample size was calculated to be 43, 22 in each group for the proposed study.

Procedure of data collection

Based on the inclusion criteria, the subjects were screened and eligible participants were recruited for the study. Explanation regarding the study was given to the patients and all those who agreed to participate were enrolled in the study after obtaining written informed consent. Subjects were then assessed for strength of shoulder internal and external rotators. All the subjects were taught to do general shoulder stretches as a warm up program. With comfortable, loose dress and upper limbs sufficiently exposed, the subjects were asked to lie supine on the bed, with shoulder in 90^0 abduction, forearm perpendicular to supporting surface and 0^0 supination. The humerus was completely supported over the bed except for the elbow. A pad was placed below the humerus. The fulcrum was fixed at the olecranon process, the fixed arm along the ulna. The subjects were asked to move their arm inside for internal rotation and outside for external rotation without lifting the shoulder or scapula. The moving arm was moved along the ulna. The range of motion was noted down. Same method was repeated on the contralateral limb. Later, strength of the internal and external rotators was tested on the Cybex isokinetic dynamometer. The peak torque of internal rotators and external rotators were determined. The subjects were asked to sit on the chair straight with the back touching the chair. The non-dominant side was tested first. The pelvis was stabilised with a strap across it to prevent pelvic hiking, an additional strap stretched diagonally from just above the shoulder level to the opposite pelvic side. The dynamometer was calibrated. The axis of the dynamometer was aligned with the axis of the humeral head. The elbow was maintained at 90^0flexion by the device. The arm attachment was adjusted accordingly with wrist in neutral position. The minute setting such as adjusting the dyna height, dyna tilt, and chair rotation was done. The subjects were explained about the test. Three speeds were used-60^0/sec, 120^0/sec and 180^0/sec. The subjects were asked to grasp the arm attachment. They were instructed not to use the contralateral limb for support. The instructions were to push the handle as fast as possible and complete the movement without rest. Three trials were given for each speed them to get familiarised with the equipment and the speed. The actual test consisted of five repetitions. The sequence of the speed was randomised. A rest period of 30seconds was allotted after trail and after each speed test. The mode used for the testing was concentric concentric (conc/conc).

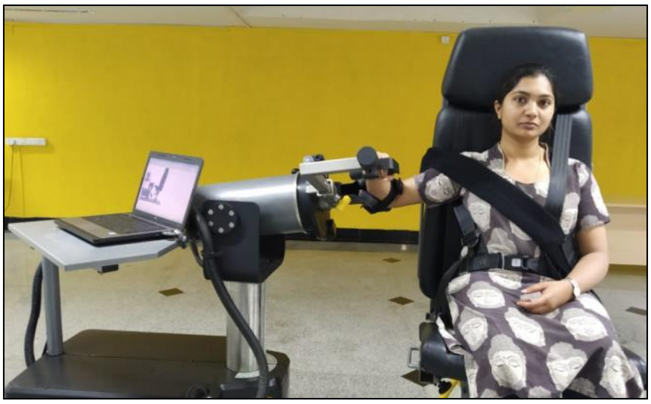

Fig 1: IR peak torque testing of dominant side

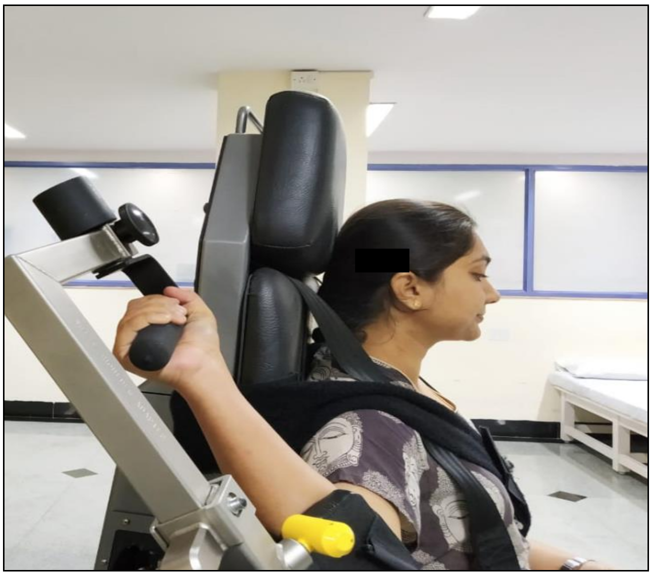

Fig 2: ER peak torque of dominant side

Statistical analysis

Data Analysis was performed with the help of Statistical Package for Social Science (SPSS) version 20 and Microsoft Excel for primary data entry and plot charts and graphs. Descriptive statistics was used for the study. Independent t-test was used to find the difference between internal rotator strength and external rotation strength of the shoulder rotators and also used to find the significance difference between shoulder rotator muscles strength between throwball players and non-players.

Results: The demographic data of the participants (n = 43) has been shown in Table 1.

Table 1: Demographic data, ROM (degree) for IR and ER of players and non-players (N=43)

	Players Mean +SD	Non-Players Mean + SD
Age(years)	20.05+1.39	19.96 + 1.33
Height(cm)	157.36+5.92	158.18+5.38
Weight(kg)	59.66+14.60	63.24+12.63
Left IR (degree)	74.61+9.01	68.80 + 6.17
Left ER (degree)	83.27+8.28	81.92 + 8.24
Right IR (degree)	69.33+13.0	67.92+5.84
Right ER (degree)	81.88+8.30	85.12+7.21

Table 2: Peak torque of internal rotator strength and external rotator strength at 180^0/sec, 120^0/sec and 60^0/sec of players and non-players (N=43)

	Speed(degrees/sec)	Mean + SD	Mean + SD
Left IR	180	12.05 + 4.03	10.52 + 5.60
	120	13.94 + 4.41	12.80 + 4.95
	60	15.65 + 3.23	13.2+ 3.54
Left ER	180	4.38 + 0.97	4.48 + 1.12
	120	6.16 + 2.89	6.40 + 3.22
	60	5.65 + 1.81	6.32 + 2.11
Right IR	180	14.22 + 4.72	11.52 + 4.95
	120	14.72 + 4.37	12.24 + 4.00
	60	15.72 + 2.67	14.52 + 2.70
Right ER	180	4.27 + 0.95	4.24 + 1.05
	120	5.33 + 2.08	5.48 + 2.38
	60	5.22 + 1.39	5.80 + 1.70

Table 3: Comparison of peak torque between players and non-players (N=43)

	Speed(degrees/sec)	t-value	P-value
Left IR	180	0.99	0.32
	120	0.78	0.43
	60	2.32	0.02*
Left ER	180	-0.27	0.78
	120	-0.24	0.80
	60	-1.05	0.29
Right IR	180	1.8	0.07
	120	1.92	0.06
	60	1.44	0.15
Right ER	180	0.12	0.90
	120	-0.21	0.83
	60	-1.17	0.24

* The mean peak torque of Left IR at 60^0/s showed significant changes with p-value < 0.05

Discussion

The primary objective of the study was to determine the strength of internal rotators and external rotators of bilateral shoulders in collegiate level female throwball players. The secondary objectives were to determine the strength of internal rotators and external rotators of bilateral shoulders in collegiate female non players and compare the strength between the two groups.

Rom

According to this study, in the players group, the mean and standard deviation of IR ROM on dominant and non-dominant side was 69.33+13.0 and 74.61+9.0 respectively. The ROM of ER of dominant and non-dominant side was 81.88+8.30 and83.27+8.28 respectively. There was reduced ROM in both IR and ER of dominant side compared to non-dominant side. This result can be attributed to the fact that repetitive overhead action and overstretched anterior capsule, causes physiological adaption of shoulder joint leading to fibrosis of the posterior capsule and impingement which may reduce the range of motion. The study done by Hsing-Kuo Wang *et al*. also reported similar results in volleyball players. There was no statistical difference in ER ROM between the two groups [10].

Peak torque: Players

At 180^0/s speed, the mean peak torque of IR on dominant side (14.22+4.72) was greater than the non-dominant side (12.05+4.03). However, the mean peak torque of ER was found to have no statistical significance. The non-dominant side had greater mean peak torque over ER (4.38+0.97). In the above result, it was observed that the strength of the dominant IR was greater than on the non-dominant side at all three speeds. The difference in the strength between the two sides may be because the internal rotators are overstretched followed by sudden explosive contraction during deceleration phase or during the ball release. The internal rotators undergo plyometric contraction with repetitive overhead movement. The mean peak torque of ER on non-dominant side was greater than the dominant side could be due to stretch weakness over the retractors during the deceleration phase. The eccentric load over the posterior cuff may cause tear of the intramuscular connective tissue causing inflammation and weakness of the muscles. These findings were in consistent with the findings of mean peak torque of shoulder rotators in 30 male cricket players at 300^0/s, 1800/s, 90^0/s and 60^0/s speed. The mode used for the study was conc/conc [11].

At 120^0/s speed, the IR mean peak torque on dominant side was greater (14.72+4.3) and the ER peak torque was higher on the non-dominant side (6.16+2.89). The results are similar to the results obtained in elite volleyball athletes in U.K. The study assessed concentric and eccentric rotators strength at 120^0/s and 60^0/s. the results showed weaker rotator strength on concentric and eccentric mode. The study found increased peak torque in concentric mode and increased peak torque of IR on dominant side compared to the non-dominant side [8]. The peak torque values in high school and collegiate pitchers between throwing and non-throwing shoulder also found no significant difference in ER peak torque at same speed [9].

At 60^0/s speed, the IR mean peak torque on dominant side was again greater than the non-dominant side (15.72+2.67). The ER mean peak torque was greater on non-dominant side (5.65+1.81). This result is also in agreement with a study done by Claudio Andre Barbosa de Liva *et al*, 2019, on adolescent asymptomatic male volleyball players. The author used two speeds 60^0/s and 240^0/s. The mode of testing used was concentric for IR at both speeds and eccentric for ER at 240^0/s speed. The isokinetic strength of shoulder rotators showed no significant difference in peak torque of external rotators. But the dominant limb had significant higher peak torque in internal rotators at concentric speed of 60^0/s speed (48.7+13.7) [10, 12].

There may be many reasons or explanations for the imbalance of internal and external rotator strength. One of the explanations could be that weakness of the external rotators in the dominant side of players may display weakness and atrophy of the infraspinatus muscle due to suprascapular nerve entrapment. According to Jobe *et al*., the external rotators are most active during the follow-through phase of pitching. This may be one of the reasons for reduced ER strength on dominant side which any lead to nerve impingement [13].

Peak torque: Non-players

The mean peak torque of IR at 180^0/s and 60^0/s was greater on dominant side compared to the non-dominant side i.e. 11.52+4.95 and 14.52+2.70 respectively. The mean peak torque of ER at all the three speeds was greater on non-dominant side. The reason for increased mean peak torque on dominant side is same as for the players.

At 120^0/s speed, the peak torque of IR showed greater value on non-dominant side exhibited increased peak torque compared to dominant side with mean value of 12.80+4.95. The results obtained in this study are not in agreement with the results obtained in many studies that compared rotator strength of dominant and non-dominant side in various sports. Further research is required in this aspect with respect to reduced dominant side IR peak torque.

At 60^0/s speed, the mean peak torque of IR on dominant side was higher (14.52+2.70) for whereas the ER of the non-dominant overrules the strength of dominant side with mean peak torque of 6.32+2.11. The physiology behind increased IR strength on dominant side compared to the non-dominant could be as simple that even in normal individuals; the dominant side is used repetitively for everyday activities. This repetitive movement caused structural changes in the musculature increasing the strength of the dominant side. The larger cross-section internal rotators muscles produce more muscle force (lattissimus dorsi, pectoralis major) compared to small cross-section external rotators (infraspinatus, teres minor). This could be one of the reasons for IR being stronger than the ER [10].

Comparison of peak torque of IR and ER between players and non-players

On comparing between the groups, there was no significant difference in the peak torques at 180^0/s and 120^0/s speed. But the study found significant difference in the peak torque of IR at 60^0/s speed with p value 0.02 and t-value of 2.32.

In the above result, it was observed that the strength of the non-dominant ER in both the groups was greater than on the dominant side. This could be possible because repetitive overhead movement of the dominant arm cause stretch weakness over the retractors during the deceleration phase. The eccentric load over the posterior cuff may cause tear of the intramuscular connective tissue causing inflammation and weakness of the muscles [11].

The strength of IR in non-dominant side overruled the dominant side at 60^0/s speed. This contradicts the results of many studies which showed strength of the dominant side IR was stronger than the non-dominant side. The physiology behind this result can be explained that repetitive movement caused concentric loading and strengthening of the internal rotators increasing the strength compared to non-dominant side. But in our study, though there was no significant difference between the IR strength of dominant and non-dominant side, the mean peak torque on the non-dominant side could be explained with respect to velocity time. The time taken by the dominant arm to accelerate at the required higher velocity is much more than the non-dominant arm. This may be because the dominant arm requires more time for better control and co-ordination of the throw. Whereas, the non-dominant arm finds difficulty to throw the ball with better performance as the control and co-ordination is weaker than the dominant. This is the reason the non-dominant side requires less velocity time [14].

Summary and Conclusion

Overhead throwing athletes present unique musculoskeletal profile. Considering the importance of muscle strength and imbalance to prevent injury in sports population, the aim of this study was to assess the strength of the rotators in college level throwball players and compare the strength with the normal and find if there was any significant difference between the groups. This study also provides normative value for female collegiate throwball players which could be used for further research on comparing the IR/ER ratio. Since there was no significant difference between the groups except for IR at 60^0/s, it is clear that the players need strengthening program for their shoulder. The players had asymmetrical IR values but no difference in the ER strength. Thus, preventive strengthening program for shoulder focusing on strengthening the external rotators and non-dominant side internal rotators should be emphasised.

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