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Sakina A Dadla
Intern-P.E.S. Modern College of Physiotherapy, Shivaji Nagar, Pune, Maharashtra, India

Dr. Asmita C Moharkar
Intern-P.E.S. Modern College of Physiotherapy, Shivaji Nagar, Pune, Maharashtra, India

Correspondence Author:
Sakina A Dadla
Intern-P.E.S. Modern College of Physiotherapy, Shivaji Nagar, Pune, Maharashtra, India

Effectiveness of kinetic chain exercises on pain and functional performance in young throwball players with supraspinatus impingement syndrome at the end of 6 weeks-an experimental study

Sakina A Dadla and Dr. Asmita C Moharkar

Abstract
Throwball requires generous amount of shoulder and scapula strength along with drive from large leg muscles and hip rotation, for the propulsion of the ball across the net.
Impingement caused by the sport causes pain and renders low functional performance of the athlete.
Kinetic chain rehabilitation approaches the shoulder as a part of the kinetic link system & attempts to address the shoulder function in a proximal-to-distal (i.e. foot to shoulder).
It employs these natural motor programs by focusing on the neuromuscular system rather than on isolated movement and muscle activation.
Method: In this study, 40 samples were collected as per the inclusion criteria. The treatment protocol was explained in detail to them, consent was taken.
The protocol was then administered for 6 weeks; 3 sessions per week on alternate days.
Pre and post data collection and was done using Numerical Pain Rating Scale (NPRS) and Kerlan-Jobe Orthopedic Clinic Score Questionnaire (KJOC).
Result: It has shown significant results post intervention in reducing pain (NPRS; difference: 0.6944 to 1.414, t=5.944, p<0.001) and improving functional performance (KJOC; difference: -4.809 to-3.191, t= -10.026, p<0.001).
Conclusion: This concludes that kinetic chain exercises for throwball players with supraspinatus impingement syndrome is effective in reducing pain and improving functional performance.

Keywords: Throwball, kinetic chain exercises, supraspinatus impingement

Introduction
Throwball is a non-contact ball sport, played across a net, between two teams of nine players, popular in Asia.

About the Sport
Service is done from the service zone and must cross the net.
The ball is received and thrown only above shoulder-line and with one hand only.
The ball must cross the net when thrown with one hand, in rally and service both.

Biomechanics of Throwing
Throwing is a whole body activity that commences with drive from large leg muscles and rotation of hip, progresses through segmental rotation of the trunk and shoulder girdle. Continues with a 'whip-like' transfer of momentum transferring propulsive force to the ball [1].

Phases of Throwing
Preparation/wind-up
Establishes rhythm, or pitch of the throw. During this phase, the hip and shoulders rotate so that it is at 90 degrees to the target. The major forces arise in the lower half of the body and develop a forward-moving controlled fall. The shoulder muscles are relatively inactive during this phase [1].

Cocking
The cocking movement positions the body segments to contribute to ball propulsion. The shoulder moves into abduction, horizontal extension and external rotation. When the scapula is maximally retracted, the acromion starts to elevate. This phase ends with the body positioned to transfer energy from the lower extremities to the distal segment for ball propulsion [1].

Acceleration
This is the most explosive phase of throwing. There is rapid release of the stored elastic forces. It generates excessive forces at the gleno-humeral articulation, thus the rotator cuff musculature remains highly active to keep the humeral head positioned in the glenoid cavity. There is a critical role of the muscles stabilizing scapula-thoracic region in this phase as well [1].

Deceleration/Follow-Through
In this phase, very high forces pull forward on the gleno-humeral joint following ball release which places large stresses on the posterior shoulder structures. During this time, both intrinsic and extrinsic shoulder muscles fire at significant percentages of their maximum attempting to develop forces to slow the arm down. [1]

Muscle Work during Throwing
Cocking Phase
Deltoid, supraspinatus, subscapularis, trapezius, serratus anterior, levator scapulae [3]

Acceleration Phase
Serratus anterior, latissimus dorsi, rotator cuff [3]
Deceleration phase: Trapezius, rotator cuff, serratus anterior [3]

Supraspinatus Impingement Syndrome
Internal impingement occurs mainly in overhead athletes, during the cocking stage of throwing, when impingement of the supraspinatus occurs, between undersurface of the acromion and the greater tuberosity of humerus as soon as the arm is elevated above shoulder level. It's a normal physiological process, but may become pathological in the overhead athlete due to repetitive overhead action leading to trauma. With inflammation, there will be swelling and pain along with tendon thickening, thus hampering the efficient passage [3].
The prevalence of supraspinatus impingement syndrome in throwball players is 5% [6].

Role of Scapula in Normal Biomechanics [5]
Stable socket for humerus
Retracts and protracts along thoracic wall
Rotates to elevate acromion
Key link in kinetic chain
Base for muscle attachment

Role of Proximal Musculature in Throwing Action
Leg and trunk activation are associated with segmental joint acceleration, that move COG upwards toward unilateral shoulder flexion [5]
Postural adjustments to counteract the disturbance in equilibrium due to voluntary movement [5].
Proximal segments, legs and trunk accelerate the entire system & transfer momentum to the distal segment [5]
Helps to reduce forces created by shoulder by transferring segmental velocity through kinetic chain [5]

Kinetic Chain Rehabilitation
Kinetic chain rehabilitation approaches the shoulder as a
Part of the kinetic link system & attempts to address the shoulder function in a proximal-to-distal manner [5]
Normal motor patterns of voluntary upper extremity movement while standing, include lower extremity & trunk muscle activation before the arm motion. [5]
The task of rapidly reaching forward with the right hand to shoulder level produces a consistent pattern of activation and de-activation of leg and trunk muscles before deltoid activation [5].
Kinetic chain shoulder exercises employ these natural motor programs by focusing on the neuromuscular system rather than on isolated movement and muscle activation [5].
By using multiple body segments in the exercises adjacent segments can facilitate the activation of involved muscles to develop appropriate shoulder motion and function [5].

1. Need of Study
- No studies have been done using kinetic chain rehabilitation for shoulder on pain and functional performance in throwball players.
- Previous researches have not considered the role of athletic stance while training for better efficiency and game performance of the athlete.
- Shoulder impingement is very common in overhead throwing activities and can worsen due to poor scapular stability.
- The conventional protocol usually focuses on isolated muscle strengthening, thus ignoring the role of proximal musculature in overhead throwing motions.
- The role of proximal-to-distal sequencing is not usually incorporated in the treatment protocol for overhead athletes.
- Since throwing is not an isolated shoulder action, the strengthening protocol must not be limited to only shoulder, but should also incorporate the whole body.

2. AIM
Effectiveness of kinetic chain exercises on pain and functional performance in young throwball players with supraspinatus impingement syndrome at the end of 6 weeks.

3. Objectives
To study the effectiveness of kinetic chain exercises on pain in young throwball players with supraspinatus impingement syndrome
To study the effectiveness of kinetic chain exercises on functional performance in young throwball players with supraspinatus impingement syndrome

4. Hypothesis
Null Hypothesis
H0: Kinetic chain exercises will not be effective on pain and functional performance in young throwball players with supraspinatus impingement syndrome

Alternate Hypothesis

H1: Kinetic chain exercises are effective only on pain in young throwball players with supraspinatus impingement syndrome.

H2: Kinetic chain exercises are effective only on functional performance in young throwball players with supraspinatus impingement syndrome.

H3: Kinetic chain exercises are effective on both pain and functional performance in young throwball players with supraspinatus impingement syndrome.

5. Methodology

Study type: Pre and post experimental study

Sample size: 40

Study Settings: Colleges and sports organizations in and around the city

Treatment Duration: 6 weeks; 3 sessions/week

Study Duration: Minimum 6 months

Study Population: Young throwball players with supraspinatus impingement syndrome

Sampling Technique: Purposive sampling method

Inclusion Criteria

Both males and females
Young throwball players between ages 12-25; competitive players playing at college or district level since at least 2 years
Pain in shoulder in dominant arm due to supraspinatus impingement syndrome

Exclusion Criteria

Any upper limb pathologies (lateral epicondylitis, etc.)
Any lower limb pathologies (ankle sprain, etc.)
Recent fractures of upper and lower limbs (up to 6 months)
Rotator cuff injury/tear

6. Materials and Tools

Consent form
Pen and paper
Kerlan-Jobe Orthopedic Clinic Score questionnaire (KJOC)
Numerical Pain Rating Scale (NPRS)
Weights
Sling

7. Outcome Measures

Kerlan-Jobe Orthopedic Clinic Score questionnaire (KJOC)

The KJOC score questionnaire has proven to be one of the most useful tools for assessing functional performance in overhead athletes (reliability= 0.50-0.93)

The questionnaire consists of 10 questions, the athlete was instructed to give a number between 0-10 on each question. The scale and the marking system was thoroughly explained to the athlete prior to scoring.

The pre and post rehabilitation scores were taken and compared.

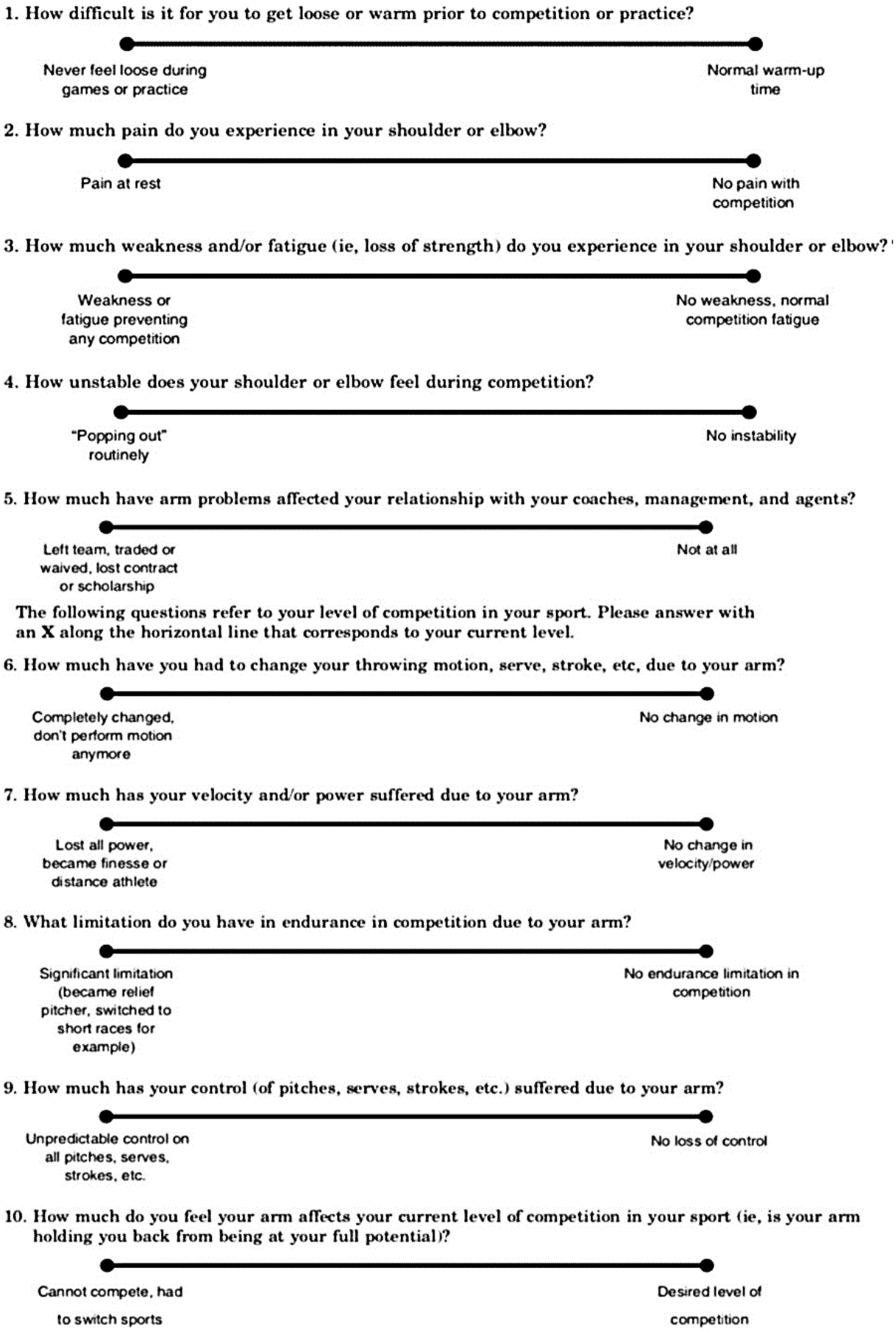
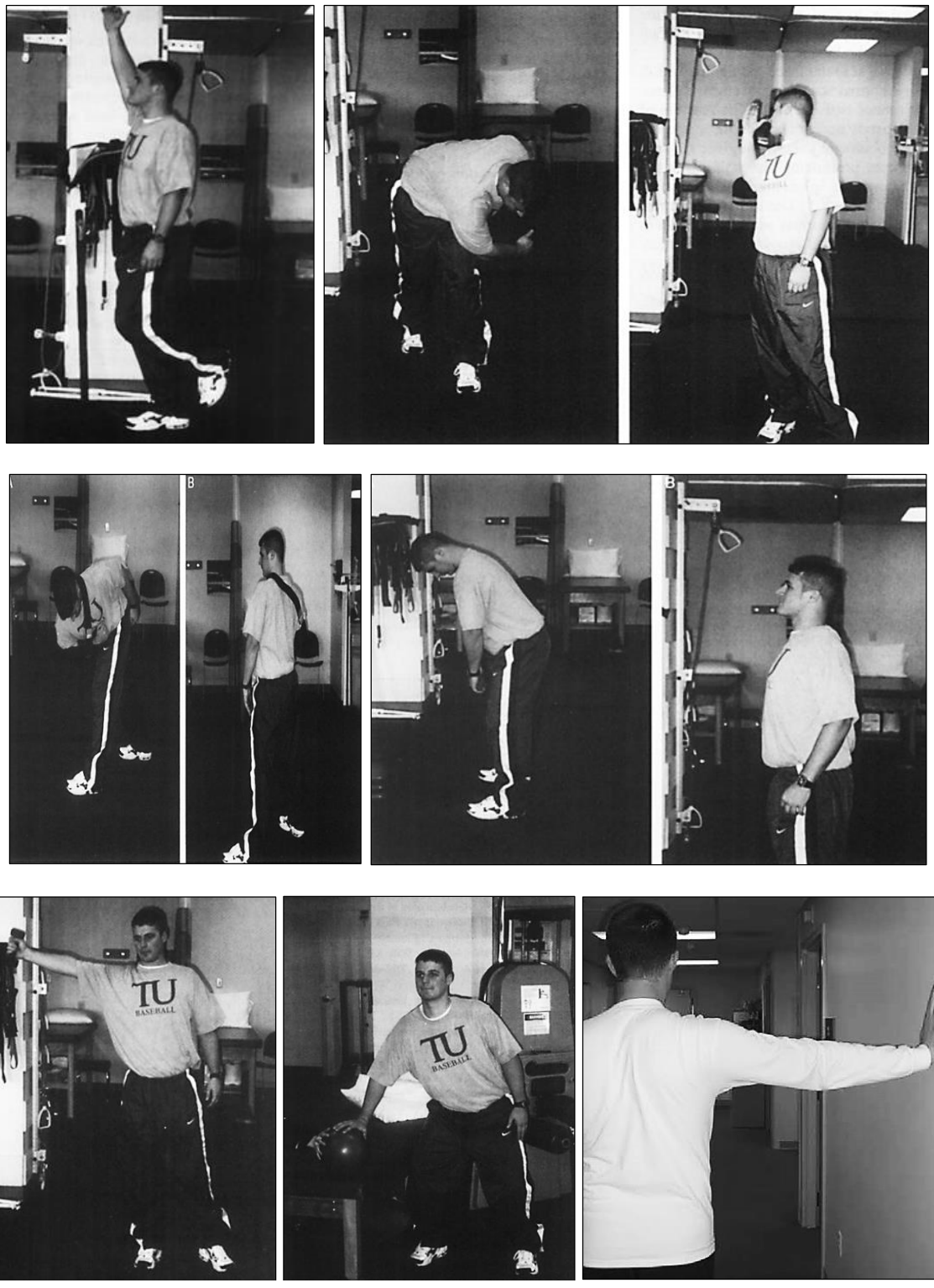


Fig 1: To take readings of the Kerlan Jobe Orthopedic Clinic Score Questionnaire (Fig 1): Show the scale to the athlete, explain that each question holds a score value of 10 points, ranging from 0-10. The score starts from 0 on the left hand side moving towards 10 on the right hand side. The players should score each question on 10. For eg: Q- How much has your control of pitches suffered due to your arm? Explanation of scoring: if player feels there is unpredictable control of the throw, he or she must score close to 0, for eg: 2 points on 10. If the player feels there is no loss of control, they must score close to 10, for eg: 9 points on 10. Calculate total score on 100. Pre and post intervention scores must be taken.

Numerical pain rating scale (NPRS)
This scale is used very commonly for rating pain. The patient must rate his/her pain on the scale ranging from 0 (no pain) to 10 (worst possible pain). The patient must give a numerical value in order to rate the pain. Pre and post rehabilitation scores were taken and compared.

8. Procedure
The study began with presentation of synopsis in front of the ethical committee at PES Modern College of Physiotherapy Ethical clearance was obtained from the committee.

Young throwball players between ages 12-25 with supraspinatus impingement syndrome, playing at competitive college or district level since at least 2 years were selected based on inclusion and exclusion criteria. The treatment protocol was explained to the participants and consent was taken. Pre-rehab KJOC score and NPRS score was taken.
Treatment intervention was given for 6 weeks; 3 sessions/week. Warm up was given before the treatment and cool down after the exercises. Consists of joint rotations and shoulder capsular stretches (15-20 minutes)
The exercises done were:



Initially the exercises were given with 10 repetitions, 10 seconds hold time; 2 sets.

Progression was done as follows

Week 1-2: Resistance: 60% of 1 RM

Repetitions: 8

Sets: 2
Rest Time: 2 minutes between each set of exercises

Week 3-4: Resistance: 70% of 1 RM

Repetitions: 8

Sets: 2
Rest time: 2 minutes between each set of exercises

Week 5-6: Resistance: 80% of 1 RM

Repetitions: 10

Sets: 3

Rest Time: 2 minutes between each set of exercises

The KJOC and NPRS scores post rehabilitation were taken.

9. Statistical Analysis

Data analysis was done by using the outcome measures Numerical Pain Rating Scale (NPRS) and Kerlan-Jobe Orthopedic Clinic Score Questionnaire (KJOC).
The data passed the normality test.
Pre and post data analysis of Numerical Pain Rating Scale (NPRS) was done by paired t-test.
Pre and post data analysis of Kerlan-Jobe Orthopedic clinic score questionnaire (KJOC) was done by paired t-test.

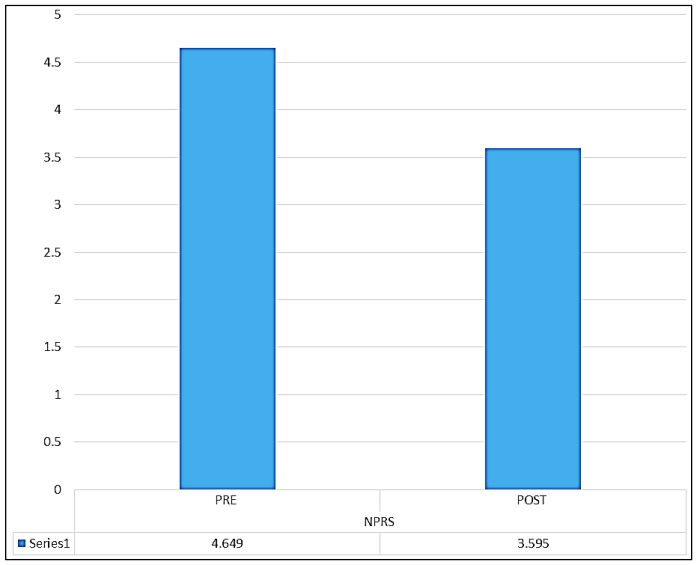
Numerical Pain Rating Scale (NPRS)

Table 1: shows the readings of NPRS, pre intervention mean reading is 4.649 and post intervention score being 3.595. This indicates that the pain in the dominant arm while throwing reduced post intervention**.**

NPRS	Pre	Post
Mean	4.649	3.595
SD	1.252	1.363

Table 2: 2 shows the p value reading of NPRS outcome which is p<0.0001 showing that the result outcome obtained is quite significant as showing by pain reducing after intervention on the Numerical Pain Rating Scale. The significance of t value (5.944) means that, the greater the t- value, greater is the evidence against the null hypothesis. This indicates that the treatment protocol given, is showing good results.

P Value	p<0.0001 (considered extremely significant)
T Value	5.944



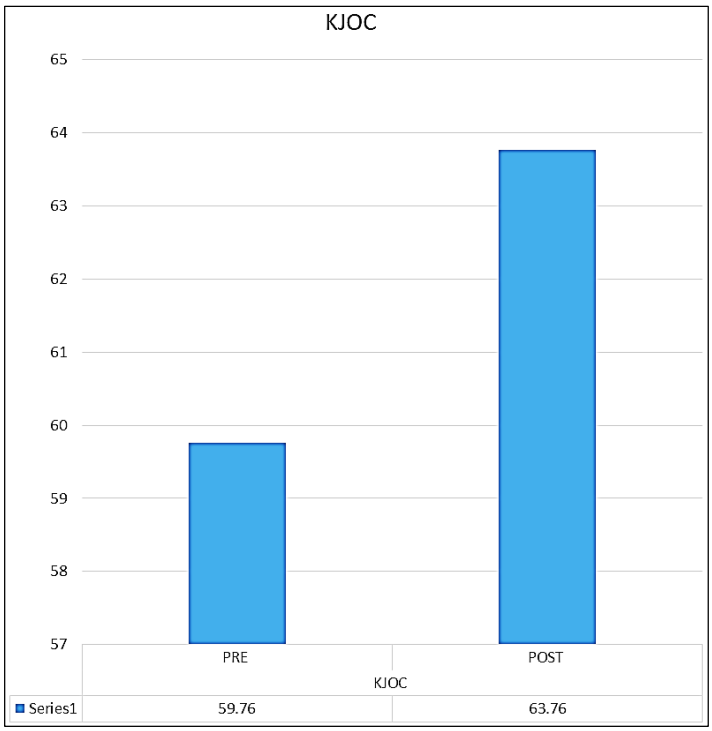
Graph: NPRS

- Mean values of NPRS were 4.649 and 3.595 pre and post respectively.
- Paired t-test was used to compare the values.
- The difference obtained was 0.6944 to 1.414 with p value being *p*<0.0001 (considered extremely significant) and t value being t=5.944

Kerlan-Jobe Orthopedic Clinic Score Questionnaire (KJOC)

Table 3: indicates the p value of the pre and post intervention Kerlan Jobe Orthopedic Clinic Score Questionnaire, the mean pre score being 59.76 and post score being 63.76. The basis of this questionnaire scoring is that, the closer the score to the value of 100, the more efficient is the functional performance of the athlete. Therefore, after intervention, the mean score has shown an aggregate increase, indicating increase in functional performance of the athlete.
The p value (p<0.0001) is considered significant. The t value in this case is -10.026.

KJOC	PRE	POST
MEAN	59.76	63.76
SD	8.665	8.285
P Value	*p*<0.0001 (considered extremely significant)	
T Value	-10.026	



Graph: KJOC

- Mean values of KJOC were 59.76 and 63.76 pre and post respectively.
- Paired t-test was used to compare the values.
- The difference obtained was -4.809 to -3.191 with p value being p<0.0001 (considered extremely significant) and t value being t= -10.026

10. Result

The mean values of NPRS were 4.649 and 3.595 pre and post respectively. The difference obtained was 0.6944 to 1.414 with p value being p<0.0001 (considered extremely significant) and t value being t=5.944.

Mean values of KJOC were 59.76 and 63.76 pre and post respectively. The difference obtained was -4.809 to -3.191 with p value being p<0.0001 (considered extremely significant) and t value being t= -10.026.

11. Discussion

Throwball is a non-contact ball sport, requiring repetitive overhead throwing motions using the dominant arm only. It requires large amount of force generation from the body through the shoulder, for propulsion of the ball several times over the net and to the other side of the court. Throwing is a whole body activity that commences with drive from the large leg muscles, rotation of hip and progresses through segmental rotation of trunk and shoulder girdle [1].

Internal impingement mainly occurs in overhead athletes due to repetitive overhead activity, the supraspinatus tendon gets impinged between the undersurface of acromion and the greater tuberosity as the arm is elevated above shoulder level [3].

The aim of this study was to measure effectiveness of kinetic chain exercises on pain and functional performance in young throwball players with supraspinatus impingement syndrome at the end of 6 weeks. The kinetic chain exercises were given to young throwball players between ages 12-25 playing at college or state level since at least 2 years. The duration was 3 times/week on alternate days for a total of 6 weeks with appropriate progression. Pre and post assessment of pain using Numerical Pain Rating Scale (NPRS) and functional performance using Kerlan-Jobe Orthopedic Clinic Score Questionnaire (KJOC) was done.

The pre and post results of both NPRS and KJOC were compared and data analysis was done. The kinetic chain exercises showed significant results in reducing pain and improving functional performance. The mechanism by which the treatment protocol was effective is due to incorporation of large leg, hip and trunk musculature in facilitation of shoulder and scapula strengthening along with an athletic stance during the exercises. [5] The proximal segments help to accelerate and transfer momentum to the distal shoulder while throwing, and therefore they must not be excluded during the treatment protocol.

Reduction in pain of the subjects was seen due to efficient strengthening mechanism of the shoulder and scapula. Proper athletic stance and posture during the exercises helped to give feedback to the athlete while playing. Since the transfer of force generated was in the correct manner, it reduced the loading on the shoulder and pain was relieved.

Functional performance improved since there was an increase in endurance and a reduction in fatigue. Athletes noted that they could play for a longer duration of time without undergoing excessive fatigue. The propulsion of the ball across the net was smoother and did not cause as much pain in the shoulder.

Since the loading on the shoulder reduces, changes of injury also decreases. If the shoulder undergoes excessive loading and the dynamic stabilizers are inefficient, it could cause shoulder injuries and possibly even dislocation. Therefore, strengthening in this manner reduces further injury risk. If throwing is a whole body action, the strengthening must also incorporate the whole body and not just be limited to shoulder and scapula.

Robert Litchfield, MD, FRCS, Richard Hawkins, MD, FRCS wrote in their paper discussing rehabilitation of the overhead athlete- 'It is critical to apply the appropriate stretching and

strengthening programs to shoulder to restore normal function of shoulder' [11] I however, in my paper have not restricted the treatment to only stretching and strengthening protocols of the shoulder, but have used postural changes, athletic stance and involvement of lower body and trunk in facilitation of shoulder and scapula.
Kinetic chain exercises are effective on both pain and functional performance in young throwball players with supraspinatus impingement syndrome.

12. Conclusion
The study concludes that kinetic chain exercises are effective on both pain and functional performance in young throwball players with supraspinatus impingement syndrome at the end of 6 weeks.

13. Limitations
1. The treatment protocol is of 6 weeks, which caused a few of the study samples to drop out of the study because of a lack of consistency
2. A few of the samples could not keep up with the progression of the weights, which caused pain. As a result, modification in the progression had to be made. They had to be given the progression with the same weights as they did in the first 2 weeks of exercises.

14. Future Scope of Study
1. In future, exercise protocol of a shorter duration can be implemented for convenience.
2. Exercises with different progression protocols can be used
3. Different methods of resistance can be used
4. Various new exercises can be devised which mimics the stances and actions of a throwball player while playing

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