

## Original Article

# OPEN KINEMATIC CHAIN EXERCISES FOR SICK SCAPULA IN COMPETITIVE ASYMPTOMATIC OVER HEAD ATHLETES FOR 3 WEEKS

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## ABSTRACT

**Background and Objective:** SICK scapula may result in ineffective energy transfer, placing added stress on the tissues around the shoulder which must compensate for a weak link in the chain. This added stress may result in further muscle fatigue and tissue injury about the shoulder. Restoring and maintaining a stable scapular base is essential to rehabilitating the shoulder and returning to the sport. So the present study intends to study the effectiveness of open kinematic chain exercises on asymptomatic overhead athletes with SICK scapula.

**Methods:** In the present experimental study 20 participants were included and received open kinematic chain exercise (OKC) protocol for 4 sessions per week for 3 weeks for 60 minutes with 20 minutes of warm and 10 minutes of cool down respectively. Pre and post intervention of Lateral Scapular Slide Test (LSST), Range of motion (ROM), Pectoralis muscle length, Davies Closed Kinetic Chain Upper Extremity Test (CKCUEST) and Functional Throwing Performance Index (FTPI) were assessed.

**Results:** Pre and post intervention characteristics were analyzed by unpaired t test. The results showed significant improvement after 3 weeks of intervention in outcome measures LSST, FTPI, ROM, CKCUEST and Pectoralis Muscle Length. The level of significance was set at  $p < 0.05$  and  $p < 0.001$  as highly significant.

**Conclusion:** Open kinematic chain exercises are effective for treating asymptomatic overhead athletes with SICK scapula.

**KEYWORDS:** SICK scapula, Overhead athletes, Asymptomatic, FTPI, CKCUEST, LSST, OKC, Rehabilitation.

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## INTRODUCTION

The shoulder complex is comprised of the sternoclavicular joint, the clavicle, the acromioclavicular joint, the glenohumeral joint (GH), the scapula, and the scapulothoracic joint<sup>1,2,3,4,5,6</sup>. In order for the GH joint to function effectively these articulations must work together. With all the mobility and very poor static stability the joint relies upon the dynamic

stabilizers, leaving it particularly vulnerable to sporting injuries<sup>2, 4, 5, 6</sup>. Stability at the scapulothoracic joint depends on the surrounding musculature. The scapula serves many roles in order for proper shoulder function to occur. Each role is vital to proper arm function and can only occur when the anatomy around the shoulder is uncompromised. The presence of bony and soft tissue injury as well as muscle

weakness and inflexibility can alter the roles of the scapula and alter scapular resting position and/or dynamic motion.<sup>7</sup>

Scapular muscle actions allow proper positioning and stability of the scapula while maintaining the glenohumeral center of rotation throughout arm motion<sup>8</sup>. An adequate scapular positioning is believed to be necessary for ideal muscle lengths, force production and (assisting with) glenohumeral joint stability<sup>9</sup>. Scapular muscle actions allow proper positioning and stability of the scapula while maintaining the glenohumeral center of rotation throughout arm motion.<sup>10, 11</sup>

An adequate scapular positioning is believed to be necessary for ideal muscle lengths, force production and (assisting with) glenohumeral joint stability.<sup>10,11</sup> Muscular imbalances in scapular force couples (action) may result in scapular dyskinesis, abnormal glenohumeral translation or rotator cuff overload. In fact, the inability to retract the scapula appears to impart several negative biomechanical effects on the shoulder structures, including a narrower subacromial space, reduced impingement-free, reduced strength of the glenohumeral muscles.<sup>12</sup>

The scapular muscles must dynamically position the glenoid so that efficient glenohumeral movement can occur. When weakness or dysfunction is present in the scapular musculature, normal scapular positioning and mechanics may become altered. When the scapula fails to perform its stabilization role, shoulder function is inefficient, which can result not only in decreased neuromuscular performance but also may predispose the individual to shoulder injury.<sup>13</sup>

The scapular musculature is often neglected in the evaluation and treatment of shoulder injuries. This lack of attention often degenerates into the incomplete evaluation and rehabilitation of scapular dysfunction. Dysfunction or weakness of the scapular stabilizers often results in altered biomechanics of the shoulder girdle. The altered biomechanics can result in (1) abnormal stresses to the anterior capsular structures, (2) the increased possibility of rotator cuff compression, and (3) decreased performance.<sup>14</sup>

In the SICK (Scapular malposition, Inferior medial scapular winging, Coracoid tenderness, and

scapular dys Kinesis) scapula syndrome, scapular position asymmetry is measured statically, but actively produces scapular dyskinesis as the shoulder goes through the throwing cycle. SICK scapula may result in ineffective energy transfer, placing added stress on the tissues around the shoulder which must compensate for a weak link in the chain. This added stress may result in further muscle fatigue and tissue injury about the shoulder<sup>11,12</sup>. Restoring a stable scapular base is essential to rehabilitating the shoulder and returning to the sport. So the present study intends to correct the poor scapular stabilization of the asymptomatic competitive overhead athletes with SICK scapula and rehabilitate with specific open kinematic chain exercises for a period of 3 weeks and thereby improve the athletic performance and prevent future shoulder injuries.

## METHODS

The ethical clearance was obtained from the Institutional Ethical Committee of KLEU Institute of Physiotherapy, Belgaum and all subjects had given an informed written consent agreeing to participate and after fulfillment of the inclusion and exclusion criteria.

The participants were included from VTU Indoor Stadium, JNMC Tennis Court and Indoor Stadium, Union Gymkhana and Rotary Club, Belgaum. Participants were included according to the fulfillment of the inclusion and exclusion criteria respectively. The inclusion criteria was- asymptomatic participants involved in competitive overhead sports, age from 18 to 30 years both male and female, positive for SICK scapula. The exclusion criteria was Symptomatic participants, shoulder pathology except SICK scapula, shoulder injury (6 months), SICK scapula type III, Scapular winging due to any neurological involvement, any musculoskeletal conditions affecting shoulder function, any behaviorally disturbed or other psychiatric problems, visual disturbances, cardiovascular insufficiency. The participants were assessed for SICK scapula using the following steps: Participants were assessed for Scapular retraction test, Scapular assistance test, Scapular malposition: The participants were observed posteriorly and side to side comparison was assessed via palpation, Infero-medial prominence: Was screened by observation,

Corocoid malposition: Was assessed using palpatory method and correlated with pectoralis minor tightness later, Scapular dyskinesia: Was screened and measured using Lateral

Scapular Side Test (LSST). Pre-test and post test performance were assessed using FTPI (Functional Throwing Performance Index), CKQUEST (Closed Kinematic Chain Upper Extremity Stability Test), LSST (Lateral Scapular Slide Test), pectoralis minor length were measured, and shoulder ROM (rotations) were assessed and recorded on 1<sup>st</sup> day and after 3 weeks of intervention. The participants received open kinematic chain exercises as the rehabilitation protocol. Prior to the rehabilitation the participants performed their routine warm up exercise for 20 minutes and cool down for 10 minutes end of session. The total time duration of the intervention lasted for 60 minutes for each individual along with warm up and cool down periods.

#### **OUTCOME MEASURES:**

**LSST:** Tape (Carpenter's Tape-GK FML) was used to measure the scapular distance. 3 positions were measured with the LSST designed by Kibler was used to assess the scapular asymmetry under varying loads. To maintain a consistent posture during the various test positions, participants were instructed to fix their eyes on an object in the examination area. First test position, the participant was instructed to keep the arms relaxed at his/her sides, the most inferior aspect of the inferior angle of the scapula and the closest spinous process in the same horizontal plane was identified through palpation and marked. The distance between the 2 reference points was measured bilaterally with the help of a tape measure. This procedure was repeated for test position 2 (participant actively placed both hands on the ipsilateral hips, and consequently the humerus was positioned in medial rotation at -45° of abduction in the coronal plane) and test position 3 (the participant was instructed to maintain thumbs down position).

**Range of Motion (ROM):** Was assessed using a 180° universal goniometer (JST Tools). External and internal rotation active range of shoulder was measured.

**FTPI:** Participants performed a 5 minute warm-

up running on a treadmill. The participant was made to stand 15 feet from a 1 foot by 1 foot square target 4 feet high on the wall from the floor. The participant was instructed to throw a 21cms rubber ball within the target square as many times as possible within a 30second time period. The participant threw with a natural overhand throwing motion using their dominant arm. The participant threw the ball under control as fast and accurately as possible catching the thrown ball's rebound.<sup>3</sup> maximal 30 second tests were performed, throwing the ball as many times as possible. A one minute rest period was allowed between each test. An accurate throw was one that lands within the target square, not on the line. The total number of throws as well as the total number of accurate throws produced that percentage score. The average percentage score from the three trials was calculated.

**CKQUEST:** Participant assumed a push-up position with their hands placed 36 inches apart tape, and their body in a straight and parallel to the ground as possible, with shoulders directly over hands. Participants performed a 15 second sub maximal test. Participants were instructed to place their hands on each strip of tape. When the go command was given the participant removed one hand from the floor and touched the opposite tape line and then replaced their hand to the original line. The participant were given 45 seconds rest before performing maximal testing. Participants performed 3 maximal tests. Participants were instructed to perform as many touches as possible in the 15 second time allowed. Participants were given 45 seconds rest between each maximal test performed. Touches were defined as when the hand crossed over and touched the opposite line. The results of the 3 maximal tests were averaged together and recorded becoming the subject's test score. The numbers of touches were counted for each subject. The numbers of touches were divided by the patient's height, normalizing that data to each subject.

**Pectoralis Minor Length:** The participant was positioned in supine lying on a standard on the examining table, with arms at the sides, elbows extended, palms upward, knees bent and lower back flat on the table. The therapist stood at the head end of the table and observed the position

of the shoulder girdle. The tightness was measured by the extent to which the shoulder was raised from the table and the amount of resistance to downward pressure on the shoulder. The distance between the examining table and acromion process was measured accordingly and recorded pre and post test.

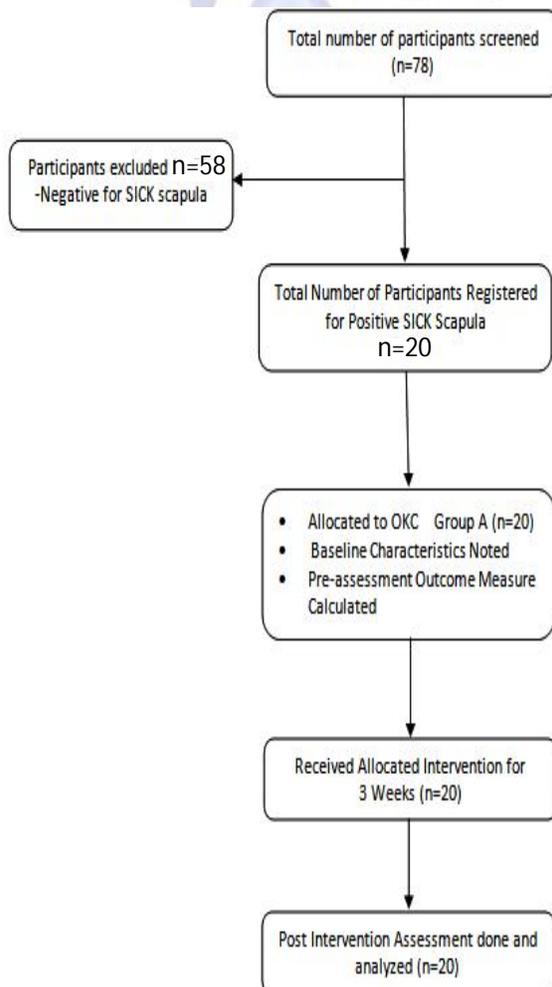
**INTERVENTION:**

Before the intervention all the participants performed 20 minutes of warm and 10 minutes of cool down. The intervention of each group was as follows:

Open kinematic chain exercises- Blackburn exercises (Photograph No.1), Dynamic hug (Photograph No.2), W exercise (Photograph No.3), lunges with dumbbells-forward, upward and diagonal (Photograph No.4), Pectoralis minor stretching (Photograph No.5).

(Theraband progression from red to green, Hygenic Corporation, VPK. And dumbbells 2kgs). The intervention is explained in Fig. No.1

**Fig. 1: Study Flowchart.**



**Photograph No 1: Blackburn Exercise-A**



**Photograph No 1: Blackburn Exercise-B**



**Photograph No 1: Blackburn Exercise-C**



**Photograph No 1: Blackburn Exercise-D**



**Photograph No 1: Blackburn Exercise-E**



**Photograph No 1:** Blackburn Exercise-F



**Photograph No.2:** Lunge Starting Position



**Photograph No.2:** Lunge: Forward



**Photograph No.2:** Lunge: Upward



**Photograph No.2:** Lunge: Diagonal



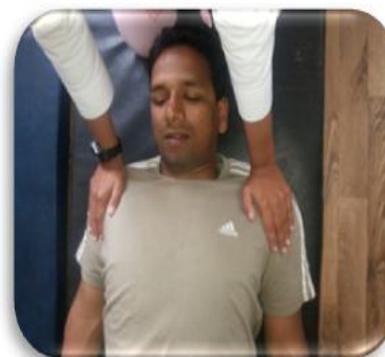
**Photograph No.3:** Dynamic Hug



**Photograph No.4:** W Exercise



**Photograph No.5:** Pectoralis Stretching



## RESULTS AND TABLES

Statistical analysis for the present study was done manually as well as using SPSS version 18 so as to verify the results obtained. Various statistical measures such as mean, standard deviation, and test of significance such as unpaired t –test were used. Probability values <0.05 were considered statistically significant <0.001 were considered highly significant.

### Demographic Profile:

Gender distribution is explained in Table 1.

**Table 1:** Distribution of male and female.

Gender	Total No.	%
Male	15	75
Female	5	25

Age of the participants in the study was between 18 to 30 years. The mean values are explained in Table2.

**Table 2:** Showing Age, BMI.

	Age (Years)	BMI
	MEAN± SD	MEAN±SD
	23.30±2.56	22.98±2.56
<b>p VALUE</b>	0.2	0.6

On comparing the age, body weight, body height and BMI by unpaired t test showed no significance difference between groups.

**Outcome Measures: (Table 3)**

**Range of Motion:** The mean external rotation ROM pre intervention was 109.65±9.14, post intervention 109.65±9.14. The p value by unpaired t test was not significant (p=0.98)

**FTPI:** The mean FTPI pre intervention was 44.04±9.71, whereas intervention after was 51.19±9.42. The p value by unpaired t test was significant (p<0.05).

**CKCUEST:** The mean CKCUEST pre intervention was 21.62±3.92, post intervention was 25.84±4.87. The p value by unpaired t test was significant (p<0.05).

**LSST:** The mean LSST test pre intervention was 1.05±0.35, post intervention was 0.88±0.22. The p value by unpaired t test was significant (p<0.05).

**Pectoralis muscle length:** The mean Pectoralis muscle length test pre intervention was 10.75±1.48, post intervention was 10.53±1.09. The p value by unpaired t test was not significant (p>0.05).

**Table 3:** Outcome measures (ROM, FTPI, CKCUEST, LSST, and Pectoralis Muscle Length).

Outcome measure	Pre intervention (Day1)	Post intervention (3weeks)	p value
Ext. Rot ROM	109.65±9.14	109.65±9.14	>0.001
Int. Rot ROM	61.65±1.53	68.95±1.00	<0.001
FTPI	44.04±9.71	51.19±8.42	<0.001
CKCUEST	21.62±3.97	25.84±4.87	<0.001
LSST	1.05±0.35	0.88±0.22	<0.001
Pectoralis muscle length	10.75±1.48	10.53±1.09	>0.001

**DISCUSSION**

The hypothesis of the present study the effect of open kinematic chain exercises for competitive overhead athletes with SICK scapula. The present study showed improvement in various parameters assessed and compared to their baseline values in terms of ROM, LSST, pectoralis minor length, FTPI and Davies closed kinetic upper extremity test pre treatment and after 3 weeks of training.

Sakiko Oyama, Joseph B. Meyers et al (2008) conducted a study on 43 players, including 15

baseball pitchers, 15 volleyball players and 13 tennis players quantified the differences in resting scapular posture between dominant and non dominant side scapula and concluded, the dominant scapula of the overhead athletes are more internally rotated and anteriorly tilted than the non dominant scapula. The dominant side of scapula in tennis players was more protracted than that of the non dominant side. The results also emphasized on the importance of baseline evaluation in this population order to accurately assess pathologic change in bilateral scapular positions and orientations after injury. Baseline evaluation of the scapula for its optimum position was taken into considered in the present study and is in conjunction with the above quoted study.<sup>14</sup>

The present study also showed pectoralis minor tightness which was measured by method explained by Kendall and by an experimental study by Nijs J, Roussel N et al (2013). The tightness of pectoralis minor muscle was due to the tightness of the posterior structures of the shoulder joint and the scapular stabilizers muscle imbalances. The present study was in consensus with the study conducted by Nijs et al. All the participants in the study had pectoralis muscle length affection which improved after 3 weeks of pectoralis muscle stretching as the length was maintained to the optimal when compared to non dominant shoulder.<sup>15</sup>

A possible causative mechanism of the altered glenohumeral mechanics is acquired glenohumeral internal rotation deficit (GIRD). This deficit is created by progressive contracture of the posterior glenohumeral capsule and decreased static and dynamic flexibility of the posterior shoulder muscles. The lack of range of motion was seen while examining the athletes muscle strength. A proper balance between the agonists and antagonists muscles is thought to provide dynamic stabilization of the shoulder. The present study, the overhead athletes exhibited increased glenohumeral external rotation increased compared to non-dominant shoulder and glenohumeral internal rotation deficit (GIRD) of the dominant shoulder and is in conjunction with the study conducted by Wilk et al (1992). After the 3 weeks of training the Internal rotation ROM showed improvement in

both the groups. Wilk et al (1992) also commented on glenohumeral range of motion, showed that pitchers exhibited an average of 13.6 degrees, plus or minus 14.7 degrees of external rotation and 40.1 degrees, plus or minus 9.6 degrees of internal rotation. There was also a variation from throwing and non-throwing shoulder exhibited 9 degrees more external rotation and 8.5 degrees more internal rotation as compared to the non-throwing shoulder.<sup>16</sup>

In the present study proper stretching was given as a part of the intervention to improve the pectoralis muscle length. As muscle length is required for proper functioning of the muscle. A possible reason for improvement in the length is stretching held for 30 seconds have shown that the stretch force gets transmitted to the muscle fibers via connective tissue in and around the fibers. It is hypothesized that molecular interactions link the non contractile unit of the muscle, the sarcomere. The lengthening occurs in the series elastic component, that leads to mechanical disruption which are influenced by neural and biochemical changes of the cross bridges as the filaments slide apart, leading to abrupt lengthening. So the stretching given to the tight pectoralis minor muscle in the present study showed improvement and thereby improving the ROM of shoulder.<sup>17</sup>

The present study is in consensus with study conducted by Pauda et al (2006) as there was improvement in throwing accuracy (FTPI) and CKCUEST, the strength improved in the group which received open kinematic chain exercises. The possible reason for improvement is open kinematic chain exercises is an effective way of improving shoulder-rotation strength by improving joint-position awareness.<sup>18</sup>

Tucker WS, Armstrong CW, Gribble PA et al studies the effect of 3 different types of closed chain exercises standard pushups, cuff link exercises and push up on Bosu found better activation of serratus anterior and trapezius muscle of athletes with shoulder impingement and scapular dyskinesia and improved throwing performance.<sup>19</sup>

Padua et al (2004) created a prospective study using OKC, CKC, and PNF exercises to determine the outcomes of these techniques performed at the shoulder on strength, active angle reproduc-

tion, sway velocity, and functional performance. The present study the rehabilitation protocol was for 3 weeks with either open kinematic chain exercises for asymptomatic overhead athletes with SICK scapula and found positive results in the throwing accuracy, strength, muscle length, ROM and reduction in the scapular malposition which is in agreement with the above study. The other difference was the duration was for 3 weeks and no PNF exercises were given, so the study is in close resemble with the study conducted by Pauda et al. and the improvement was due the closed and open kinematic chain exercises with proper stretching of the tight pectoralis minor muscle and stabilizing the scapula for efficient biomechanics and correct execution of the force couples of the shoulder joint and efficient recruitment of the muscle for throwing and preventing the progression of the SICK scapula in the asymptomatic stage itself and improving the functioning of the shoulder and sports performance.<sup>18</sup>

The findings need to be considered in light of limitations of the present study. Resistance of theraband should have been individualized. The participants were belonging to various sports and not single sports background.

The future scope of the study could be a prospective study can be taken up to evaluate the long term effects of the specified study. As the study did not take into consideration the functional aspect of sports future studies can be researched by using functional outcome measures on performance of the sport. Studies examining other components of the kinetic chain will provide further descriptions of athletes involved in overhead sports. Athletes of similar sports can be assessed for generalizing the prevalence of SICK scapula and future intervention protocol can be formulated.

## CONCLUSION

The present study concludes open kinematic chain exercises are equally helpful in treating and preventing the further progression of SICK scapula by correcting the scapular malposition and improving the athletic performance. The study gives insights of proper evaluation of the dominant shoulder and scapula malposition during the course of the athletic career and

importance of treating the muscle imbalance and correcting the component of the kinetic chain for better performance and reducing the shoulder from overuse injuries.

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**Conflicts of interest:** None

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