Comparative study between Open Kinematic Chain exercise vs. Close Kinematic Chain exercise in Scapular Dyskinesia

Rani Shethiya¹, Anagha Kadam², Shweta Aswale³

¹Intern, Department of Physiotherapy Dr. D.Y.Patil College Of Physiotherapy, Pimpri, Pune 411018, Maharashtra, India
²Intern, Department of Physiotherapy Dr. D.Y.Patil College Of Physiotherapy, Pimpri, Pune 411018, Maharashtra, India
³Intern, Department of Physiotherapy Dr. D.Y. Patil College Of Physiotherapy, Pimpri, Pune 411018, Maharashtra, India

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Abstract

Shoulder joint is the most complex joint of the body. Scapula plays several roles in facilitating optimal shoulder complex function when scapulohumeral anatomy and biomechanics interact to produce efficient movement. The scapula provides a stable base from which glenohumeral mobility occurs. Stability of scapulothoracic joint depends on coordinated activity of the surrounding musculature. Scapular muscle actions allow proper positioning and stability of scapula while maintaining the glenohumeral center of rotation throughout arm motion. Muscular imbalances in scapular force couples may result in scapular dyskinesia, abnormal glenohumeral translation or rotator cuff overload. Dysfunction or weakness of scapular stabilizers often results in altered biomechanics of shoulder girdle. The altered biomechanics can result in abnormal stresses to anterior capsular structures, increased possibility of rotator cuff compression and decreased performance. Close kinetic chain exercise promotes co contraction of rotator cuff musculature at sub maximal levels. Based on the previous literatures, there has not been any study that has compared effect of open and close kinematics chain exercises in patients with scapular dyskinesia. Most of the studies were taken on overhead athletes and there is very limited research on general population or nonathletic with scapular dyskinesia. An experimental study was performed in Dr. D.Y. Patil OPD. The study included 40 subjects between age group of 18-30 years and was randomly assign into 2 groups of 20 in each group by chit method. Group A was given close kinematic chain exercise whereas group B was given open kinematic chain exercise everyday for a week. The study concluded that close kinematic chain exercise showed significant difference than open kinematic chain exercise in the patient with scapular dyskinesia.

Keywords: Close kinematic Chain exercise, Open Kinematic Chain exercise, Scapular Dyskinesia, Thera Band, VAS.
Introduction:

Shoulder joint is the most complex joint of the body. Scapula plays several roles in facilitating optimal shoulder complex function when scapulohumeral anatomy and biomechanics interact to produce efficient movement. The scapula provides a stable base from which glenohumeral mobility occurs. Stability of scapulohumeral joint depends on coordinated activity of the surrounding musculature. The scapular muscles must dynamically position the glenoid so that efficient glenohumeral movement can occur. When weakness or dysfunction of scapula musculature is present, normal scapular positioning and mechanics may become altered (1). The scapula is only attached to the thorax by ligamentous attachments at acromioclavicular joint and through a suction mechanism provided by the muscular attachment of serratus anterior and subscapularis. This suction mechanism hold scapula in close proximity to the thorax and allow to glide during movements of the joint. Serratus anterior contributes to all components of 3D scapular movements during arm elevation, which includes upward rotation, posterior tilt, and external rotation (1). The overhead throwing motion is an extremely skillful and intricate movement. The appropriate functional scapular motion of upward rotation, posterior tilt, and external rotation increase width of subcromial space during humeral elevation, whereas a lack of proper scapular function, so called scapular dyskinesia, increase the translation of humeral and alters scapular position and motion in both static and dynamic applications (2).

Scapular dyskinesia is defined as an observable alteration in position of the scapula and the pattern of scapular motion in relation to the thoracic cage during static or dynamic movement of scapula. Kibler et al classified scapular dyskinesia in three dysfunctional patterns form observing dynamics of the scapular dyskinesia combined with the rest position of scapula. Type I characterized, at rest, by the winning of the inferior medial scapular border and during arm elevation. Type II is characterized by the projection of the entire medial border of scapula at rest and in motion. Type III is characterized by excessive superior translation, with elevation and some anterior displacement of superior border of scapula on the thorax. A symmetrical pattern and the normal scapular thoracic rhythm is classified as type IV. Scapular dyskinesia has been associated with various conditions such as shoulder injury, instability, rotator cuff tears and impingement syndrome (3). The trapezius and serratus anterior are the most important muscles in scapular kinesis, and they are coupled, resulting in upward rotation of scapula during the elevation of arm above the head. These muscles are contributed to the movement and stabilization of scapula when performing overhead work. However, some people with serratus anterior activity is diminished and upper trapezius activity is excessive during arm elevation. The scapular dysfunction that can cause secondary impingement is due to excessive activity of the upper trapezius to compensate for the lack of serratus anterior activity. Proper function of the glenohumeral joint requires a balanced activity of scapular stabilizing muscles to allow the scapula to move on the posterolateral surface of thoracic cage (scapulohumeral rhythm) (4). Abnormal scapular motion link to global weakness of the scapulothoracic muscles; others attribute scapular dyskinesia to scapular muscular imbalance rather than absolute strength deficits. In particular, excess activation of upper trapezius, combined with decreased control of lower trapezius and serratus anterior, has been proposed as contributing to abnormal scapular motion. Forward flexion in side lying, side lying external rotation, horizontal abduction with external rotation, prone extension this open chain kinematics exercise to restore intramuscular trapezius muscle balance (5). Scapular muscle actions allow proper positioning and stability of
Scapula while maintaining the glenohumeral center of rotation throughout arm motion. Muscular imbalances in scapular force couples may result in scapular dyskinesia, abnormal glenohumeral translation or rotator cuff overload. Dysfunction or weakness of scapular stabilizers often results in altered biomechanics of shoulder girdle. The altered biomechanics can result in abnormal stresses to anterior capsular structures, increased possibility of rotator cuff compression and decreased performance. SICK scapular may result in ineffective energy transfer, placing added stress on the tissues around the shoulder which must compensate for weak link in the chain (6).

Close kinetic chain exercise promotes co contraction of rotator cuff musculature at sub maximal levels. Applying axial compression through the glenohumeral joint as in closed chain exercise, decreases glenohumeral translation at various levels of elevation. Kinetic chain shoulder rehabilitation exercise use functional movement patterns to facilitate scapular motion and then to strengthen scapular musculature. In kinetic chain shoulder rehabilitation, closed kinetic chain exercise is exercise in which the hand is relatively fixed. An example of this is the scapular clock exercise; in which perform scapular elevation, depression, protraction, and retraction with hand fixed on stable surface at a safe degree of elevation. Proper posture and proximal stability are important for those exercises. The posture should be with feet shoulder width apart, weight evenly distributed, slight hip and knee flexion, back straight and hand up. A goal of these exercises is to fully integrate the strengthening of the scapular, rotator cuff musculature with day to day dynamic overhead specific movement patterns (7). Scapular stabilization prescription should begin with isometrics or closed chain exercise. Closed chain scapular exercise may be initiated early in rehabilitation, allowing for the protection of healing tendons. Open chain exercise can increase the endurance capacity of selected muscles (8).

Scapular dyskinesis was found to be present in 61% of overhead athletes and 33% of non overhead athletes. Scapular muscle exercises are included in the rehabilitation of patients with scapular dyskinesia because the muscular system is one of the major contributors of scapular positioning both at rest and during shoulder movement (9).

With respect to scapular orientation in resting position, it has also been demonstrated that individuals with neck pain may display altered postural behavior, especially when performing prolonged sitting task, such as during computer use. The physical conditioning requirements are not homogeneous: the demands on cervical and axioscapular muscle function in an elite overhead athlete will be different from those of a storeman lifting heavy boxes repetitively above chest level or from those required by an office worker working daily on a computer. It is increasingly apparent that scapular dyskinesia exists in healthy population as well (10).

Need of study:
Scapular dyskinesia has been area of limited research. Proper function of the glenohumeral joint requires a balanced activity of scapular stabilizing muscles to allow the scapula to move on the posterolateral surface of thoracic cage (scapulohumeral rhythm). Based on the previous literatures, there has not been any study that has compared effect of open and close kinematics chain exercises in patients with scapular dyskinesia. Most of the studies were taken on overhead athletes and there is very limited research on general population or nonathletic with scapular dyskinesia. Hence the study was under taken with an intension to find out the effectiveness in between open and close kinematics chain exercise in scapular dyskinesia.
Aim and objectives:

AIM: To compare the effectiveness of open and close kinematic chain exercises in general population with scapular dyskinesia.

Objectives:
1. To find out the effect of open kinematic chain exercise in general population with scapular dyskinesia.
2. To find out the effect of close kinematic chain exercises in general population with scapular dyskinesia.
3. To find out the comparison between open and close kinematic chain exercise in general population with scapular dyskinesia.

Materials and methodology:
An experimental study with purposive sampling was conducted on 40 patients with scapular dyskinesia, of age group 18-30 years, both genders. A written consent was taken prior giving any treatment, patients with any shoulder fractures, cervical pain radiating to arm, history of shoulder injury, musculoskeletal conditions affecting shoulder function, cardiovascular insufficiency were excluded from the study. A participant was assessed for scapular dyskinesia using lateral scapular slide test. Pre and post test performance was assessed using LSST and VAS was measured on 1st day and after 1 week of intervention. Materials required were theraband and inch tape.

Procedure:
Study commenced after ethical approval from college authorities. The following study included 40 subjects between age group of 18-30 years and was randomly assign into 2 groups of 20 in each group by chit method. All subjects were given an informed written consent form. Participants were included according to the fulfillment of inclusion and exclusion criteria. Group A was treated with close kinematic chain exercise and Group B was treated with open kinematic chain exercise. The physiotherapy programmed was conducted 1 time a day for 1 week.

Group a: In Group A, close kinematic chain exercise would be given to the patient. The technique was given for 40 min session for a week.

Group b: In Group B, open kinematic chain exercise would be given to the patient. The technique was given for 40 min session for a week

A participant was assessed for scapular dyskinesia using lateral scapular slide test. A participant was observed posteriorly.

Pre and post test performance was assessed using LSST and VAS was measured on 1st day and after 1 week of intervention.

Lateral scapular slide test:

1. Inferior – medial angle of scapula is palpated and marked on both sides.
2. The reference point on the spine is nearest spinous process, which is marked.
3. Distance is measured on both the sides in three different positions.
   A. At resting position
   B. With hands on hips, with fingers anterior and thumb posterior
   C. With the arms at 90 degrees with internal rotation.
A 1.5 cm asymmetry is the threshold for abnormality.

**Group A:**
Close kinematic chain exercise
Wall scapular push ups
5 days per week
1. Place your hands on a wall at shoulder height, tucking your chin slightly.
2. Widen your rib cage as you protract the scapula - your body should move away from the wall.
3. Hold for 1-2 seconds.
4. Retract the scapula, moving your body slightly toward the wall and hold for 1-2 seconds.
5. Move slowly and maintain control throughout the range of movement, moving only at the scapula.
6. Complete 12 reps of 2 sets

**Group B**
Open kinematic chain exercise
Horizontal band fly
5 day per week
1. Grab resistance band with both hands.
2. Loop the band up and over your head so that strap is lying across your upper back.
3. Extend both arms out to the sides, keeping arms slightly below shoulder level.
4. Keeping arms extended, bring them in so they are reaching straight out in front.
5. Protract the scapula to drive the band forward slightly.
6. Hold for 3 seconds, then adduct arms back out to side.
7. Retract your scapula and hold at the end of range of motion for 3 seconds.
8. Complete 12 reps of 2 sets.

Data analysis and interpretation

The data was analyzed using “Primer” statistical package software. 40 participants of general population with scapular dyskinesia were included in the study.

The data was entered into excel spreadsheet, tabulated and subjected to statistical analysis.

Statistical measures such as Mean, Standard deviation (SD), Test of significant such as paired test were used to analyze the data.

Result were concluded to be statistically significant with p<0.005.
As the data, Paired t test was used to compare the difference of scores on pre and post intervention within and between groups.

Table 1: Gender distribution

<table>
<thead>
<tr>
<th>Gender</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
</tr>
</tbody>
</table>

Graph 1: Number of males and females
Interpretation: Table 1 and Graph 1 shows number of males and females in the study. 29 individuals in the population were observed to be females whereas only 11 males found in the study population.

Table 2: Mean value of LSST pre and post measurements of Group A

<table>
<thead>
<tr>
<th>LSST</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>1.7</td>
<td>0.36</td>
</tr>
<tr>
<td>Post</td>
<td>0.72</td>
<td>0.29</td>
</tr>
</tbody>
</table>

T value: 12.75, P value <0.000

Graph 2: Analysis of lateral scapular slide test (per and post test analysis)
Interpretation: Table 2 and graph 2 shows pre and post LLST of the study population. The PRE mean of LSST was 1.7 which is changed to 0.72 in post. The standard deviation for pre LSST was 0.36 while that for post LSST 0.29. The data was statically analyzed using the paired t test which gave t value 12.751 and p value P<0.000. Table 3 and graph 3 shows statistical improvement in post treatment LSST measurement. Thus, the study is statically highly significant.

Table 3: Mean value of VAS pre and post treatment of group A

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>5.4</td>
<td>0.94</td>
</tr>
<tr>
<td>Post</td>
<td>2.8</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Graph 3: Analysis of VAS (pre and post treatment analysis)
Interpretation: Table 3 and graph 3 shows pre and post VAS of the study population. The PRE mean of VAS was 5.4 which is changed to 2.8 in post. The standard deviation for pre VAS was 0.94 while that for post LSST 0.74. The data was statically analyzed using the paired t test which gave t value 12.365 and p value P<0.000. Table 3 and graph 3 shows statistical improvement in post treatment VAS. Thus, the study is statically highly significant.

Table 4: Mean value of pre and post LSST of group B

<table>
<thead>
<tr>
<th>LSST</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>1.6</td>
<td>0.22</td>
</tr>
<tr>
<td>Post</td>
<td>0.93</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Graph 4: Analysis of pre and post treatment in LSST within group A
Interpretation: Table 4 and graph 4 shows pre and post LLST of the study population. The PRE mean of LSST was 1.6 which is changed to 0.22 in post. The standard deviation for pre LLST was 0.22 while that for post LSST 0.22. The data was statically analyzed using the paired t test which gave t value 11.53 and p value P<0.000. Table 4 and graph 4 shows statistical improvement in post treatment LSST measurement. Thus, the study is statically highly significant.

Table 5: Mean value of VAS pre and post of group B

<table>
<thead>
<tr>
<th>VAS</th>
<th>Pre</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5.2</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>2.7</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Graph 5: Analysis of VAS post treatment of group A and B
Interpretation: - Table 5 and graph 5 shows post VAS of group A and B the study population. The PRE mean of VAS was 5.7 which is changed to 2.7 in post. The standard deviation for pre VAS was 0.1.01 while that for post VAS 0.91. The data was statically analyzed using the paired t test which gave t value 18.42 and p value P<0.001. Table 5 and graph 5 shows statistical improvement in post VAS. Thus, the study is statically highly significant.

Table 6: Mean value of LSST between Group A and B

<table>
<thead>
<tr>
<th>LSST</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Post</td>
<td>0.72</td>
<td>0.93</td>
</tr>
<tr>
<td>Group B Post</td>
<td>0.93</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Graph 6: - Post treatment comparison in group A and B
Interpretation: - Table 6 and graph 6 shows post LSST in Group A and B of the study population. The Post mean of group A was 0.72 and group B was 0.93. The standard deviation for group A post LSST was 0.93 and group B post LSST was 0.22. The data was statically analyzed using the paired t test which gave t value -2.77 and p value P<0.012. Table 6 and graph 6 shows statistical improvement of post LSST in group A. Thus, the study is statically highly significant.

Table 7: Post Mean Value of VAS between Group A and B

<table>
<thead>
<tr>
<th>VAS</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A post</td>
<td>2.8</td>
<td>0.74</td>
</tr>
<tr>
<td>Group B post</td>
<td>2.7</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Graph 7: Post treatment comparison of VAS
**Interpretation:** Table 7 and graph 7 show post VAS in Group A and B of the study population. The Post mean of group A was 2.85 and group B was 2.75. The standard deviation for group Post VAS was 0.74 and group B post VAS was 0.91. The data was statically analyzed using the paired t test which gave t value 0.309 and p value P<0.761. Table 7 and graph 7 shows statistically not significant.

**Discussion**

The objective of this study was to find out effect close vs. open kinematic chain exercise in general population with scapular dyskinesia. Scapular dyskinesia is alteration in the position of the scapular and patterns of scapula motion in relation to thoracic cage. A change in scapular position and motion influence the lengths of muscles attached to the scapula. Scapular dyskinesia can occur in pain free individuals. The serratus anterior originates from the lateral aspects of upper eight ribs and inserts on the anteromedial border and inferior angle of scapula, positioning scapula close against the thorax and stabilizing the scapula, which prevents the medial border and inferior angle from projecting posteriorly.

In this study, there were 40 participants who were screened for lateral scapular slide test and Visual analog scale. Quantitative measurement was taken with the help of this test. Lateral scapular slide test evaluated three in three position and non-injured sides in relation to fixed point on spine.

There are 3 components which make usage of closed kinetic chain exercise advantageous in early rehabilitation. First, the exercise environment can be controlled. This allow the focus to be taken away from the arm as an integrated unit with high dynamic demands and place it in a stable, axially loaded and static setting. Secondly, closed chain exercise are ideal for working at specific ranges of motion which help to provide a snapshot within full arc of normal motion and finally, closed chain exercises allow the rotator cuff and scapular musculature to be unloaded by decreasing the amount of force generated and stress applied to the involved soft tissue. (3) Close kinetic chain exercise requires weight bearing position of extremity by fixing the terminal
segment meets some considerable external resistance that prohibits or restrains its free motion. Close kinetic chain exercise often involves multijoint movement and weight bearing conditions that affect the biomechanical and neuromuscular demands of the body. \(^{(10)}\)

A significant amount of agonist-antagonist muscular co-contraction exists around joints in addition to increase compressive force during Close kinetic chain exercise performance. Close kinetic chain exercise movements are consider to be one of the commonly performed exercise for upper limb, using ground and wall or device such as ropes, slings, aiming at addressing shoulder stability and improving joint position sense. Close kinetic chain exercise movement results in more symmetrical scapular motion, especially to 90 degree of shoulder elevation, which requires more muscular support to maintain shoulder stability and mobility. Dilmaet. Al. suggests that Close kinetic chain exercise exercise may establish early proximal stability of joint providing stable base for upper limb to function. \(^{(11)}\)

CKC movement tested in this study Hardwick et, al (2006) showed increased serratus anterior muscle activation during close kinetic wall exercise. Axial loading may result in changes in force couple activation and may lead to alteration in scapular kinematics and symmetry. Patients who have painful active shoulder motion may benefit from Close kinetic chain exercise because obtained changes in kinematics and more symmetrical scapular movements. \(^{(12)}\)

Serratus anterior muscle plays an important role in stabilizing the shoulder joint and scapula in complement to upper trapezius muscle while fixing inner side of the scapular and lower angle to the thorax in upper limb movements. Close kinetic chain exercise has the advantage of simultaneously increase proprioceptive stimulation and stability due to intra articular compression. Prianaet. Al. (2014) reported result on advantages of close kinetic chain exercise motion for selective muscle activation of serratus anterior. This suggest that close kinetic chain exercise is more affective exercise control and neuromuscular control of serratus anterior and upper trapezius then open kinetic chain exercise and may also help the stability of shoulder joint and scapula. \(^{(13)}\)

Soft tissue inflexibility, tightness of pectoral minor and posterior glenohumeral capsule stiffness has result in to abnormal scapular position. The resistance of front wall push up activates the serratus anterior and middle and lower trapezius muscles. Wall scapular pushups is close kinematic exercise produces compression force that corrects the abnormal scapular position. Scapular dynamic stability has primarily been investigated in association with shoulder pathologies where reduced clavicle retractions, scapular upward rotation, scapular posterior tilt and increased clavicle elevation has been reported. These changes in scapular kinematics can be attributed not only to altered scapular recruitment patterns (e.g., altered serratus anterior serratus anterior muscle activity) or muscle performance, but also flexibility deficits in the soft tissue surrounding the scapula may restrict normal scapular movement during daily activity.

**Conclusion:**

In this study there is evidence of scapular kinematic alteration associated with weakness of muscles and pain. The findings suggest that scapular protraction with shoulder 90 degree flexion at the closed kinematic chain exercise is more effective in increasing serratus anterior muscle activation and decreasing upper trapezius muscle activation. The close kinematic chain exercise
showed significant difference than open kinematic chain exercise in the patient with scapular dyskinesia.

**Limitation**

1. Sample size was small.
2. Rehabilitation period was short.

**Future scope**

Study can be carried out in a larger population for more accurate results.
Study can be carried out for longer period of time.
Study can be carried out use of EMG for exact muscle activity.
Study can be obtained function test post treatment.

**Reference:**

12. AfsunNodehiMohgadam, BS, MSc, PhD; at al. JMIR Res protocols 2017;6(12):e240