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"Effect of proprioceptive neuromuscular facilitation vs closed kinetic chain training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis: A randomized controlled trial"

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Keywords

Scapular dyskinesis,
Asymptomatic adults,
Scapular muscles imbalance,
Strength deficit,
Flexibility,
Scapular position

Abstract

Background: Scapular dyskinesisis an alteration or deviation in the normal resting or active position of the scapula during shoulder movement. The strength deficits or muscular imbalance of scapular muscles lead to disoriented scapular movement, which may contribute to future shoulder injuries. Aim of the present study was to compare the effect of proprioceptive neuromuscular facilitation technique vs closed kinetic chain exercise training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.

Methodology: In present study, 63 asymptomatic adults with scapular dyskinesis were selected based on the selection criteria and were then randomly allocated into three groups i.e. experimental group (group A and B) and control group (group C) with 21 in each group. Intervention was given for five days in a week for four weeks. Post intervention means were compared by one way ANOVA test at 5% level of significance.

Result: Results showed that there was statistically significant difference in mean Strength of muscles, Flexibility of pectoralis minor and scapular position in both experimental groups during four-week intervention period($p<0.05$). Between group comparison results showed that there was statistically significant difference between groups in mean difference of strength and scapular position.

Conclusion: Both the treatment approaches are effective in improving strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis. However, the participants who received closed kinetic chain exercise training had significantly higher improvement than the PNF

Introduction

Scapular dyskinesis (SD) is defined as visible alterations in scapular positions & motion patterns & is believed to occur as a result of changes in activation of scapular stabilizing muscles.[1] Scapular dyskinesis, may adversely affect overhead function.[2] Dyskinesis by itself is not an injury or a musculoskeletal diagnosis. Scapular dyskinesisis a condition that is frequently observed clinically but not often understood.

Dyskinesis can be identified by alterations in a single plane or across multiple planes. Alterations include: prominence of the inferior angle, medial border prominence (winging), and dysrhythmia. Prominence of the inferior angle is indicative of excessive anterior tipping of the scapular and may be a result of tightness/dominance of the pectoralis minor and weakness of the Serratus anterior. Medial border prominence (winging), is indicative of excessive protraction of the scapula, and may be a result of tightness of the pectoralis minor and weakness of the retractors which include the middle trapezius and rhomboid muscle group. Dysrhythmia indicates a more general lack of dynamic control of the scapula and is visible with early shrugging during humeral elevation and/or rapid downward rotation during humeral lowering.[3]

The commonest causative mechanisms of dyskinesis have a soft tissue component, involving either intrinsic muscle pathology or inflexibility or inhibition of normal muscle activation. Decreased flexibility of pectoralis minor have been shown to create anterior tilt and protraction of the scapula as a result of their pull on the coracoid.[4]

In a 2020 systematic literature review of clinical trials on scapula dysfunction, Moghadam et al.[5] reported that the main causes of the scapula dyskinesia are muscle weakness and inappropriate movements, increasing the risk of impact and reduction of the scapular muscles strength which leads to future shoulder or scapula related injuries.

The diagnosis of scapular dyskinesis is made typically only by the correct physical exam tests performed by clinician, but is often missed. X-rays and MRI are typically not needed as this is a dynamic process best observed on physical examination.[6]Miachiro NY et al. (2014) found that the clinical observational assessment of the scapulothoracic rhythm was considered appropriate for the diagnosis of dyskinesis.[7] Scapular dyskinesis becomes more apparent with dynamic testing, particularly during the lowering phase of arm movement.

A recent kinematic study using principal component analysis found that both healthy and symptomatic individuals with dyskinesis displayed similar dysrhythmias that were also different when compared to controls.[8] Dyskinesis has been hypothesized to relate to changes in Glenohumeral angulation, Acromioclavicular joint strain, subacromial space dimension, shoulder muscle activation and humeral position and motion. Although it is typically associated with shoulder pain, dyskinesis also can be present in asymptomatic population.[9] Scapular dyskinesis is not associated with pain and does not alter measures of shoulder function in amateur adolescent, but it might occur because of scapular muscle imbalance in asymptomatic adults. It is increasingly apparent that scapular dyskinesis exists in asymptomatic populations as well.[10] Also, postural variations such as forward head, rounded shoulder, excessive thoracic kyphotic posture may also cause the scapular muscle imbalance and that can lead to scapular dyskinesis in asymptomatic adults.

A study done by Divya Khare et al.[11] to study the Prevalence of Scapular Dyskinesiain Gymers and Non Gymers and found that Scapular dyskinesia is present in gymers as well as in non gymers. Another systemic review and meta-analysis done in 2017 found that the presence of scapular dyskinesis in asymptomatic athletes appears to increase the risk of developing shoulder pain by 43% and suggest that this information may be useful as part of the periodic health examination and in the design of injury prevention programmes.[12]

More recent evidence suggests that scapulardyskinesis is a risk factor for shoulder pain that may warrant screening as a preventative measure. Scapuladyskinesis should be evaluated and treated, as part of normal shoulder rehabilitation program, because the untreated condition may exacerbate shoulder symptoms or adversely affect treatment outcomes.

Scapular Dyskines is treatment should focus on strengthening exercises of the stabilizing muscles, to restore flexibility of tightened tissues and to restore the scapular position and dynamics. One study done by RR Desai et al.[13] have given PNF Vs CKC in hospital housekeeping staff with scapular dyskinesis and found reduction in the pain and upper extremity work related musculoskeletal disorders. The authors have only focused on pain and UE work related musculoskeletal disorders. Cigercioglu NB et al.[14] did a study on PNF Training to improve Scapular Muscle Strength and Pectoral is Minor Length in Individuals with Asymptomatic Scapular Dyskines is and found Scapular muscle balance improved following scapular PNF training. But in that study, author had included only PNF without control group and sample size was also too small.

The Closed Kinetic Chain exercises (CKC) involve exercises or movements where the distal aspect of the limb is fixed to a stationary object and the proximal segment is free to move. The CKC exercises of the upper extremity cause the muscles around the scapulatoco-contract in order to achieve normal scapular position and motion thereby reducing the risk of subacromial impingement, increase rotator cuff efficiency and help in preventing further shoulder injuries.[15]

The Proprioceptive Neuromuscular Facilitation (PNF) techniques assist in achieving an optimal state of neurological and musculoskeletal system, and are built on the fact that motor recruitment can be enhanced by appropriately utilizing reflexes and proprioceptive inputs which in turn improve the participants postural responses, movement patterns, strength.[16] The main objective of performing the exercises in PNF pattern is to enhance the functional movement through facilitation, inhibition, strengthening, and relaxation of muscle groups.[17]

However, noprevious study has investigated the effects of scapular PNF exercises and CKC exercises in asymptomatic adults with scapular dyskinesis rehabilitation. Therefore, there was a need to know and compare the effect of PNF Vs CKC on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis. Present study aims to know that which exercise can be better to prevent future shoulder or scapula related injuries which are caused by muscular imbalances. On the basis of this study, we can provide evidence to available literature about the effect of CKC exercise training and PNF training on parameters such as strength, flexibility and scapular position in asymptomatic adults. The present study will provide significant information regarding which exercise is more beneficial to prevent future shoulder related injuries.

Aim and objectives of the study

Aim: To study the effect of proprioceptive neuromuscular facilitation technique vs closed kinetic chain exercise training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.

Objectives:

1. To find out the effect of proprioceptive neuromuscular facilitation technique on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.
2. To find out the effect of closed kinetic chain exercise training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.
3. To compare the effect of proprioceptive neuromuscular facilitation technique vs closed kinetic chain exercise training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.

Methods

Study Design: A Randomized controlled trial

Population: Asymptomatic adults with Scapular dyskinesis

Sampling Technique: Simple random sampling

Study Duration: 1 year

Sample Size: For sample size calculation in this study, the effect size was calculated from the result of the pilot study. The sample size was estimated in G Power 3.1.9.7 version with effect size 0.42 and α=0.05 at 80% power. Sample size calculated was 57, with a drop out chances of 20% the total sample size was n=63. So, 63 participants with scapular dyskinesis were included in this study i.e. 21 in each group.

Study Setting: Asymptomatic adults from different physiotherapy colleges of south Gujarat.

Inclusion Criteria: [13]

- Age group between 18-25 years.
- Participants having Type I, Type II or Type III scapular dyskinesis.
- Participant with unilateral Scapular dyskinesis.
- Both male and female participants were included.
- Those who were willing to participate in the study.

Exclusion Criteria: [13,18]

- Having any pain related to shoulder or scapulothoracic region.
- Any pathology or trauma or surgery of shoulder or scapulothoracic region.
- Any congenital or acquired deformity of shoulder or scapulothoracic region.
- Any cervical or shoulder neurological movement disorder.
- Gymersorath letes who were engaged with any sports/recreational activities.

Outcome Measures:

- ❖ Handheld dynamometer[9,19]- For Strength of scapular muscles
- ❖ Pectoralis minor index (PMI)[20]- For Flexibility
- ❖ Lateral scapular slide test (LSST)[21]- For Scapular position

Procedure

- The ethical approval for the research was taken from the Institutional Ethical Committee.
- Procedure of how participants were included in the study is shown in flow chart. [FIGURE-1]
- Prior to the commencement of the study, detailed procedure of the study was explained to the participants and a signed informed consent form was taken from them.

- Pre-intervention outcome measures were assessed and participants were randomly allocated into three groups using computer generated random numbers.
- Appropriate physiotherapy interventions were given to the participants in all groups and assessment of outcome measures was done after 4 weeks duration. The duration of intervention was for5days per week for 4weeks.
- In Group A(experimental group) participant received PNF training.
- In Group B (experimental group) participant received CKC exercise training.
- In Group C (Control group) participant received scapular mobility exercises.

Procedure of Randomization and blinding

- The assigned list of numbers of those included in experimental and control groups, were written on the paper and wrapped in an aluminum foil. These aluminum foils, were again inserted in an opaque envelope. This opaque envelope had a code written on it and were placed sequentially. The participants then were instructed to pickup any envelope of his or her choice and with respect to the number wrapped in the aluminum foil, they were allotted to the respective group.
- Participants were blinded on either type of intervention and to which group they belonged.
- Throughout the treatment sessions, participants from all three groups were not allowed to have any interaction to each other and the participants were not aware of what kind of treatment they received and its effects.
- Separate trained physiotherapist assessor was assigned to take pre and post outcome.

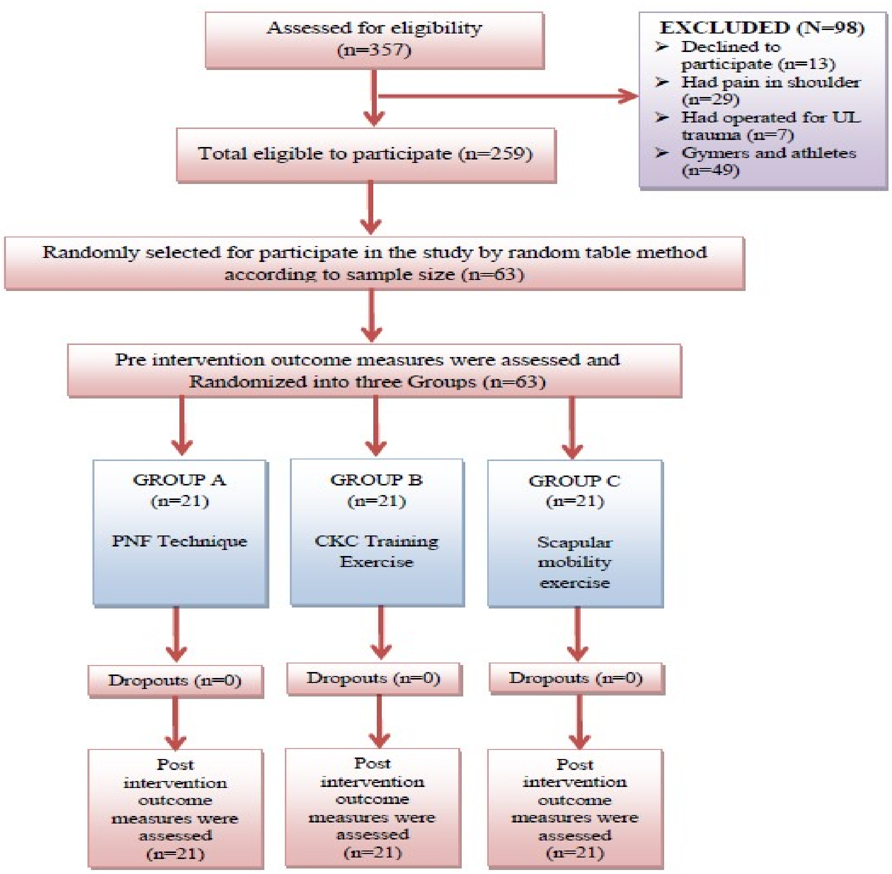


Figure-1 Consort Flow Diagram

Procedure of identifying scapular dyskinesis in a symptomatic adults [22]

- Scapular dyskinesis was assessed by clinical observation of the scapular motion during bilateral overhead arm elevation with part exposed. Privacy and dignity of participants were maintained.
- Arm elevation was performed with 2.5 kg dumbbell for participants with more than 68 kg and 1.5 kg dumbbell for less than 68 kg in scaption position (45° anterior to the frontal plane).
- Participant were allowed for three familiarization trials before test and after that they perform five successful trials for test.
- Participants were asked to simultaneously elevate their arms to a 3-second count using the "thumbs up" position, and then lower to a 3-second count.
- The movement speed was determined by the metronome in a synchronize dmanner.
- Participants were diagnosed with Type I scapular dyskinesis if they had prominence of the inferior medial scapular angle, Type II scapular dyskines is if they had prominence of entire medial scapular border or Type III scapular dyskines is if they had prominence of superomedial border could be observed in 3/5 trials of arm elevation in the scaption plane.

Intervention

➢ For Group A: Proprioceptive neuromuscular facilitation technique[17,23,24]

Scapular PNF exercises was performed in side lying position. Scapular PNF was applied by a trained therapist in two diagonals, anterior elevation and posterior depression and posterior elevation and anterior depression with 20 repetitions. Repeated contractions technique of PNF was used to perform scapular pattern which include the following motion. The rest interval between repetitions was 20 seconds.[25]

1. Anterior Elevation Posterior Depression:

Participant lie on the uninvolved side. Therapist Stand behind the participant, place one hand over superior border of scapula and other on inferior angle of scapula. The participant was instructed to Pushup and pushdown the scapula against the manual resistance given by therapist.

2. Posterior Elevation Anterior Depression:

Participant lie on the unaffected side. Therapist and behind the participant, placing one hand over superior border of scapula and other on inferior angle of scapula. The participant was instructed to Push back and Push front the scapula against the manual resistance given by therapist.

3. Upper extremity PNF pattern was performed in supine position using the slow reversal technique of PNF:

Participant perform shoulder flexion-abduction external rotation movement starting with their arm on the contralateral side of their waist and bringing arm up above the ipsilateral side of the head in supine. Extension adduction internal rotation was performed by the participant starting with their arm above the ipsilateral side of the head and bringing it down toward the contralateral waist.

- The therapist resists the movement performed by participant in one direction, As the end of the desired range of motion approaches the therapist reverse the grip on the distal portion of the moving segment and without relaxation, gives resistance to the new motion starting with the distal part.
- Participants performed 2 sets of 10 repetitions each of the scapula and upper limb PNF exercises for week 1 and 2, progression in the exercises will be made by performing three sets of 10 repetitions in week 3 and 4.
- Intervention was given as one session per day for 20 to30 minutes, five consecutive days per week for four weeks period.[26]

➢ For Group B: Closed kinetic chain exercise training[27,28]

- Closed kinetic chain exercise training exercises was performed by participants, which include following exercises.

- **Modified plank:** Participant position was on his/her hands and knees. Then they tuck their toes under and straighten the legs and lift hip and butt up and back (V- shaped pose). Then they slowly lower down the hip and butt and will back to starting position. [Figure-2 (A)]

- **Quadruped Scapular pushup:** Participant position was in a quadruped position with the hands under shoulders and knees under hips and push into the floor and to allow shoulder blades to protract around rib cage. Then, and retract the shoulder blades while keeping the elbows locked out. [Figure-2 (B)]

- **Scapular dip:** Participant placed their hands on the side of a flat table. so that body was in perpendicular to the table and feet will be placed out in front of the participant body and knees should be bent at a 90-degree angle. Then Keeping their torso upright and arms straight, he/she moved down towards the floor then push his/her torso back up to the starting position by driving shoulder blades down. [Figure-2 (C)]

- **Prone bridge:** Participant was in prone position with supported on forearm and bend legs. Then they lift their body and form one line with knees, pelvis and head. The position will be hold for 3-5 second and then participant lower down the body. [Figure-2 (D)]

- **Scapular clock:** Participant position was in standing and hands were placed on the wallin front of body and they moved the hand in direction of 12 and 6o'clocktoelevate and depress the scapula. Then move hands towards 9 o' clock and 3 o'clock direction to protract and retract the scapula. [Figure-2 (E)]

- Participants perform two sets of 10 repetition each of the closed kinetic chain exercises for week 1 and 2, progression in the exercises were made by performing three sets of 10 repetition in week 3 and 4. Intervention was given as one session per day for 20 to 30 minutes, five consecutive days per week for four weeks period.

Group C: Conventional Exercise (Control group) Two sets of 10 repetition for 20 to30 minutes, 5 times weekly for 4 weeks were performed in standing position. [66] Scapular protraction and retraction, Scapular elevation and depression, Scapular up ward and down ward rotation.

Statistical Analysis

Statistical analysis was done using JAMOVI version 2.3.28 Software. Microsoft word 2016 and Excel 2016 was used to generate graphs and tables. Shapiro-Wilk test was applied to check the normality of data. All quantitative data of this study follows the normal distribution ($p>0.05$). Paired t-test was used for within group comparison and One-way ANOVA test was used for between groups comparison. Confidence interval was kept 95% and the level of significance for all statistical data was set $\alpha = 0.05$.

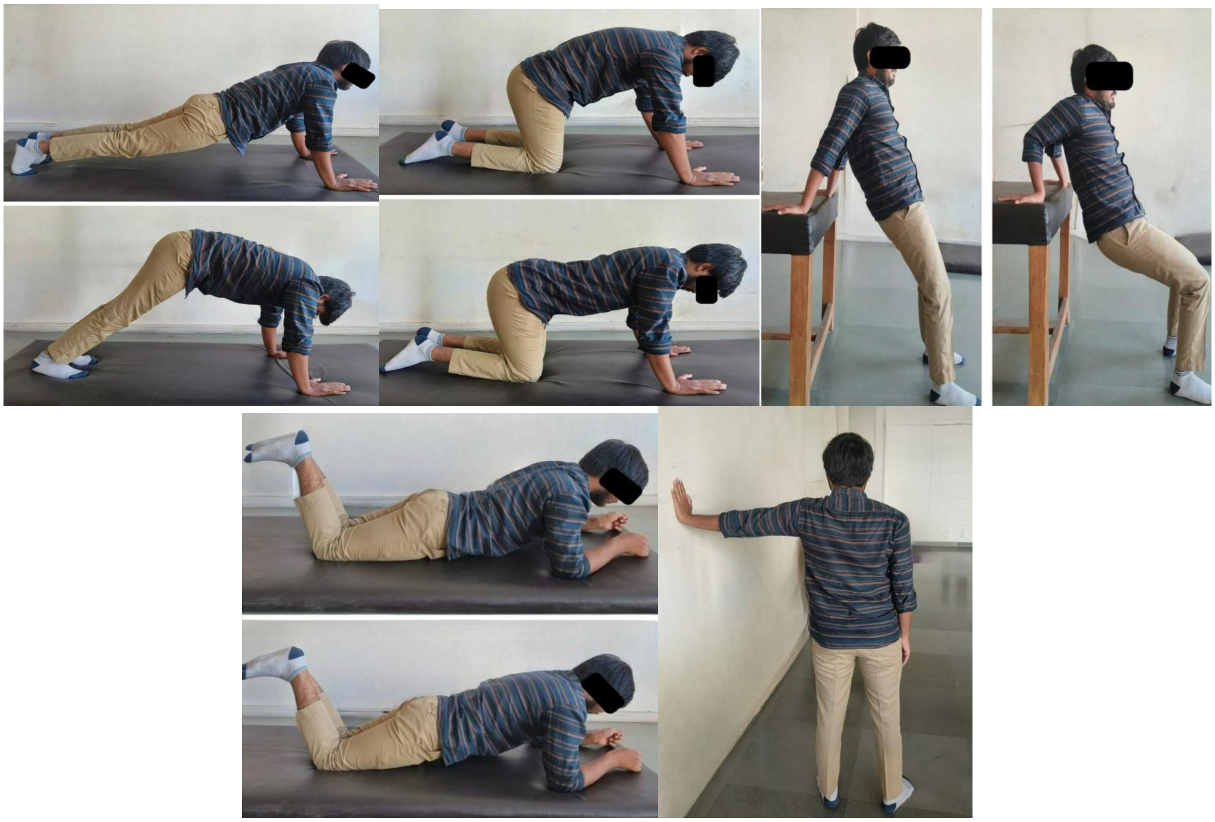


Figure-2: closed kinetic chain exercises(a) modified plank, (b) quadruped scapular pushup, (c) scapular dips, (d) prone bridge, (e) scapular clock

Result

Total 180 asymptomatic adults were assessed for eligibility. Out of them 61 participants were enrolled in the study on the basis of inclusion criteria and randomized into one of the treatment groups (21 in each group). Pre intervention outcome measures were assessed in 61 participants. There were no dropouts. Hence all outcome measurements were completed on 61 participants after 4 weeks of intervention**.** Table-1 shows analysis of demographics and pre intervention outcome measures of participants between groups by using One way ANOVA test for continuous variables and chi square test was used for categorical variables.

Paired t-test was used to compare the pre-intervention values of outcome measures score with post intervention values within the groups. Table-2 shows analysis of intra group comparison of pre and post mean of outcome measures. One way ANOVA was used to analyse the pre-post intervention differences between groups for the mean values of outcome measure scores. Table-3 shows inter groups comparison of mean pre-post intervention difference of outcome measures using one-way ANOVA test.

The result of between groups analysis shows that there is significant statistical difference in mean pre-post values of scapular muscle strength and scapular position between groups. while thereis no significant statistical difference in mean pre-post value of flexibility i.e. PM length between groups. Tukey’s post hoc test was applied for further analysis, results suggested that group A showed better result, when compared to group B and group C for all the outcome measures.

Table-1:Base line Demographics And outcome measures Of all groups

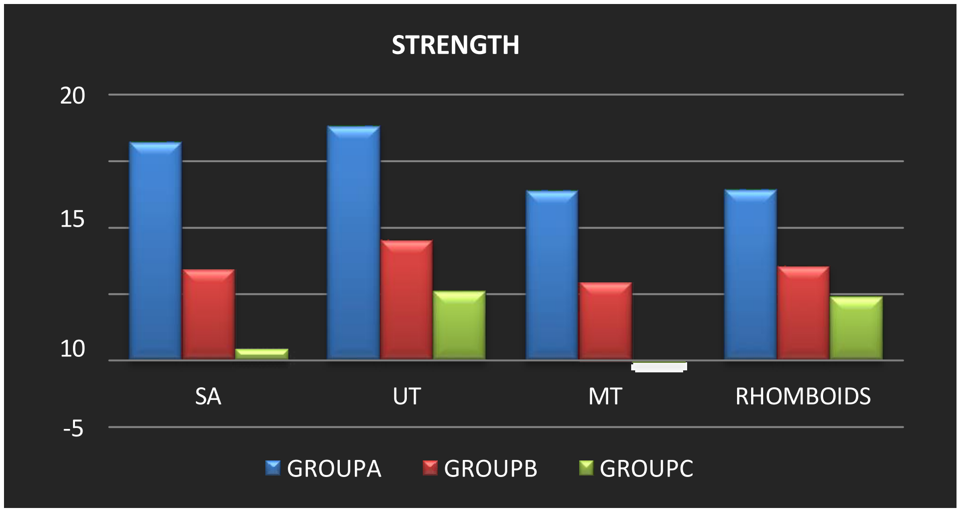
CHARACTERISTICS		GROUP A	GROUP B	GROUP C	P- VALUE
AGE (Y)		20.52 ± 1.50	20.47 ± 1.69	22.14 ± 1.11	<0.001
BMI (kg/m^2)		24.26 ± 3.30	24.00 ± 4.30	23.91 ± 1.99	0.949
GENDER	F	13 (62 %)	16 (76.19 %)	17 (81 %)	0.351
	M	8 (38 %)	5 (23.81 %)	4 (19 %)	
DOMINANT SIDE	Rt	18 (85.71%)	17 (81 %)	18 (85.71 %)	0.888
	Lt	3 (14.29%)	4 (19 %)	3 (14.29 %)	
SIDE OF AFFECTION	Rt	9 (42.86 %)	11 (52.38 %)	10 (47.62 %)	0.836
	Lt	12 (57.14 %)	10 (47.62 %)	11 (52.38 %)	
TYPE OF SD	TYPEI	18 (85.71%)	17 (81 %)	16 (76.19 %)	0.734
	TYPEII	3 (14.29%)	4 (19 %)	5 (23.81 %)	
STRENGTH	SA	44.36±9.41	64.08±17.90	46.62±14.47	<.001
	UT	67.58±13.74	64.65±10.24	66.93±12.80	0.693
	MT	26.87±8.30	28.54±8.37	38.10±7.36	<.001
	RH	24.36±7.92	25.00±4.88	26.54±7.13	<.001
FLEXIBILITY	PM LENGTH	8.33±1.28	9.36±1.16	9.55±1.19	0.007
SCAPULAR POSITION	ATREST	8.57±1.26	8.69±1.23	8.60±1.37	0.949
	45^{0}ABD	9.69±1.24	9.81±1.18	11.24±1.14	0.945
	90^{0}ABD	10.57±1.21	11.24±1.14	10.90±1.24	0.201

Table-2:Within group comparison of pre and postmean of Outcome Measures

VARIABLES		GROUPA (CKC)			GROUP B (PNF)			GROUP C (Control)		
		Pre Mean ± SD	Post Mean ± SD	P-value	Pre Mean ± SD	Post Mean ± SD	P-value	Pre Mean ± SD	Post Mean ± SD	P-value
STRENGTH	SA	44.36 ± 9.41	60.79±14.11	<.001	64.08 ± 17.90	70.89 ± 17.14	<.001	46.62 ± 14.47	47.50 ± 17.72	0.628
	UT	67.58±13.74	85.19±15.05	<.001	64.65 ± 10.24	73.69 ± 9.87	<.001	66.93 ± 12.80	72.15 ± 12.59	0.005
	MT	26.87±8.30	39.65±12.01	<.001	28.54 ± 8.37	34.38 ± 10.89	<.001	38.10 ± 7.36	38.01 ± 8.66	0.958
	RH	40.36±7.92	53.21±11.03	<.001	25.00 ± 4.88	32.10 ± 7.58	<.001	26.54 ± 7.13	31.31 ± 5.73	0.013
FLEXIBILITY	PM	8.33 ±1.28	7.67 ±1.25	<.001	9.36 ± 1.16	8.64 ± 1.26	<.001	9.55 ± 1.19	9.10 ± 1.38	0.004
SCAPULAR POSITION	ATREST	8.57 ±1.26	7.62 ±1.42	<.001	8.69 ± 1.23	8.24 ± 1.20	<.001	8.60 ± 1.37	8.31 ± 1.42	0.477
	45^0ABD	9.69 ±1.24	8.81 ±1.33	<.001	9.81 ± 1.18	9.29 ± 1.20	<.001	9.71 ± 1.23	9.21 ± 1.31	<.001
	90^0ABD	10.57±1.21	9.64 ±1.20	<.001	11.24 ± 1.14	10.71 ± 1.16	<.001	10.90 ± 1.24	10.38 ± 1.26	<.001

Table-3:Between group comparison of pre-post diff of mean of outcome measures.

VARIABLES		GROUP A	GROUP B	GROUP C	P-value
		Pre-Post diff Mean ± SD	Pre-Post diff Mean ± SD	Pre-Post diff Mean ± SD	
STRENGTH	SA	16.43 ± 11.12	6.80 ± 6.23	0.88 ± 8.20	<.001
	UT	17.60 ± 11.13	9.03 ± 4.32	5.22 ± 7.56	<.001
	MT	12.78 ± 9.87	5.83 ± 4.26	-0.09± 7.72	<.001
	RH	12.85 ± 10.49	7.09 ± 5.07	4.77 ± 8.00	0.028
FLEXIBILITY	PM	-0.66± 0.57	-0.71± 0.25	-0.45± 0.25	0.231
SCAPULAR POSITION	ATREST	-0.95± 0.61	-0.45± 0.31	-0.28± 1.87	0.008
	45^0ABD	-0.88± 0.31	-0.52± 0.29	-0.50± 0.35	<.001
	90^0ABD	-0.92± 0.39	-0.52± 0.29	-0.52± 0.29	<.001



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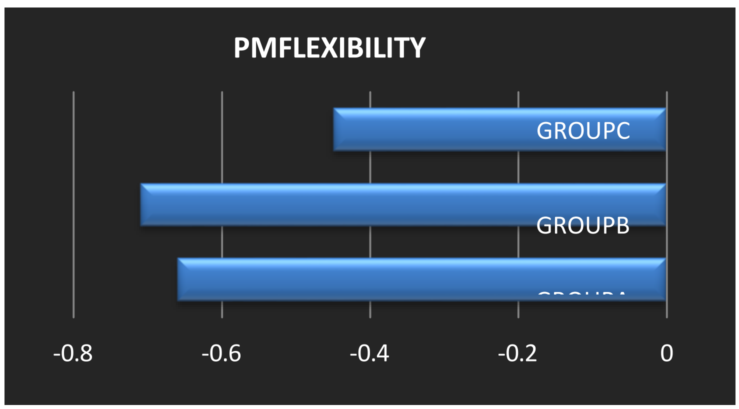

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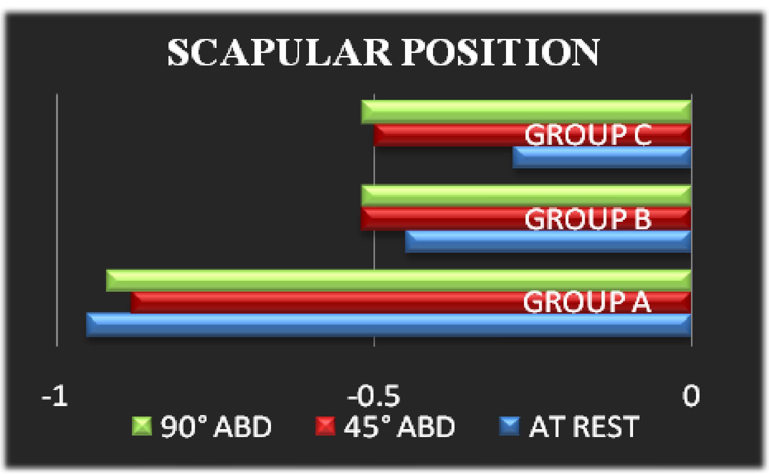

C

Graph-1:Illustration of between group comparison of pre- Post Diff Of Mean Of Outcome Measures (A) Strength, (B) Flexibility, (C) Scapular Position

2. Discussion

Scapular dyskinesis has been defined as alterations in scapular positioning at rest aswellasduringdynamicmovement.Theabsenceof adequatemusclecoordinationinthe shoulder joint complex tends to alter the scapular position and movement.[29] This dysfunction is considered a predisposing factor in shoulder pathologies, such as rotator cuff tendonitis, rotator cuff tendon rupture, and subacromial impingement syndrome, among others.[30] A recent kinematic study done by Rossi et al 2018 using principle component analysis found that both healthy and symptomatic individuals with dyskinesis displayed similar dysrhythmias that were also different when compared to controls.[8]

The primary goal of this study was to find out the effect of closed kinetic chain exercise training and proprioceptive neuromuscular facilitation training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis and to compare the effect of PNF training and CKC exercise training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.

PNF stimulates the proprioceptive myoreceptors of the muscles and tendons, that lead to activation of the golgi tendon organs. PNF exercises cause a decrease in CNS inhibition, reduced sensitivity of the golgi tendon organ and changes at the myoneural junction of the motor unit. These factors lead to an increase in the recruitment, rate and synchronisation of the firing of motor units thereby improving motor learning and co- ordination.[71] The PNF leads to changes in the distribution of the muscle fiber type leading to a unidirectional pattern of transformation of fast twitch fibers to slow twitch fibers. Irradiation occurring due PNF exercises produces an activation of the weaker muscles by stimulating the stronger group of muscles thereby improving their strength.[31]

These techniques also help the muscles to relearn the normal timing of recruitment and amount of activation so as to maintain the balance between different groups of muscles.

There are certain possible mechanisms which are responsible for the reduction in muscle stiffness. One possible mechanism is known as stress-relaxation. A study done by Taylor et al. stated that if a viscoelastic material such as a muscle is stretched and then held at a constant length, the stress at that length gradually declines. Another possible mechanism is the connective tissue surrounding the muscle fibers.[32] Connective tissue, particularly the perimysium, is considered a major extracellular contributor to muscle stiffness. Lengthening deformation of the connective tissue within the muscle belly has been suggested to influence passive muscle stiffness.[33,34]

Rosa DP et al. in their study found that Decreased muscle length may lead to loss of extensibility due to decreased number of sarcomeres in series, fewer actin-myosin cross bridges, the type of titin protein, and shortening of connective tissue. They proposed that the stretching protocol decrease the muscle passive resistance and improve connective tissue extensibility and influence neural activation patterns.[35]

The physiological mechanism behind stretching of a muscle fibers begin with the sarcomere, the basic unit of contraction in the muscle fibers. As the sarcomere contracts, the area of overlap between the thick and thin myofilaments increases. As it stretches, this area of overlap decreases, allowing the muscle fibers to elongate. Once the muscle fibers are at its maximum resting length (all the sarcomeres are fully stretched), additional stretching places force on the surrounding connective tissues as the tension increases, the collagen fibers in the connective tissue align themselves along the same line of force as the tension. Therefore, when you stretch, the muscle fibers are pulled out to its full-length sarcomere by sarcomere, and then the connective tissue takes up the remaining slack. When this occurs, it helps to realign any disorganized fibers in the direction of the tension. Proprioceptors: The proprioceptors related to stretching are located in the tendons and in the muscle fibers Muscle Spindles (intrafusal fibers) lie parallel to the extrafusal fibers. Muscle spindles are the primary proprioceptors in the muscle. Another proprioceptor that comes into play during stretching is located in the tendon near the end of the muscle fiber and is called the Golgi tendon organ. A third type of proprioceptor, called a pacinian corpuscle, is located close to the golgi tendon organ and is responsible for detecting changes in movement and pressure within the body.[36]

There is a lack of evidence for beneficial effects of exercise in improving scapular position and motion in asymptomatic adults with scapular dyskinesis. One study done by Micoogullari M. et. al [37] on effect of scapular stabilizer muscles strength on scapular position and found that there were positive and statistically significant correlations between the isometric muscle strength of the SA, UT, MT, and LT muscles in the LSST ($P<0.05$). The UT and SA muscles greatly affected the changes in the position of the inferior region of the scapula (24.5%). The LT (11.3%) in neutral position, MT (25.4%) with arm abducted at 45°, and SA (34.5%) with arm abducted 90° had a major effect on the changes in the mediolateral position of the scapula. Their study showed that strength of the MT and SA muscles becomes effective as the shoulder elevation increases. SA and UT muscle strength have a greater effect on the position of the inferior region of the scapula.

An experimental study done by Shankar P et al.[38] to see the effect of scapular stabilization exercises for type II scapular dyskinesis in subjects with shoulder impingement. They gave closed kinematic chain exercises (scapula clock), Black burn exercises, Sleepers stretch, and Thera B and exercises aimed to balance force couple of upper, lower trapezius and serratus anterior for 3 sessions per week for 2 weeks. Lateral scapular slide test and SPADI (Shoulder pain and disability index) were taken as an outcome measurements preand post interventions. At the end of the studythey concluded that the Scapular stabilization exercise incorporating early closed kinetic chain exercise were effective in reducing disability and pain in type II Scapula Dyskinesia. So, according to this article Closed kinetic chain exercise training is found to show better improvement in scapular position which was measured by LSST.

The purpose of this study was to compare the effect of closed kinetic chain exercise training and proprioceptive neuromuscular facilitation training on strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis. Result of present study confirms alternative hypothesis that there is significant statistical and clinical difference between the effect of proprioceptive neuromuscular facilitation training and closed kinetic chain exercise training on strength, flexibility and scapular positionina symptomatic adults with scapular dyskinesis. Present study reported that the closed kinetic chain exercise training is more useful than proprioceptive neuromuscular facilitation training for improving strength, flexibility and scapular position in asymptomatic adults with scapular dyskinesis.

Limitations of the study are there was no follow-up once the treatment was completed, hence long-term effects were not evaluated. In this study there is gender biasas number of females were more compared to number of males. In this study asymptomatic adults from different colleges were included, further study can be conducted on asymptomatic adults from different fields and places. This study was conducted on participants with unilateral scapular dyskinesis, further study can be executed in asymptomatic adults with bilateral scapular dyskinesis. Effect of these interventions on functions were not assessed and analyzed; further study can be done by including these parameters in asymptomatic adults with scapular dyskinesis.

Conclusion

This study concludes that the technique used in the present study i.e. Closed kinetic chain exercise training and Proprioceptive neuromuscular facilitation training are effective as compared to control, however in comparision of these two techniques, Closed kinetic Chain exercise is more effective than PNF training for improving scapular muscle strength of SA, UT, MT and rhomboids, flexibility of PM and scapular position at rest, at 45^0abduction and 90^0 abduction in asymptomatic adults with scapular dyskinesis

Declarations

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References

1. Khare D, Deshmukh SV. To Study the Prevalence of Scapular Dyskinesia in Gymers and Non Gymers. International Journal of Science and Research. 2015;6(6):911-5.
2. Inman VT, Saunders JD, Abbott LC. Observations on the function of the shoulder joint. JBJS 1944 Jan 1;26(1):1-30.
3. Oliveira VM, Silva HA, Pitangui AC, Passos MH, Araújo RC. Scapular dyskinesis was not associated with pain and function in male adolescent athletes. BrJP. 2018 Jan;1:40-5.
4. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. JOrthopSportsPhys Ther 2005; 35: 227–238.
5. Moghadam, A.N.; Rahnama, L.; Dehkordi, S.N.; Abdollahi, S. Exercise therapy may affect scapular position and motion in individuals with scapular dyskinesis: A systematic review of clinical trials. J. Shoulder Elb. Surg. 2020, 29, e29–e36.
6. https://stanfordhealthcare.org/medical-conditions/bones-joints-and-muscles/scapular-dyskinesis.html#:~:text=Scapular Dyskinesis or scapular dysfunction, of the presenting shoulder pain.
7. Miachiro NY, Camarini PM, Tucci HT, McQuade KJ, Oliveira AS. Can clinical observationdifferentiateindividualswithandw ithoutscapulardyskinesis?.Brazilian journal of physical therapy. 2014 May;18:282-9.
8. Rossi DM, Resende RA, da Fonseca ST, de Oliveira AS. Scapulothoracic kinematic pattern in the shoulder pain and scapular dyskinesis: a principal component analysis approach. Journal of biomechanics. 2018 Aug 22;77:138-45.
9. Hannah DC, Scibek JS, Carcia CR. Strength Profiles In Healthy Individuals With And Without Scapular Dyskinesis. Int J Sports Phys Ther. 2017 Jun;12(3):305-313.
10. Myers JB Oyama S Hibberd EE. Scapular dysfunction in high school baseballplayers sustaining throwing-related upper extremity injury: a prospective study.J Shoulder Elbow Surg. 2013;22(9):1154-1159.
11. Khare D, Deshmukh SV. To Study the Prevalence of Scapular Dyskinesia in Gymers and Non Gymers. International Journal of Science and Research. 2015;6(6):911-5.
12. Hickey D, Solvig V, Cavalheri V, Harrold M, Mckenna L. Scapular dyskinesis increases the risk of future shoulder pain by 43% in asymptomatic athletes: a systematic review and meta-analysis. British journal of sports medicine. 2018 Jan 1;52(2):102-10.
13. Desai Rr, Steven Vj, Joshi R, Rathi Ma, Palekar Tj, Desai Ps. Proprioceptive Neuromuscular Facilitation Techniques

versus Closed Kinematic Chain Exercises in Scapular Dyskinesia among Hospital Housekeeping Staff: An Experimental Study. Journal of Clinical & Diagnostic Research. 2021 Nov 1;15(11).
14. CiğercioğluNb, ÜnüvarE, HazimliogluP, FıratTa, Kilinc He, DenizHg. Proprioceptive Neuromuscular Facilitation Training Improves Scapular Muscle Strength and Pectoralis Minor Length in Individuals with Scapular Dyskinesis. Journal of Basic and Clinical Health Sciences. 2022 Jan 1;6(1):238-46.
15. Kibler, Benjamin W. MD; Sciascia, Aaron MS, ATC, NASM-PES; Wilkes, Trevor MD. Scapular Dyskinesis and Its Relation to Shoulder Injury. Journal of the American Academy of Orthopaedic Surgeons 20(6):p 364-372, June 2012. | DOI: 10.5435/JAAOS-20-06-364
16. Rezasoltani A, Khaleghifar M, Tavakoli A, Ahmadi A, Minoonejad H. The effect of proprioceptive neuromuscular facilitation program to increase neck muscle strength in participants with chronic non-specific neck pain. World Journ of Sport Sci. 2010;3(1):59-63.
17. Adler SS, BeckersD, Buck MPNF in Practice – An Illustrated Guide. 2003 2nd India Springer.
18. Pretshia DR, Senthilselvam P, Sundaram MS, AppaRao P, Kumar CS. Effects Of Muscle Energy Technique On Shoulder Dysfunction Among The Collegiate Swimmers With Scapular Dyskinesia. Ann. For. Res. 2022;65(1):4166-75.
19. Junior RM, Netto WA, CarvalhoGF, Zanca GG, Zatiti SC, Mattiello SM. Concurrent validity of handheld dynamometer measurements for scapular protraction strength. Brazilian Journal of Physical Therapy. 2019 May 1;23(3):228-35.
20. Struyf F, Meeus M, Fransen E, Roussel N, Jansen N, Truijen S, Nijs J. Interrater and intrarater reliability of the pectoralis minor muscle length measurement inparticipants with and without shoulder impingement symptoms. Manual therapy. 2014 Aug 1;19(4):294-8.
21. Curtis T, Roush JR. The Lateral Scapular Slide Test: A Reliability Study of Males with and without Shoulder Pathology. NAmJSportsPhysTher.2006Aug;1(3):140- 6.
22. McClure P, Tate AR, Kareha S, Irwin D, Zlupko E. A clinical method for identifying scapular dyskinesis, part 1: reliability. J Athl Train. 2009 Mar-Apr;44(2):160-4.
23. Burkhart, S.S.; Morgan, C.D.; Kibler, W.B. The disabled throwing shoulder: Spectrum of pathology partIII: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy2003,19,641–661.
24. Norkin CC, White DJ. The Shoulder. Measurement of Joint Motion: A Guide to Goniometry. 2nd ed. Philadelphia, PA: F.A. Davis Company, 1985:49-64.
25. Balcı NC, Yuruk ZO, Zeybek A, Gulsen M, Tekindal MA. Acute effect of scapular proprioceptive neuromuscular facilitation (PNF) techniques and classic exercises in adhesive capsulitis: a randomized controlled trial. J Phys Ther Sci. 2016 Apr;28(4):1219-27.
26. Khare D, Deshmukh SV. To Study the Prevalence of Scapular Dyskinesia in Gymers and Non Gymers. International Journal of Science and Research. 2015;6(6):911-5.
27. https://www.lorpt.com/blog/upper-back-stiffness-and-shoulder-pain.
28. https://www.muscleandstrength.com/exercises/quadruped-push-up-plus
29. Burkhart SS, Morgan CD, Kilber WB (2003) The disabled throwing shoulder: spectrum of pathology Part I: Pathoanatomy and biomechanics.Arthroscopy19, 404–420.
30. KiblerW,SciasciaA,WilkesT.Scapulardyskinesisanditsrelationtoshoulder injury. J Am AcadOrthop Surg. 2012; 20(6): 364–72.

31. Kisner C,Colby LA. Therapeutic Exercises, Foundation and Techniques.6th ed.Chapter6: Resistance exercise for impaired muscle performance;2012;Pp.147.
32. Taylor D.C., Dalton J.D., Jr., Seaber A.V., Garrett W.E., Jr., (1990) Viscoelastic properties of muscle-tendon units. The biomechanical effects of stretching.The American Journal of Sports Medicine 18, 300-309.
33. Umehara J, Nakamura M, Nishishita S, Tanaka H, Kusano K, Ichihashi N. Scapular kinematic alterations during arm elevation with decrease in pectoralis minor stiffness after stretching in healthy individuals. Journal of shoulder and elbow surgery. 2018 Jul 1;27(7):1214-20.
34. Umehara J, Nakamura M, Saeki J, Tanaka H, Yanase K, Fujita K, Yamagata M, Ichihashi N. Acute and Prolonged Effects of Stretching on Shear Modulus of the Pectoralis Minor Muscle. J Sports Sci Med. 2021 Mar 1;20(1):17-25.
35. Rosa DP, Borstad JD, Pogetti LS, Camargo PR. Effects of a stretching protocol for the pectoralis minor on muscle length, function, and scapular kinematics in individuals with and without shoulder pain. Journal of Hand Therapy. 2017 Jan 1;30(1):20-9.
36. Appleton B.Stretching and Flexibility Every thing younever wanted to know.World. 1998;68.
37. Micoogullari M, Uygur SF, Yosmaoglu HB. Effect of Scapular Stabilizer Muscles Strength on Scapular Position. Sports Health. 2023 May;15(3):349-56.
38. Shankar P,JayaprakasanP, DeviR.Effect of scapular stabilisation exercises for type 2 scapular dyskinesis in participants with shoulder impingement. International Journal of Physiotherapy. 2016 Feb 1;3(1):106-10.

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