RESEARCH ARTICLE

ClinicalPractice

Effect of passive pectoralis minor stretching on scapular kinematics in scapular dyskinesia

Abstract

Purpose: To determine the effect of Passive pectoralis minor muscle stretching on scapular kinematics in individuals with scapular dyskinesia.

Materials and Methods: The sample size was 30 subjects, who were randomly assigned to one of two groups: Group A, which received passive pectoralis minor stretch, or Group B, which received traditional exercises three days a week for four weeks. The outcome measurements, pectoralis minor length, scapular upward rotation, and lateral scapular sliding test, were measured before and after therapy.

Results: The results obtained, prove a significant difference between pre and post mean values of pectoralis minor length in group A (pre 21.91 ± 3.40, post 22.87 ± 3.40) and in group B (pre 23.55 ± 2.72 posts 23.99 ± 2.72); scapular upward rotation in group A (pre 49.95 ± 1.06, post 50.61 ± 1.04) and group B (pre 52.64± 3.46, post 53.51± 3.50); lateral scapular slide test at 0 abductions in group A (pre 6.613 ± 1.04, post 6.14 ± 0.99) and group B (pre 6.84 ± 1.00, post 6.22 ± 1.01); lateral scapular slide test at 45 abductions in group A (pre 7.14 ± 1.05 and post 7.12 ± 1.03) and group B (pre 8.18± 0.99, post 7.53 ± 0.93). With an inter-group analysis, it was found, that the mean of pectoralis minor length, scapular upward rotation, and LSST at 0 abductions in group A was more significant than in group B ($p<0.05$).

Conclusion: In individuals with scapular dyskinesia, passive pectoralis minor stretching combined with traditional strengthening exercises was found to be more effective in improving scapular kinematics.

Keywords: Scapulohumeral rhythm, scapular upward rotation, rounded shoulders, scapular strengthening

Introduction

A combined, coordinated, and coupled motion between the scapula and humerus brings about an efficient arm movement, biomechanically to provide for asynchronous scapular rotation on humeral motion, serving as a strong base for rotator cuff activation and an important functional link in the kinetic chain [1].

The scapula upward rotation happens around a fixed axis, as an arc of about 60-65 as the shoulder achieves full abduction or elevation. This movement occurs through a balanced function between the glenohumeral joint and scapula stabilizers [2]. The scapula's upward rotation during arm elevation is the classic description of the so-called scapulohumeral rhythm. This movement gives a 2:1 ratio to the rhythm. Thus, for every 2 degrees of glenohumeral motion-abduction, there occurs 1 degree of scapulothoracic motion-upward rotation [2,3].

The presence of muscle imbalance, bony or soft tissue injury or muscle weakness, and inflexibility can alter the role of the scapula, its resting position, and the dynamic motion leading to dyskinetic movement, termed Scapular dyskinesis [4,5]. Kibler classified scapular dysfunction into 3 types, type I involves inferior angle prominence in the sagittal plane, type II involves medial border prominence in the transverse plane, and type III, a superior dysfunction is seen as early and excessive elevation of the scapula during arm elevation [6].

Postural deviation and muscle imbalance around the shoulder area are frequently concurrent [7]. Poor kyphotic or slouched posture for a prolonged duration and over time can result in gradual elongation of the posterior scapular stabilizers, which may become weaker and on the other hand, shorten/tighten the pectorals, which become stronger enough to bring about

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a change in the anatomical position or plane of the shoulder girdle [8,9]. As a result, force imbalance develops between those two muscle groups, which in time, may result in changes in resting scapular position and dyskinetic movement involving excessive scapular anterior tilting and deficient upward rotation of the scapula during shoulder elevation [10].

Based on the theories of muscle imbalance, clinicians postulate that targeted exercise protocols of the rotator cuff and scapular retractors strengthening, and pectoral stretching are believed to restore the normal kinematics of glenohumeral and scapulothoracic motion and thus establish proper scapulohumeral rhythm [11,12]. On one hand, pectoralis minor stretching should be effective with relevant techniques and duration to bring about an absolute lengthening of the muscle, significant enough to contribute to the restoration of scapular kinematics during rehabilitation [13]. On the other hand, strengthening exercises should target the muscles involved in force couple to produce normal scapula rotation which are the serratus anterior, upper trapezius, and lower trapezius [14]. Along with these prime movers, the rhomboids, levator scapulae, and rotator cuff muscles should also be comprehensively strengthened to improve the global stability of the scapula [14,15].

The muscle imbalance occurring is chiefly corrected by strengthening weak scapular muscles and stretching the pectoralis minor, but this stretch is often neglected as compared to strengthening [12,16]. The exercises performed for pectoralis minor stretching are mostly gross stretches that would not significantly affect the length of pectoralis minor length and thus the scapular kinematics to correct the dyskinesia [17-19]. The purpose of this study is to see the effect of focused passive stretch aimed at lengthening the pectoralis minor and the subsequent effects on scapular kinematics.

Methodology

Between March 2019 and February 2020, the research was carried out in the physiotherapy department of Dr. D.Y. Patil Medical College, Hospital, and Research Centre in India. The ethical committee of the Dr. D.Y.Patil College of Physiotherapy granted clearance (Approval number: DPU/R&R (P)/448(25)/19). This research got no funding. All subjects signed the required consent before beginning the study 30 subjects between 40 and 60 years of age meeting and fulfilling inclusion criteria were then randomly allocated into 2 groups by a chit method. Data was collected from Dr. D.Y. Patil Hospital and Research Centre, Pune, India. Both experimental and control groups consisted of 15 subjects each. In this study inclusion criteria were: Positive lateral scapular slide test, positive scapular load test with 1RM, and age group 20-50 years. Patients with a recent (less than 6 months) history of any shoulder injury, any involved upper extremity surgery is done, congenital shoulder or hand deformities, any ongoing treatment for dyskinesia, undergoing weight training, and those who were not willing to participate, were excluded from the study.

Outcome measures used in the study are Pectoralis minor length, measured using a Vernier caliper [20,21], Scapular upward rotation, measured using a pro 360 digital inclinometer [22], and Lateral scapular slide test (Lateral shift of scapula) at 0°, 45° and 90° of arm abduction measured using Vernier caliper [23].

Pre-treatment assessment was done for all subjects. For the control group conventional pectoral stretch and conventional, elastic band exercises were given. The experimental group received a combination of two different passive pectoral stretches, as well as elastic band exercises. Treatment duration was 4 weeks with 3 sessions per week. At the end of 4 weeks, a post-treatment assessment was taken for all subjects.

Outcome measures

1. Pectoralis Minor Length (PML): A standard inch tape measurement was taken from the 4^{th} rib (1 inch lateral from sternum) to the coracoid. **(FIGURE 1)**[17,24].
2. Scapular upward rotation, It is the static, kinetic measurement taken during humeral elevation in the scapular plane. For this, the Pro 360 digital inclinometer was used. A cardboard piece is attached to the base of the device and aligned with the spine of the scapula during the resting position of the arm. The angle at the end of the full scaption is measured with the horizontal by the device and the value is noted down as the degree of scapular upward rotation. **(FIGURE 2)** [25]

Lateral Scapular Slide Test (LSST), Side to side comparison is done between the distance of the thoracic spine to the inferior angle of the scapulae and performed in 3 different arm positions: 0º (arms adducted), 45º (with thumbs facing backward and outward) and 90º of shoulder abduction (maximal internal rotation of the shoulders). The measurements were taken with a Vernier caliper. The lateral arm of the caliper was placed at the inferior angle of scapula and the medial arm, at the corresponding spinous process after palpation and markings **(FIGURE 3)** [23,26].

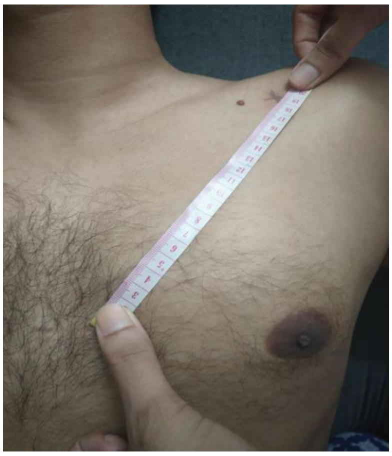

FIGURE 1. Measurement of PML.

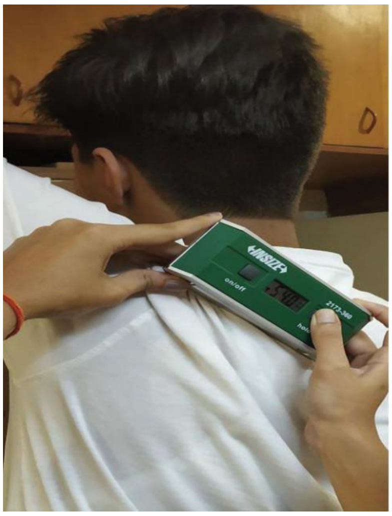

FIGURE 2. Measurement of the scapular upward rotation with pro 360 digital in clinometer.

FIGURE 3. LSST was measured at 3 different positions (A): 0º abduction, (B): 45º abduction and (C): 90º abduction with full internal rotation with a Vernier caliper.

■ Exercise protocol is given to Experimental group A

The experimental group was the Passive pectoralis minor stretching group. A focused and a gross stretch were applied as passive stretches. To perform the focused stretch, the patient was taken in a supine lying position with the treatment arm placed at about 160º abduction while the other arm is by the side of the body in adduction **(FIGURE 4)**. 17 Therapist stabilizes the scapula and humeral head of the shoulder treated with one hand while giving a slight overpressure so as to retract the scapula and the fingers of the other hand are placed obliquely over the proximal origin heads on 3rd, 4th and 5th ribs, of pectoralis minor muscle. A superolateral tensile stretch with the pulp of the 2nd, 3rd, and 4th digits mainly are applied with a pressure enough to target the muscle (and not just the skin and fascia) in direction of the fibers, covering the span of the muscle **(FIGURE 4)** [14,17]. To perform the gross stretch, the subject was taken in a supine lying position and the therapist takes a walk stance position on the treatment side of the patient holding the treatment arm in one hand and stabilizing the coracoid process, scapula with the other keeping the elbow in 90° abduction and shoulder in 90º lateral rotation [27]. The therapist then passively abducts and laterally rotates the arm to complete the arc or full range of motion with an end overpressure. The patient was asked to simultaneously retract both the shoulders getting the medial border of both the scapulae together. At the end range, while one hand continues to maintain the end range abduction and lateral rotation, the other hand is now shifted to stabilize the proximal origin heads of the muscle. This stretch was held for 30 seconds. 10 repetitions of both the gross and focused stretch were performed in each session. **(FIGURE 5)** [17,27,28]

FIGURE 4. Focused, passive pectoralis minor stretching.

FIGURE 5. Gross, passive pectoralis minor stretching.

■ Exercise protocol is given to control group B

Group B was given a self-administered, active (but supervised) corner stretch as a control. The patient was instructed to flex both elbows to 90º while keeping them supinated such that the palm is placed on the wall. The feet, on the other hand, are placed together at the same elbow distance from the wall. The patient was then instructed to bear weight on the palm, keeping elbows flexed at 90º and feet in the same position so as to incline the whole body forward into the wall corner. Anterior stretch over the pectoral region and retraction is felt by the patient with the correct technique. This stretch is held for 30 seconds and 10 repetitions are performed per session **(FIGURE 6)** [29,30].

Strengthening exercises were given with a resistance band [31] to both the groups targeting the posterior scapular musculature: Low rows (targeting rhomboids) **(FIGURE 7)**, Scapular punches (targeting the serratus anterior) **(FIGURE 8)**, Scapular Y's (targeting middle trapezius and lower trapezius) **(FIGURE 9)**, Scapular W's (targeting lower trapezius and rhomboids) **(FIGURE 10)** and Scapular T's (targeting middle trapezius and upper trapezius) **(FIGURES 11 and 12)** [32-34].

■ Statistical analysis

Data analysis was done using WinPePi (version

FIGURE 6. Corner stretch.

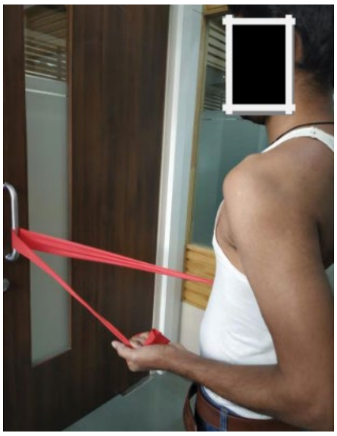

FIGURE 7. Low Rows.

FIGURE 8. Scapular punches.

11.65) and SPSS (version 22) statistical packages. Normality of the data was checked using Shapiro Wilk Test in WinPepi software. The intra-group analysis was done by means of Friedman test and the inter-group comparison was done by means of Kruskal-Wallis test in SPSS software.

Results

Participant's demographic characteristics are presented in **TABLE 1**. The mean age of males was 29.75 ± 2.36 in group A and 32.11 ± 2.43 in group B whereas, mean age of females was 33 ± 1.75 in group A and 31.83 ± 2.21 in group B. Mean number of males in group A was 8 and 9

FIGURE 9. Scapular Y's.

FIGURE 10. Scapular W's.

FIGURE 11. Scapular T's.

in group B. Mean number of females in group A was 7 and in group B was 6. There were no dropouts in this study. At the end of 4 weeks of treatment to both the groups, pectoralis minor length, and scapular upward rotation increased ($p<0.05$) and LSST values decreased, showing a reduction in the lateral shift of scapula ($p<0.05$) in both groups. Mean pectoralis minor length improved in both groups, from 21.91 ± 3.40 to 22.87 ± 3.40 in group A and in group B from 23.55 ± 2.72 to 23.99 ± 2.72. Similarly, mean scapular upward rotation improved in both groups, from 49.95 ± 1.06 to 51.35 ± 1.04 ($p<0.05$) in group A and from 52.64 ± 3.46to 53.51 ± 3.50 in group B. LSST mean values at 0° (Group A 6.61 ± 1.04 to 6.14 ± 0.9, Group B 6.84 ± 1.00 to 6.22 ± 1.01), 45º (Group A 7.74 ± 1.05 to 7.12 ± 1.03, Group B 8.18 ± 0.99 to 7.53 ± 0.093) and 90° (Group A 9.95 ± 0.99 to 8.35 ± 0.94, Group B 9.45 ± 1.06 to 8.77 ± 1.20) also showed equal improvement in both groups ($p<0.05$). In the inter-group analysis, it was found, that mean of pectoralis minor length in group A (0.96 ± 0.12) was significant ($p<0.05$) to group B (0.44 ± 0.12); mean of scapular upward rotation in group A (1.39 ± 0.25) was significant (<0.05) to group B (0.86 ± 0.15); mean of LSST at 0° abduction in group A(0.46 ± 0.12) was significant ($p<0.05$) to group B (0.62 ± 0.14).Whereas, no group was superior to others in LSST at 45° (group A 0.62 ± 0.16, group B 0.64 ± 0.11) and 90° abduction (group A 0.60 ± 0.14, group B 0.68 ± 0.12) parameters **TABLES 2 and 3**.

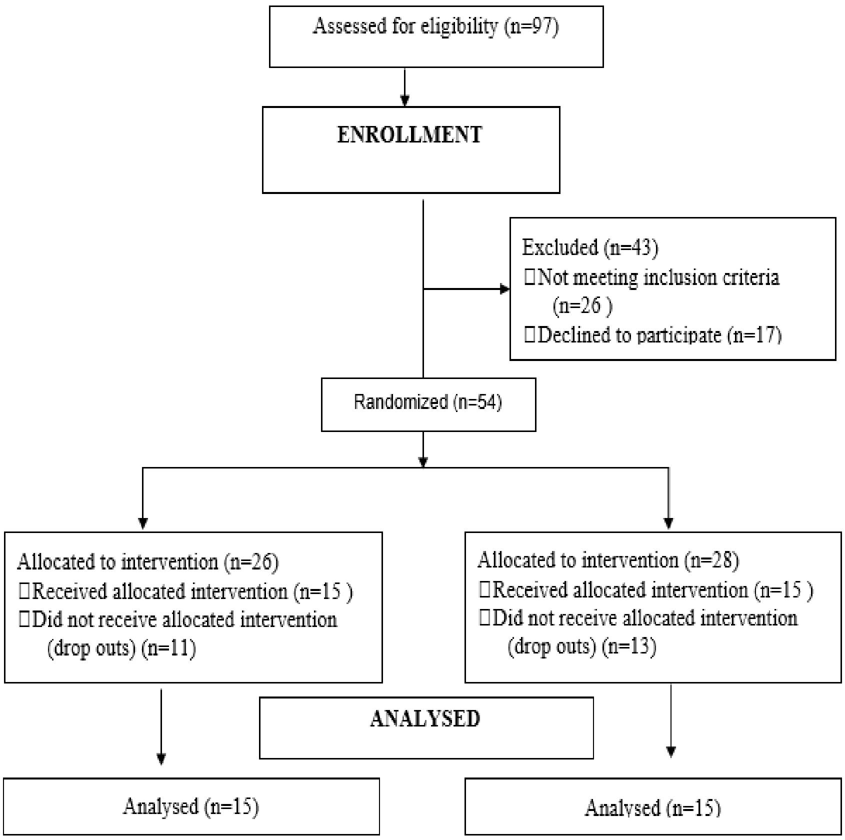

FIGURE 12. Design of the trial.

TABLE 1. Shows the Mean ± SD values of mean age and gender in both groups.

Parameters		Group A	Group B
Age	Males	29.75 ± 2.36	32.11 ± 2.43
(Mean years)	Females	33 ± 1.75	31.83 ± 2.21
Gender (n)	Male0073	8	9
	Females	7	6

TABLE 2. Shows the comparison of pre and post-treatment mean and SD values, depicting significant changes in Pectoralis minor length, scapular upward rotation and LSST at 0º, 45º and 90º abduction.

Parameters		Group A (0-4th week)		Group B (0-4th week)	
		Pre	Post	Pre	Post
Pectoralis minor length	Mean ± SD	21.91 ± 3.40	22.87 ± 3.40	23.55 ± 2.72	23.99 ± 2.72
	p-value	<0.05		<0.05	
Scapular upward rotation	Mean ± SD	49.95 ± 1.06	51.35 ± 1.04	52.64 ± 3.46	53.51 ± 3.50
	p-value	<0.05		<0.05	
LSST 0° abduction	Mean ± SD	6.613 ± 1.04	6.14 ± 0.9	6.84 ± 1.00	6.22 ± 1.01
	p-value	<0.05		<0.05	
LSST 45° abduction	Mean ± SD	7.74 ± 1.05	7.12 ± 1.03	8.18 ± 0.99	7.53 ± 0.093
	p-value	<0.05		<0.05	
LSST 90° abduction	Mean ± SD	9.95 ± 0.99	8.35 ± 0.94	9.45 ± 1.06	8.77 ± 1.20
	p-value	<0.05		<0.05	

TABLE 3. Shows the intergroup comparison of all the outcome measures depicting statistically significant results of pectoralis minor length, scapular upward rotation and LSST at 0º abduction in group A.

Parameters		Group A	Group B
Pectoralis minor length	Mean ± SD	0.96 ± 0.12	0.44 ± 0.12
	p-value	<0.05	
Scapular upward rotation	Mean ± SD	1.39 ± 0.25	0.86 ± 0.15
	p-value	<0.05	
LSST 0° abduction	Mean ± SD	0.46 ± 0.12	0.62 ± 0.14
	p-value	<0.05	
LSST 45° abduction	Mean ± SD	0.62 ± 0.16	0.64 ± 0.11
	p-value	>0.05	
LSST 90° abduction	Mean ± SD	0.60 ± 0.14	0.68 ± 0.14
	p-value	>0.05	

Discussion

The purpose of this study was to compare the effects of 2 passive stretch maneuvers versus an active stretch on pectoralis minor length with a scapular lengthening program and see its effect on scapular kinematic outcomes of upward rotation and Lateral Shift (LSST).

Our results revealed that there was a significant change in pectoralis minor length in both groups when a pre-post analysis was done. The focused and gross passive stretches of group A were performed by the therapist in supine lying keeping the shoulder in abduction and external rotation while the active corner stretch was done by patients of group B. Both the groups showed changes in length at the end of 4 weeks and our findings were supported by the results of Arpit and Saleem who in their study found that a passive gross and focused stretch was effective in bringing about a change in length of the pectoralis minor [17]. Borstad and Ludewig in their study showed an improvement in length with the corner stretch in a 90º-90º arm position. Thus, irrespective of an active or passive force there was an improvement in both the groups in a pre-post analysis [27].

There was a significant increase in the scapular upward rotation in the pre-post analysis of both the groups suggesting an improvement in scapular kinematics. The rationale for this would be a decrease in the muscular imbalances seen in scapular dyskinesia. Lengthening of the pectoralis minor and an improvement in the strength of the posterior scapular muscles allow for better scapular positioning thereby rectifying the imbalance deficit to a significant level and facilitating better scapular mobility and rhythm [16,35]. This rationale was supported by the study done by Hyunn Lee and Cynn who concluded that there was a significant increase in scapular upward rotation after pectoralis minor stretching than in their control group which did not give the pectoral stretch, suggesting that there is a relation between the length on the pectoralis minor in the normal scapular kinematics, in terms of upward rotation [30].

An improvement in the muscle strength was observed with a reduction of lateral shift after the scapular strengthening program was administered to both groups over 4 weeks. Resisted exercises with an elastic band improved the weak posterior scapular musculature from the chronic rounded shoulder posture of asymptomatic sitting job professionals.

Resisted exercises bring about an improvement in muscle activity and contraction while also improving muscle mass and positioning in relation to its bony attachments [31,36]. This was also validated from feedback given by all the patients of both the groups who felt a difference in strength in the shoulder musculature and an improved tolerance to long sitting hours with a reduction in the forward head and rounded back postures common in them.

In a between-group analysis done for pectoralis minor length, there was a significant improvement in group A with passive focused and gross stretches compared to the active corner stretch of group B. These results were significant statistically and clinically. Our study was supported by the research by Arpit and Saleem on the acute effects of two passive stretch maneuvers on pectoralis minor length and scapular kinematics among colligate swimmers, who found that the group which was administered with gross stretch shoulders had a significant increase in pectoralis minor length compared to the control group patients who did not show similar improvement [17]. The gross stretch performed in our study was similar to Borstad & Ludewig's study in which the self-stretch was performed and both stretching maneuvers placed the humerus in an abducted and externally rotated position while stretching the shoulder while also retracting the scapula as done in this study [27]. And similar to Borstad & Ludewig's results, the gross stretch done in this study showed an improvement in the pectoralis minor length compared to control shoulders clinically [27]. This shoulder position was in accordance with other investigators' research who suggest that applying a stretch to the pectoralis minor will need the movement of the muscle's insertion posteriorly with retraction of the scapula, thereby lengthening the muscle effectively. We specifically performed the gross stretch with the subject's supine since it allowed for better control of the amount of overpressure applied during the stretches for the investigator [17,27]. Group B was not statistically significant as the patients were performing the corner stretch actively and independently in a standing position which may show different amounts of applied overpressure to the shoulder during the stretch.

A statistically and clinically associated improvement was seen in scapular upward rotation in group A when the between-group analysis was done. The rationale for this would be that there was a better and statistical improvement in pectoralis minor length in group A than in group B and also from a decrease in the muscular imbalances seen in scapular dyskinesia. This rationale was supported by the study done by Hyunn Lee and Cynn who concluded that there was a significant increase in scapular upward rotation after pectoralis minor stretching than in their control group which did not give the pectoral stretch, suggesting that there is a relation between the length on the pectoralis minor in the normal scapular kinematics, in terms of upward rotation [31].

A strengthening program for posterior scapular musculature was given commonly to both groups with a resistance band. So, when a between-group analysis was done, it concluded that no group was superior to the other in terms of the lateral shift outcome in all the ranges at 0°,45°, and 90°. The resisted exercises are given with an elastic band i.e., the scapular Y, T, W along with low rows and scapular punches work comprehensively to improve the weak posterior scapular musculature, which is: All the fibers of the trapezius, rhomboids, serratus anterior and external rotators of the arm [32,37,38]. These muscles lengthen and weaken as a result of the chronic rounded shoulder posture of asymptomatic sitting job professionals in both groups. Resisted exercises bring about an improvement in muscle activity and contraction while also improving muscle mass and positioning in relation to its bony attachments [31]. The exercises improved the muscle strength of the concerned scapular muscles responsible for the imbalance and rounded shoulder posture through the targeted elastic band exercises at the end of the 4-week protocol of this study in both groups as all the patients were given the same strengthening exercises with the same number of repetitions [10,22]. This was also validated from feedback given by all the patients of both the groups who felt a difference in strength in the shoulder musculature and improved tolerance to long sitting hours with a reduction in the forward head and rounded back postures common in them of both the groups. Thus, it explains that a positive, similar result in strength would be found in both the groups as understood from the pre-post analysis.

Conclusion

From the above study, it is concluded that the intervention given in both the groups had similar effects in improving scapular kinematics and pectoralis minor length. However, the passive stretch technique in conjunction with strengthening was found to be a better approach in bringing about effective pectoralis minor lengthening and thereby, reducing the overall dyskinetic movements of the scapula.

Conflict of interest

None.

Funding

None.

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