A Comparative Study Between Scapular Proprioceptive Neuromuscular Facilitation With Conventional Therapy And Conventional Therapy Alone, On Non Specific Neck Pain, Posture And Function

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Abstract: Background: In an estimated 50–80% of cases involving back or neck pain, an underlying pathology cannot be determined. One of the factors that has been implicated in the pathogenesis of neck pain is scapular function. Various studies correlate scapular dysfunction with a decrease in cranio-vertebral angle, i.e., forward head posture. Aim & Objectives: Our study aimed to compare between scapular proprioceptive neuromuscular facilitation with conventional therapy and conventional therapy alone on non-specific neck pain intensity using the Visual Analogue Scale, head – neck posture (Craniovertebral angle)using a modified goniometer, scapular posture using a modification of the Lateral Scapular Slide Test, and function using the Neck Pain and Disability Scale. Material And Methods: 60 patients with non specific neck pain and scapular dysfunction on the Lateral Scapular Slide Test were included. They were allocated into two separate groups. Treatment in both groups was given every alternate day for 4 weeks. A home exercise program was prescribed to be performed twice a day. Result: Results showed significant improvement in pain intensity, head-neck posture, scapular posture, and function in both groups. However, when compared, scapular PNF, along with conventional therapy, demonstrated significantly better results than conventional therapy alone in all parameters, which were satisfied at 95% CI with significance 0.05. Conclusion: This implies the need for identification and treatment of scapular dysfunction in neck pain patients. [M M Natl J Integr Res Med, 2020; 11(4):33-41]

Key Words: Non Specific Neck Pain, Proprioceptive Neuromuscular Facilitation, Scapular Dysfunction, Upper Crossed Syndrome

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Introduction: Neck pain is becoming increasingly prevalent in the general public. Disability associated with neck pain appears to be persistent and is the second most causal factor for time missed from work, leading to considerable economic consequences[1,2].

Forward head posture (FHP) has been strongly correlated with neck pain and disability[3]. There've been studies that correlated scapular dysfunction and a decrease in cranio-vertebral (CV) angle, i.e., FHP[4,5]. It has been theorized that altered axioscapular muscle function potentially contributes to neck pain due to abnormal loading of the cervical spine[6,7] or through the formation of myofascial trigger points[8,9]. Most studies on neck pain have focused principally on the abnormalities seen in the upper trapezius. However, recently, several studies have also demonstrated an altered activity of the serratus anterior[10,11,12,13].

One of the key causes of the loss of muscular equilibrium is proprioceptive dysfunction[14,15]. Critical to effective motor control is precise sensory information of the internal and external environment. Hence proprioception is essential for the neuromuscular control of the dynamic restraints[16]. Proprioceptive Neuromuscular Facilitation (PNF) is a technique based on diagonal movement patterns that facilitate and correct sensorimotor function. It has been suggested that PNF corrects the impaired impulses emerging from proprioceptive receptors in the muscles[15,17].

We aimed to compare two treatment protocols for non specific neck pain – one which included PNF of scapular muscles along with conventional physiotherapy exercises, and one which included only conventional exercises. Our objective was to compare the effects of these two protocols on neck pain intensity – using the Visual Analogue Scale, head – neck posture (Craniovertebral angle) using a modified goniometer, scapular posture using the modified Lateral Scapular Slide Test (LSST) and function using the Neck Pain and Disability Scale.

Material & Methods: Institutional ethical committee approval was taken before commencing the study. Sample size was calculated using the below formula.

$$\text{n (Size per Group)} = \frac{\text{SD} \times (Z_\alpha + Z_\beta)^2}{\left(\text{SD}/\text{Effect Size}\right)^2}$$

Informed consent was procured from every patient in the study. 78 patients complaining of neck pain in an outpatient physiotherapy department of a tertiary care centre were examined. After a thorough screening, 60 patients were included in the study.

Patients were included if they satisfied the following: 1) Adults in the age group 18-40 years of both sexes 2) Neck pain bound superiorly by the superior nuchal line, inferiorly by an imaginary transverse through the T1 spinous process and laterally by the lateral borders of the neck 3) Sub- acute and chronic neck pain, i.e., onset > four weeks 4) Presence of scapular dysfunction on the Lateral Scapular Slide Test 5) Willing to participate in the study.

Patients were excluded if they suffered from any neurological disorder affecting the upper quadrant and trunk, any traumatic musculoskeletal disorders of the upper quadrant and trunk, vertebro basilar artery insufficiency symptoms, spinal surgeries and instabilities, and/or infective or malignant diseases of spine (Excluded = 18, Did not meet inclusion criteria =11, Declined to participate = 4, Dropouts = 3).

Pain intensity was documented using the Visual Analogue Scale. The scapular position was measured using the Lateral Scapular Slide Test (LSST). The head-neck posture was measured using a modified goniometer. The functional status of the patient was recorded using the Neck Pain and Disability Scale (NPAD).

A coin was tossed to decide the placement of the first patient, i.e., either in Group C (Control/ Conventional) or Group E (Experimental). After that, every patient was placed in the alternate group. After 4 weeks of intervention, the pain intensity, head-neck posture, scapular posture, and function was re-recorded for both groups.

Experimental Group (Group E): Patients in Group E were given Scapular PNF on the affected side only. The PNF technique used was rhythmic stabilization. Knott and Voss described this technique as resisting the agonist and antagonist pattern alternately without relaxation. It's used to improve strength, stability, balance, and to decrease pain 18,19. Scapular PNF was given in addition to the conventional exercise protocol. The PNF exercise was carried out by the therapist for three sessions every week on alternate days[20].

Figure 1: Anterior Elevation And Posterior Depression (Diagonal 1)

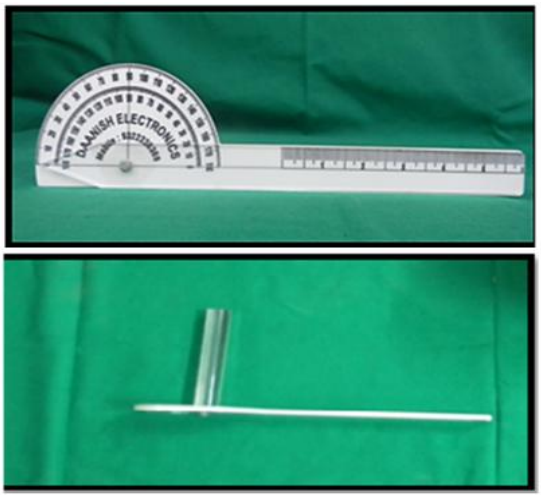
Figure 2: Anterior Depression And Posterior Elevation (Diagonal 2)

Conventional Group (Group C): Patients in Group C underwent conventional physiotherapy, encompassing posture correction exercises, and active neck mobility. Posture correction techniques included chin tuck exercises, stretching, and resisted isometrics for the neck muscles.

The protocol for both groups (Experimental and Conventional) was of a 4-week duration, with three sessions every week on alternate days[20]. The patient was advised a home program encompassing, neck mobility, resisted isometrics and self-stretching, to be performed twice a day in both groups.

Scapular And Head Neck Posture: The position of the scapula was measured using the Lateral Scapular Slide Test. The LSST distance is the difference between the affected and unaffected side of the distance between the inferior angle of the scapula and the corresponding spinous process. The LSST distance was measured in three shoulder positions – 0, 45, and 90 degrees of shoulder abduction. A difference of more than 1.5cm was considered pathological[21]. We modified this test to include the rotation component of the scapula. The head-neck posture was attained by measuring the craniovertebral angle - formed at the intersection of a horizontal line through the spinous process of C7 and a line through the tragus of the ear. An angle of less than 500 indicates forward head posture[22]. We used a modified tri-planar goniometer (Fig 3). Reliability testing for the modified goniometer was conducted, which showed statistically significant interrater and intrarater reliability, at p <0.01 .

Figure 3: Modified Goniometer



Modification of the LSST: The rotation of the scapula was calculated mathematically using the distance between inferior angle to spine, superior angle to spine and the inferior angle to superior angle. A reliability study was conducted, checking interrater and intrarater reliability using the Interclass Correlation Coefficient or ICC.

Moderate to excellent reliability was found for the measurements of the inferior angle of scapula to the spinous process, superior angle of scapula to the spinous process, and root of the spine of scapula to the spinous process, in all three shoulder positions.

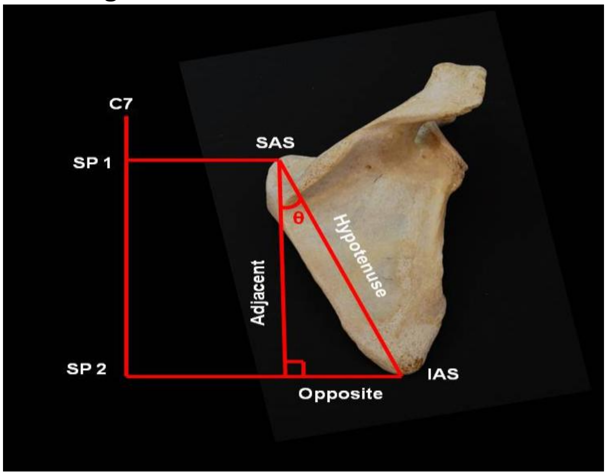
As shown in Figure 4, if a perpendicular is dropped from the superior angle of the scapula (SAS) to the horizontal line joining the inferior angle of the scapula (IAS) and the spinous process (SP2), a right-angled triangle is formed.

Hypotenuse = (SAS to IAS).Base of triangle= {(SP 2 to IAS) – (SP 1 to SAS)}. The angle of rotation of scapula θ, formed between the superior angle and the perpendicular, is then calculated using the trigonometric formula;

Sinθ = opposite ÷ hypotenuse, i.e.,
The base of the triangle ÷ hypotenuse
θ = sin -1 (base of the triangle ÷ hypotenuse)

A positive result indicates upward rotation, and a negative result indicates a downward rotation.

Figure 4: Modified LSST Calculation



Results: All data analysis was performed using SPSS version no 24.0. The data was tested for normality using the Shapiro Wilke Test. It was found to be normally distributed. All tests were performed considering two tails, 95% confidence intervals, and significance at 0.05. Sixty patients (30 from each group) were considered for the analysis.

All "pre" values, of Group E and C, were compared using Welch's t-test, which showed that variances were equal in both groups (i.e., not significant).

All data pertaining to VAS, Craniovertebral Angle, Lateral Scapular Slide Test, and NPAD was analyzed as per the information in the below Table 1.

Visual Analogue Scale: Both groups demonstrated a decrease in VAS, i.e., a reduction in pain intensity, which was statistically significant with p<0.0001 (Mean decrease in VAS; Group E 4.14 ± 0.11 with z = -4.785: Group C 3.39 ±0.14 with z = -4.784).

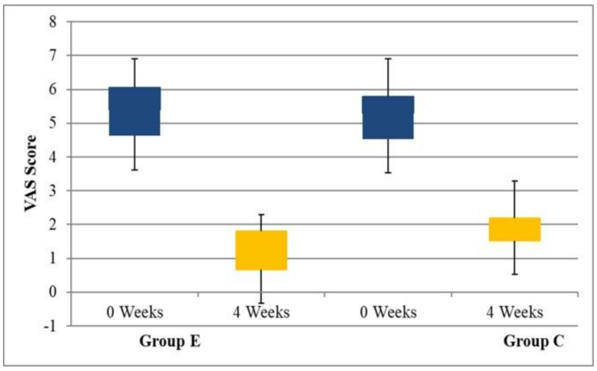
Both groups also demonstrated a large effect size (Group E dcliff = 0.618 Group C dcliff = 0.617), which implies that the change was clinically significant.

Group E demonstrated more statistically significant improvement when compared to Group C with z = -3.739, p = .000. Group E, when compared to Group C, showed a moderate effect size with dcliff = 0.483, which implies that the change is clinically significant. (Graph 1)

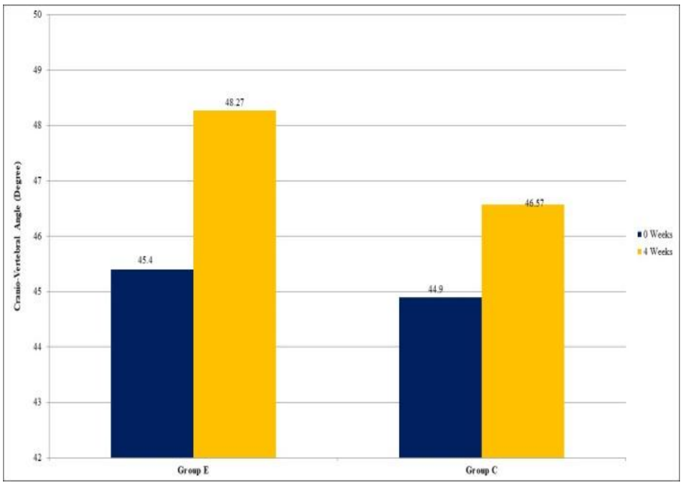
Table 1: Data Analysis

	Visual Analogue Scale (VAS)	Cranio Vertebral Angle (CVA)	Lateral Scapular Slide Test (LSST) Distance	Lateral Scapular Slide Test (LSST) Angle	Neck Pain and Disability Scale (NPAD)
Objective	Pain Intensity	Head Neck Posture	Scapular Posture	Scapular Posture	Function
Measured In	Score	Degrees	Centimetres (cms)	Degrees	Score
Type of Data	Qualitative	Quantitative	Quantitative	Quantitative	Qualitative
Test Used Within a Group For Statistical Significance	Wilcoxon's Signed Rank Test	Paired t-Test	Paired t-Test	Paired t-Test	Wilcoxon's Signed Rank Test
Test Used Between Two Groups for Statistical Significance	Mann Whitney Test	Unpaired t-Test	Unpaired t Test	Unpaired t Test	Mann Whitney Test
Test Used Within a Group For Clinical Significance	Effect Size using Cliff's delta	Effect Size using Cohen's delta	Effect Size using Cohen's delta	Effect Size using Cohen's delta	Effect Size using Cliff's delta
Test Used Between Two Groups for Clinical Significance	Effect Size using Cliff's delta	Effect Size using Klauer's correction of Cohen's delta	Effect Size using Klauer's correction of Cohen's delta	Effect Size using Klauer's correction of Cohen's delta	Effect Size using Cliff's delta

Graph 1: Comparative Box Plot Representing The Effect Of Group E And Group C On Pain Intensity Among The Non-Specific Neck Pain



Graph 2: Comparative Bar Graph Representing The Effect Of Group E And Group C On The Craniovertebral Angle In Non Specific Neck Pain Patients



Craniovertebral Angle: Both groups demonstrated an increase in CV Angle i.e. a decrease in FHP which was statistically significant (Mean increase in CV Angle Group E -2.87 ± 0.12 degrees; t = -23.04, p = .000; Group C –1.67 ± 0.09; t = -19.03, p = .000). Both groups also demonstrated a large effect size (Group E dcohen's 1.819; Group C dcohen's 1.007), which implies that the change was clinically significant.

Group E demonstrated a more statistically significant improvement when compared to Group C with p = .000 (Mean difference -1.2 ± .152, t = -7.88, p = .000). Group E, when compared to Group C, showed moderate effect size (DKorr = 0.719), which implies that the change is clinically significant (Graph2).

Lateral Scapular Slide Test (Lateral Translation): There was a decrease in the LSST distance, at 0-degree abduction, 45-degrees, and 90-degrees abduction, seen in both groups, i.e., a decrease in lateral translation, which was statistically significant. Both groups demonstrated a large effect size, which implies that the change is clinically significant in all three shoulder positions (Table 2). Group E demonstrated a change that is statistically and clinically significant over the change seen in Group C and a large effect size, at 0, 45, and 90 degrees of shoulder abduction (Table 2).

Table 2: LSST Distance At 0, 45 And 90 Degrees Of Shoulder Abduction

LSST distance (cm)	Statistical Significance (Mean Change ± SE)		Clinical Significance (Effect Size)	
	Group E	Group C	Group E	Group C
0 Shoulder Abduction	0.47 ± 0.04 cm t=13.39 p=0.000	0.25 ± 0.02cm t=11.22 p=0.000	$d_{cohen's}$ =2.46 Large Effect Size	$d_{cohen's}$ = 1.062 Large Effect Size
	t=-5.312 p =0.000		D_{Korr} = 1.029 Large Effect Size	
45 Shoulder Abduction	0.48 ± 0.02cm t=20.43 p =0.000	0.23 ± 0.02cm t=12.86 p=0.000	$d_{cohen's}$ =2.026 Large Effect Size	$d_{cohen's}$ =1.435 Large Effect Size
	3.1E-11 p <0.0001		D_{Korr} =1.061 Large Effect Size	
90 Shoulder Abduction	0.47 ± 0.01cm t=40.28 p=0.000	0.18 ± 0.01cm t=12.96 p=0.000	$d_{cohen's}$ =3.031 Large Effect Size	$d_{cohen's}$ = 1.439 Large Effect Size
	t=-15.96 p=0.000		D_{Korr} = 2.014 Large Effect Size	

Lateral Scapular Slide Test – Modification (Degree of Upward Rotation): At 0, 45, and 90-degrees shoulder abduction, there was an increase in the scapular rotation seen in both groups, i.e., an increase in upward rotation of the scapula. At all three angles, both groups demonstrated a statistically significant change. At 0 and 45 degrees, Group E demonstrated a moderate effect size, and at 90 degrees, demonstrated a large effect size showing the results to be clinically significant. At all three angles of shoulder abduction Group C demonstrated a small effect size, which implied that the change might not have been clinically significant. (Table 3). Group E, when compared to Group C, demonstrated a change that is statistically significant at all three angles of shoulder abduction. At 0 and 45 degrees, Group E showed a small effect size when compared to Group C, which implied that the change might not have been clinically significant. At 90 degrees, however, Group E, when compared to Group C, showed a moderate effect size, which implied that the change was clinically significant. (Table 3)

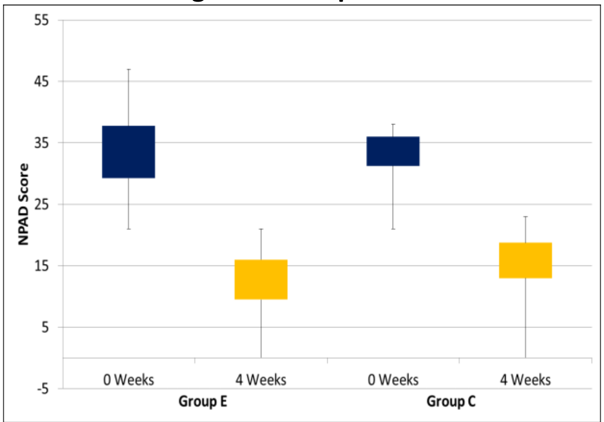
Table 3: Scapular Rotation At 0, 45 And 90 Degrees Of Shoulder Abduction

Scapular Rotation (degrees)	Statistical Significance (Mean Change ± SE)		Clinical Significance (Effect Size)	
	Group E	Group C	Group E	Group C
0 Shoulder Abduction	0.92 ± 0.13 deg t=-6.013 p =0.000	0.37 ± 0.09deg t=-2.650 p=0.013	$d_{cohen's}$ = 0.705 Moderate Effect Size	$d_{cohen's}$ = 0.179 Small Effect Size
	t=2.029 p=0.047		D_{Korr} = 0.342 Small Effect Size	
45 Shoulder Abduction	1.28 ± 0.11deg t=-6.518 p=0.000	0.75 ± 0.12deg t=-4.182 p=0.00	$d_{cohen's}$ = 0.787 Moderate Effect Size	$d_{cohen's}$ = 0.386 Small Effect Size
	0.04 p <0.05		D_{Korr} = 0.288 Small Effect Size	
90 Shoulder Abduction	1.90 ± 0.26deg t=-5.487 p=0.000	0.67 ± 0.17deg t=-3.681 p=0.00	$d_{cohen's}$ = 0.968 Large Effect Size	$d_{cohen's}$ = 0.259 Small Effect Size
	t=-3.147 p=0.003		D_{Korr} = 0.533 Moderate Effect Size	

Neck Pain And Disability Scale: Both groups demonstrated a decrease in NPAD score in both groups, i.e., an increase in function, which was statistically significant with $p<0.0001$ (Mean decrease in NPAD; Group E 22.73 ± 0.94: Group C 17.8 ± 0.59). Both groups also demonstrated a large effect size (Group E dcliff's = 0.618 and Group C dcliff's = 0.618), which implies that the change was clinically significant.

Group E demonstrated a more statistically significant improvement when compared to Group C with p <0.0001. Group E, when compared to Group C, showed a moderate effect size (dCliff = 0.495), which implies that the change is clinically significant (Graph 3).

Graph 3: Comparative Box Plot Representing The Effect Of Group E And Group C On The NPAD Scale Among The Non-Specific Neck Pain



Discussion: Sensorimotor control of stable upright posture relies on the afferent information from the vestibular, visual, and proprioceptive systems. The cervical spine has an essential role in providing proprioceptive input. Muscle spindles are found in high densities, especially in the suboccipital region where there are up to 200 muscle spindles that relay information to the central nervous system.

The cervical afferents are involved in 3 reflexes (cervico-collic reflex, cervico-ocular reflex, and tonic neck reflex). Out of these, the cervico-collic reflex is responsible for maintaining a neutral head posture. It is activated in response to the stimulation of muscle spindles located in these muscles[24,25]. Alterations in muscle spindle activity can possibly lead to reduced sensitivity to changes in the position of the head. As PNF works by using various proprioceptors in the body, it may have had a facilitatory effect on the muscle spindle function[26,27,] which may have led to increased sensitivity to change in head posture and optimal functioning of the cervico-collic reflex. The neuromuscular system, in most cases, is trying to identify the most efficient and coordinated manner to perform tasks, but in dysfunctional states like FHP, it is unable to make the appropriate corrections. Through the use of principles of PNF, namely repetition and resistance, the system experiences more efficient and coordinated recruitment[27]. This could possibly aid in the relay of information to the CNS, providing enhanced feedback regarding the posture of the head in relation to the body, and thus may perhaps have been accountable for the more effective correction in the CV angle in the Group E.

Using autogenic inhibition, the PNF technique of rhythmic stabilization takes advantage of the viscoelastic properties of the musculotendinous units by adding resistance to an already tensed (tight) muscle, allowing it elongate[28,29].

During reciprocal inhibition, the relaxation of the antagonist (target) muscle is a result of the decrease in the neural activity, and the increase of inhibition of proprioceptive structures in the muscle. The Ia afferents from the agonist that lead to excitatory efferents to the muscle group also send inhibitory efferents to the antagonist (target) muscle group. The resulting inhibition of target muscle motor neurons can be further augmented by increased excitatory input arising from opposing muscle Ia afferents converging onto the same Ia-inhibitory interneurons. This increase in Ia afferent input is commonly seen in PNF, which could explain the superior results seen in Group E[26,30].

Stress relaxation is what occurs when the musculotendinous unit (MTU), which involves the muscles and the connected tendons, is under a constant stress. Stress on the muscle with constant activation or resistance can cause passive torque (resistance to stress) and muscle stiffness to decrease. Hence through the PNF patterns, the tight, overactive muscles can relax more efficiently[29].

Resistance applied during rhythmic stabilization leads to the storage of elastic energy, which increases the force production in contracting muscle. As force production is directly related to motor unit activation, a maximum number of motor units are activated, resulting in the possible improvement of serratus anterior activity. The use of maximal resistance improves the ability of muscles to contract and induces better motor control and motor learning and also increases awareness about the movement and the direction[31]. This correction in the length-tension relationship of the scapular rotators such as levator scapulae and pectoralis minor, and increase in the recruitment of the serratus anterior and trapezius, possibly brought about by the scapular PNF in Group E, may have lead to its more significant improvement in scapular rotation, as compared to that in Group C.

As the scapula moves from 0 degrees to 90 degrees of shoulder abduction, the length-tension relationship of the agonists improves, leading to a more forceful contraction. The effect of stretching to the antagonists can be optimally appreciated when the scapula upwardly rotates, and places them in a stretched position. Hence, the statistical and clinical effects are seen more at 90 degrees of shoulder abduction.

During rhythmic stabilization, when the muscle is resisted, a large force is produced in the muscle, which stimulates the mechanoreceptors. As the mechanoreceptor afferents get activated, they block the pain signals trying to pass through the spinal cord. Hence the pain – gate mechanism could be a probable reason for the added reduction in the pain intensity, on the VAS score, in Group E.

Conclusion: Scapular PNF is an easily applicable technique, and it does not require extra space or any specialized equipment. It brings about significantly more improvement in neck pain intensity as well as head-neck and scapular posture. Improvement of the posture of the head and scapulae leads to improved stability of the cervicothoracic spine, which reduces disability and improves function Hence identification of scapular dysfunction and treatment of the same using the PNF technique of rhythmic stabilization should form an integral part of physiotherapy management for patients with non specific neck pain.

Limitations: Reversibility of the effects was not observed after the study duration was over. The inclusion criteria for scapular dysfunction did not include scapular rotation values. The thoracic spine posture was not monitored, which may have influenced the results of our study.

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