MET to Levator Scapulae Versus MET to Anterior Scalene: Comparative Effects on Craniovertebral Angle and Cervical Joint Position in Forward Head Posture

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Background: Forward head posture (FHP) results in an accentuated posterior curve in the higher thoracic vertebrae and an accentuated anterior curve in the lower cervical vertebrae. Dysfunction leads to muscle imbalance, where one side of the neck and scapula muscles become weak and the opposite group of muscles become tight. Strategies to correct this imbalance by treating flexibility and improving strength are the need of the hour.

Purpose: The aim of this study is to assess the effectiveness of muscle energy technique (MET) to levator scapulae versus MET to anterior scalene in improving craniovertebral angle (CVA) and joint position sense.

Setting: This study was conducted at the outpatient department of Dr. D. Y. Patil College of Physiotherapy, Pune, India.

Participants: Both males and females aged between 18 and 30 years with a CVA <48° were included.

Research design: This was an experimental study.

Intervention: A comparative experimental study was done on subjects aged between 18 and 30 years with CVA<48°. Group A (n = 15) received MET to levator scapulae muscles with conventional treatment and group B (n = 15) received MET to anterior scalene muscles with conventional treatment for 4 weeks, three sessions per week. The outcome measures assessed were CVA and cervical joint position error, pre- and post-intervention.

Main outcome measures: CVA and cervical joint position sense.

Results: MET to levator scapulae and anterior scalene significantly improved the FHP (p = 0.001 for both the groups) and cervical proprioception (p = 0.001 for both the groups) using the Wilcoxon signed rank test for pre–post comparison. However, on comparison between groups using the Mann–Whitney U test, MET to levator scapulae was better in improving the FHP (p = 0.002). No significant difference was found in the cervical joint position sense between both the groups.

Conclusion: Levator scapulae and anterior scalene flexibility should also be considered in FHP. Applying MET to these two muscles is not only beneficial in realigning the FHP but also in improving the cervical joint position sense.

KEYWORDS: Posture; cervical spine; proprioception; MET

INTRODUCTION

The most prevalent deviation from the ideal head posture in the cervical area is the forward head posture (FHP), defined as the head extending forward into the sagittal plane such that it is anterior to the trunk.[1] It results in an accentuated posterior curve in the higher thoracic vertebrae and an accentuated anterior curve in the lower cervical vertebrae to preserve balance.[2] FHP affects 66% of patients and is particularly common among university students and desktop workers because of their prolonged use of computers and smartphones or their poor posture during lecture hours. There is also a lack of knowledge about the importance and maintenance of a good cervical posture in most of the population.[3] Normally, the head's center of gravity is located anteriorly to the atlanto-occipital joint, and

there is little movement of the muscles responsible for stabilizing and upholding a neutral head posture. However, when the head leans forward or is moved forward in the sagittal plane, compared to the trunk, there is a sharp increase in muscle activity, particularly at the back of the neck, to name a few: upper trapezius, sternocleidomastoid, and levator scapulae. FHP alters the length of the cervical extensors and flexors' muscle–tendon units and hinders the function of the neck's deep as well as superficial stabilizing muscles, frequently leading to hyperactivity in those muscles.[4] This compensation causes muscle imbalance and alters the stress–strain diagram, which causes cervical spine overload.[5] Additionally, it increases the strain on the levator scapulae muscles, causing them to co-contract for extended cervical extension. Since FHP involves an excessive anterior placement of the neck, the scalene muscles are also affected.[6] These muscles when tight pull the lower cervical vertebrae in an anterior direction, exaggerating the FHP. According to the findings of the study by Kang et al., an extreme forward head position also reduces the forced vital capacity and increases activation of the anterior scalene and sternocleidomastoid muscles during breathing.[7] All these factors cause a decrease in the range of motion and a reduction in cervical joint play, thereby affecting the proprioception.

Proprioception is the sense of the body's movement and position wherein the neck musculature is rich in muscle spindle density which reflects a copious proprioceptive system.[8] It affects joint stability, body alignment, changes in muscle recruitment timing, movement control, and accuracy, leading to an inability to identify the positioning of joints.[9,10] In FHP, since the lower cervical spine is pulled in a rigidly flexed position and chronically holding this posture pulls the upper cervical vertebra in the continuously extended position, an excessive levator scapular and anterior scalene activity is observed causing its tightness. This issue of lack of flexibility can be treated by active stretching techniques like muscle energy techniques (METs).

MET is a soft tissue manipulation technique that works on the principle of autogenic inhibition. MET uses the energy or force of a muscle that is tight or shortened against an isometric resistance followed by relaxation of the same muscle. Using the post-isometric relaxation (PIR) principle, the muscle spindle and the Golgi tendon organs (GTOs), the two primary proprioceptors found in the muscles, are reflexively inhibited, reducing hyperactivity and tightness. This improves the range of motion and thereby the joint play and proprioception. Thus, when it comes to causing muscular relaxation, lengthening, and enhancing the range of motion, MET is the technique of choice. For addressing neck pain and FHP, the effectiveness of MET is researched commonly on muscles like the upper trapezius and suboccipital muscles[11,12,13]; however, there is a research gap in addressing the effectiveness of applying MET to particularly two muscles: anterior scalene and levator scapulae in FHP.[5] Shortening and hyperactivity of both these muscles are reported in FHP causing tightness, which might be improved by MET as both the muscles are responsible for maintaining the cervical posture and equilibrium.[14] Levator scapulae being a posterior muscle and anterior scalene being an anterior neck muscle, the influence of both these muscles in improving the posture is still under-explored. There is a gap in the literature that has reported changes in cervical joint position sense using MET. Hence, the purpose of this study is to find the effect of MET on levator scapulae and anterior scalene in subjects with FHP and also to compare both these techniques.

METHODS

Design

This was a comparative experimental study.

Ethical Consideration

Ethical approval was obtained from the Institutional Ethical Committee of Dr. D. Y. Patil College of Physiotherapy, Pune (number: DYPCPT/IEC/05/2023). Voluntary participation was ensured and written informed consent was obtained from all participants before enrollment.

Randomization

An investigator was assigned for performing the randomization of the samples using the sealed envelope method who was blinded to the interventions.

Participants

Both males and females between the ages of 18 and 30 years with craniovertebral angle (CVA) <48° were included in the study. Participants having cervical spine fusion, congenital anomalies of the spine, fractures of the upper limb, radiculopathy, vertigo, cardiovascular diseases, and neurological conditions affecting the functioning of the upper and lower limbs and higher mental functions were excluded.

Sample Size Calculation

The sample size was calculated via openEpi version 3, an open-source calculator. The initial sample size calculated was 12 in each group with an α level confidence interval of 95%, and a β power of 80. Considering the attrition, 15 samples were included in each group. The odds ratio was kept at 37.

Outcome Measures

1. **Measurement of FHP through CVA:** The measurement of CVA was done using the Kinovea software which requires photographs of the lateral view of the neck which are further analyzed and uploaded using the software.[15] The subject was seated on a chair and a lateral view picture of the neck was clicked from the shoulder level. The OnePlus 7t Shenzhen model was used to click the pictures which were then uploaded to the Kinovea software to measure the CVA. To measure the CVA, the angle between the horizontal line passing through C7 and a line extending from the tragus of the ear to C7 was calculated using the Kinovea software.[16,17] A CVA <48°–50° is defined as FHP.[17]
2. **Measurement of cervical joint position error (JPE):** The cervical relocation test was used to measure the cervical joint position sense. This involves getting the neck back in a neutral position as accurately as possible on the targeted area. A laser pointer was fixed to a cycling helmet or headband. The target was made of concentric circles drawn on a graph paper that was placed on a wall at a distance of 90 cm from the subject. The concentric circles were drawn in 1 cm increments reaching up to 40 cm diameter of the outer circle. The circles were divided into four quadrants intersecting at zero. With the patient's eyes open, the laser point was first centered at the midpoint or the bull's eye point. A single trial session of neck rotation to the right and left, neck flexion and extension, and then reaching the center again was given. The same procedure was then done with eyes closed for three trials for all the movements of the neck; the subject was instructed to reach the neutral position and then the distance/error from the center was measured in centimeters. Using this distance, the Ø angle is calculated as follows[10,18]:

   Formula to calculate JPE :

   $\varnothing = \tan^{-1}$(error distance divided by 90 cm).

Procedure

After obtaining permission from the institutional ethical committee, the study was registered under the Clinical Trials Registry of the Government of India (https://ctri.nic.in/Clinicaltrials/login.php; registration number: CTRI/2023/06/053417) and written informed consent was obtained from the subjects. Subjects were screened based on the eligibility criteria. For those fitting the criteria, baseline measurements of the above outcome measures were taken on day 0 as pre-measurements and then the subjects were randomized to group A who were given MET to levator scapulae muscles with conventional protocol and to group B who were given MET to anterior scalene muscles with convention protocol for 4 weeks, three times a week. The Consolidated Standards of Reporting Trials (CONSORT) flow chart of the methodology is given in Figure 1.

For MET to the levator scapulae, the subject was in a supine position with the arm of the side to be treated, stretched out alongside the trunk with the hand supinated. The therapist's forearm lifted the neck into full flexion and then the head was turned fully into side flexion and rotation away from the side being treated. With the shoulder held caudally by the practitioner's other hand, and the head/neck in full flexion, side flexion, and rotation (each at its resistance barrier), all available slack was removed from the levator, from both ends. The subject was then asked to take the head backward toward the table, and slightly to the side from which it was turned, against the practitioner's

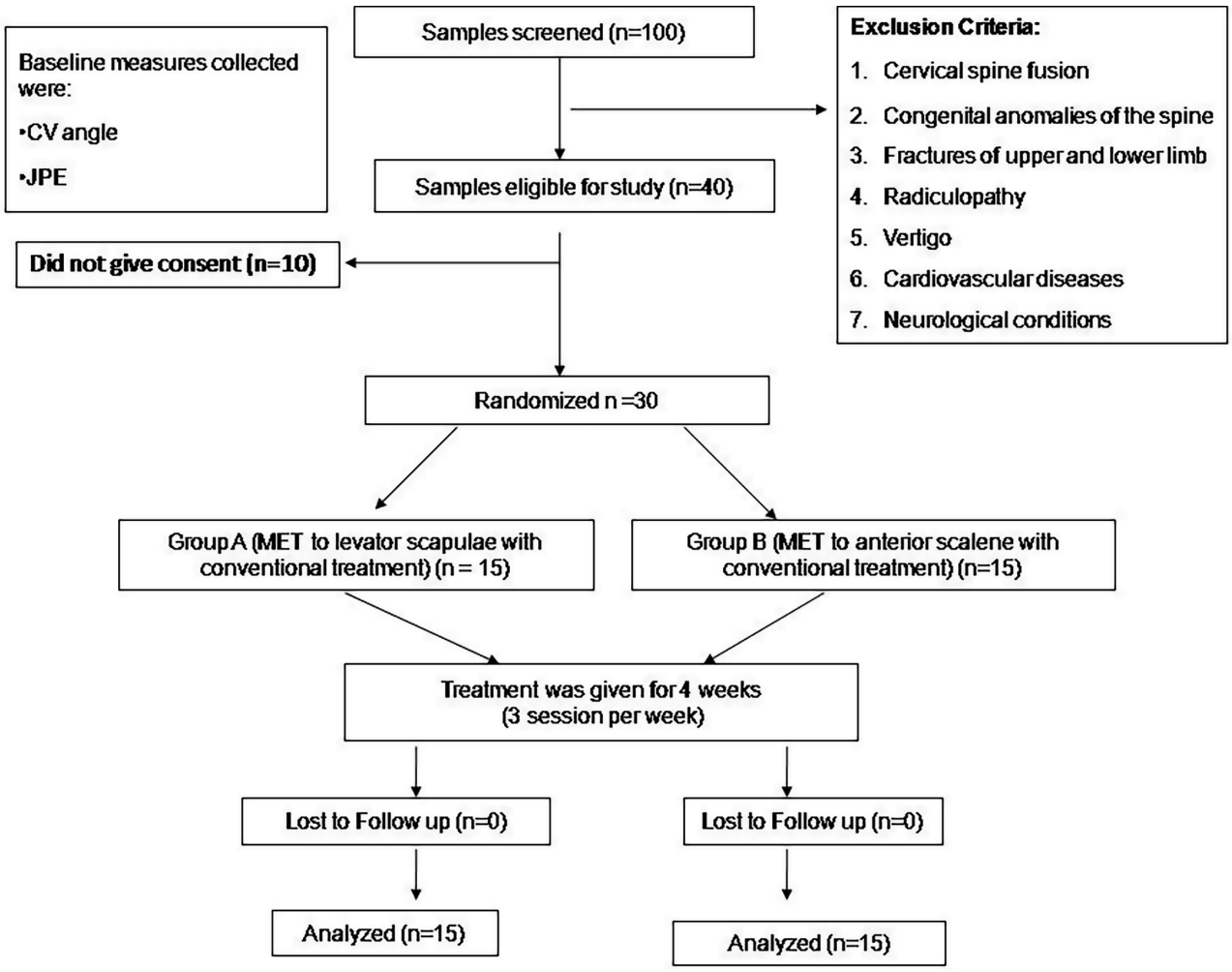

Figure 1. CONSORT flow chart. CV = craniovertebral; JPE = joint position error.

unmoving resistance, while at the same time a slight (20% of available strength) shoulder shrug (or superior movement of the scapula) is asked for, and resisted.[19]

For the treatment of anterior scalene, the subject was taken supine with a cushion or folded towel under the upper thoracic area so that, unless supported by the practitioner's contralateral hand, the head would fall into extension. The head was rotated contralaterally (away from the side to be treated). The practitioner's free hand was placed on the side of the subject's face/forehead to restrain the isometric contraction, which will be used to initiate the release of the scalene. The subject was instructed to attempt to lift the forehead a fraction and to attempt to turn the head toward the affected side, resisted by the practitioner's hand to prevent both movements, together with appropriate breathing cooperation ("breathe in and hold your breath as you 'lift and turn,' and hold this for 7–10 s").[19]

Both the groups were given MET for three repetitions with 10-s hold, progressing to five repetitions with 10-s hold in the fourth week.

Both groups were given the conventional protocol of the FHP that included hot fermentation for 10 min, chin tucks initially given for 5 repetitions of 5-s hold progressing to 10 repetitions with 5-s hold in the fourth week, scapular sets beginning with 5 repetitions of 5-s hold progressing to 10 repetitions of 5-s hold during the fourth week, and cervical range of motion exercises, initially given for 5 repetitions increasing to 10 repetitions in the fourth week.[20]

Statistical Analysis

Data were checked for normality using histogram or QQ plot. Distribution is not

normal; hence, non-parametric tests were used. Descriptive statistics was used for demographic analysis. A between-group analysis of group A and group B was done using the Mann–Whitney U test, while a pre–post comparison for each group was done using the Wilcoxon signed rank test. Data were calculated using Statistical Package for Social Sciences (SPSS), version 25.

RESULTS

Demographic Analysis

The mean age of the population was 23.4 ± 1.54 years in group A and 23.4 ± 2.58 years in group B. Among the samples, females had more prevalence of FHP as compared to males in both the groups, with the number of females being 12 in group A while 11 in group B. Table 1 depicts the baseline data comparison of both groups showing no statistical difference.

Difference of Variables in the Groups

Pre–post comparison of both the groups using the Wilcoxon signed rank test showed that group A as well as group B improved the FHP as described through the CVA (in degrees) with p = 0.001 depicting highly significant value for both the groups. Cervical joint position sense as measured through the JPE (in degrees) also showed highly significant improvement, with p = 0.001 for the right and left JPE in both the groups. The details of the within-group comparison are provided in Tables 2 (for group A) and 3 (for group B). For between-group comparison, the Mann–Whitney U test was used where the mean difference of the FHP in group A as compared to group B showed a significant improvement with a p-value of 0.002 as described in Table 4. Changes in the JPE were similar in both the groups on comparison, with p = 0.158 for right JPE and 0.055 for left JPE. The confidence intervals for the above variables range from 0.000 to 0.181 for the Wilcoxon signed rank test, while for the Mann–Whitney U Test, it ranges from 0.000 to 0.193 for CVA changes and JPE improvement.

DISCUSSION

The current study compared the effectiveness of MET to levator scapula versus anterior scalene on CVA and proprioception in FHP subjects. The results showed a significant improvement in CVA and cervical joint position sense before and after the interventions in both groups. However, in comparison, both techniques were equally effective although the FHP improved better with MET to levator scapulae muscles than anterior scalene. The mean age of the population affected by FHP was 23.4 years. A study done by Sirajudeen et al. on the prevalence of FHP in students aged ≥18 years showed that because of the increasing use of gadgets like mobiles and computers for a longer duration, the neck undergoes sustained flexion posture, leading to FHP.[21] Similarly, a study done by Elhafez et al. showed the prevalence of the age group affected by FHP was between 20 and 24 years.[3]

When assessing for FHP, the present study found a higher prevalence of FHP in females as compared to males. These results are similar to those of a study done by Mahmoud et al. who found that females were more prone to FHP than males.[22] In a study done by Sheth et al., it was also found that women had double the incidence of FHP compared to men. Females are more prone to postural changes due to reduced pain threshold and reduced physical activity.[23] Another possible contributing reason to the findings might be the habitual

TABLE 1. Baseline Data Analysis

Outcome	*Group A*			*Group B*			*p-Value*	*z*
	Mean ± SD	*Standard Error*	*Median*	*Mean ± SD*	*Standard Error*	*Median*		
CV (°)	37.29 ± 2.93	0.75	37.60	38.18 ± 3.72	0.96	39.10	0.395	−0.851
JPE right (°)	5.65 ± 2.13	0.55	6.34	5.36 ± 1.76	0.45	5.71	0.691	−0.397
JPE left (°)	5.42 ± 1.86	0.48	5.07	5.78 ± 1.85	0.47	5.71	0.425	−0.798

CV = craniovertebral; JPE = joint position error; SD = standard deviation.

TABLE 2. Pre–Post Analysis—Group A using the Wilcoxon Signed Rank Test

Outcome	*Pre*			*Post*			*p-Value*	*z*
	Mean ± SD	*Standard Error*	*Median*	*Mean ± SD*	*Standard Error*	*Median*		
CV (°)	37.29 ± 2.93	0.75	37.60	42.75 ± 2.86	0.73	42.2	0.001**	−3.408
JPE right (°)	5.65 ± 2.13	0.55	6.34	2.16 ± 1.27	0.32	1.9	0.001**	−3.409
JPE left (°)	5.42 ± 1.86	0.48	5.07	2.41 ± 0.93	0.24	2.54	0.001**	−3.413

CV = craniovertebral; JPE = joint position error; SD = standard deviation.

p < 0.05 significant, **p-value highly significant.

TABLE 3. Pre–Post Analysis—Group B using the Wilcoxon Signed Rank Test

Outcome	*Pre*			*Post*			*p-Value*	*z*
	Mean ± SD	*Standard Error*	*Median*	*Mean ± SD*	*Standard Error*	*Median*		
CV (°)	38.18 ± 3.72	0.96	39.10	41.47 ± 3.23	0.83	42.2	0.001**	−3.408
JPE right (°)	5.36 ± 1.76	0.45	5.71	2.79 ± 1.56	0.4	1.9	0.001**	−3.325
JPE left (°)	5.78 ± 1.85	0.47	5.71	3.84 ± 1.52	0.39	3.81	0.001**	−3.184

CV = craniovertebral; JPE = joint position error; SD = standard deviation.

p < 0.05 significant, **p-value highly significant.

TABLE 4. Comparison of Outcome Measures Between Both the Groups Using Mean Difference—Mann–Whitney U Test

Mean Difference	*Group A*			*Group B*			*p-Value*	*z*
	Mean ± SD	*Standard Error*	*Median*	*Mean ± SD*	*Standard Error*	*Median*		
CV(°)	5.46 ± 1.75	0.45	5	3.28 ± 1.27	0.32	3.10	0.002**	−3.154
JPE right (°)	−3.49 ± 1.11	0.28	−3.78	−2.57 ± 1.48	0.38	−3.13	0.158	−1.413
JPE left (°)	−3.01 ± 1.76	0.45	−3.17	−1.93 ± 1.35	0.34	−1.90	0.055	−1.916

CV = craniovertebral; JPE = joint position error; SD = standard deviation.

p < 0.05 significant, **p-value highly significant.

adoption of 2°–3° more cervical flexion by females than by males.[24] According to anatomical structure, the chest/bust size of females is larger than that of males, due to which there is a possible occurrence of the rounded shoulder inducing changes in the cervical and thoracic curves. Rounded shoulder is one of the most common adaptations which is seen and this correlates with the FHP and upper crossed syndrome.

The MET is a soft tissue mobilization technique where the primary focus is improving muscle flexibility by active contraction followed by relaxation. Both the groups in this study showed an improvement in FHP and cervical joint position sense after the PIR technique of MET. A study done by Adkitte et al. concluded that MET improves the flexibility of the involved muscles.[25] Likewise, another research by Ahmed et al. claimed that PIR application results in greater alterations in muscular extensibility.[26] In another study, Abraham quoted that applying MET is better in improving flexibility than stretching.[27] The results of the present study are in alignment with those of all the above cited studies depicting that MET is an effective technique for

improving the FHP. MET improves extensibility and strengthening through neck exercises which will eventually strengthen the weak muscles, altogether improving muscle imbalance, reducing the pain associated with the cervical area.[25]

Mechanoreceptors found in musculotendinous tissue include muscle spindles that are embedded in the muscle tissue and GTOs, which are arranged at different intervals along the musculotendinous junction. Muscular tendon fibers intended to link to muscle fibers travel through each GTO. Due to this series structure, as well as the sensory terminals' relatively low threshold and great dynamic sensitivity, GTOs may transmit input to the central nervous system on muscle tension. Rather than passive stress, which is created during inactive muscle stretching, GTOs predominantly communicate active muscular tension, which is developed during contraction. This phenomenon is specifically addressed by the MET technique.[28] Since the GTO and muscle spindle are influenced by MET, an indirect effect might also be seen on the proprioception.[29] Lowering motor neuronal discharges and relaxing the musculotendinous unit by resetting its resting length and altering the Pacinian corpuscle, the inhibitory activities of GTOs in the tight muscle may contribute to a decrease in FHP.[29] The execution of the cervical sensorimotor control occurs through the cervical muscles by maintaining the cervical posture, thereby creating equilibrium. Thus, improvements in FHP will directly affect the head posture and balance. MET by targeting this sensorimotor control thereby improves posture and proprioception.[29] In the study done by Bagherzadeh et al., it was shown that MET is an effective procedure for improving proprioception along with the range of motion. Similarly, in the current study, both the experimental groups were given MET which improved proprioception and corrected the FHP.[30] This also suggests that the proprioceptive muscle spindle activity is negatively impacted by the shortened neck muscles brought on by the FHP, which lowers joint position sensing. Hence, after MET, the JPE reduced significantly.[28,30] One of the literature by Phadke et al.[31] claimed that MET when compared to static stretching was more beneficial in reducing pain and disability in neck pain patients. This might be because of the improvement in the tolerance toward stretch by stimulating the mechanoreceptors of the muscle which are accurately targeted in the PIR technique of MET.

The present study demonstrated that MET to levator scapulae improved posture and proprioception. When the cervical spine is stable, the levator scapulae acts as a scapular elevator and downward rotator but, if the upper extremity is stable, it will cause the cervical spine to extend and rotate ipsilaterally.[32] Shear force and compressive stress on the cervical spine can be increased by levator scapulae shortening, which can also impair muscular coordination and proprioception. A levator scapulae length deficit can impede motion by affecting muscle balance and movement. Levator scapulae are more prone to become shortened and dominant in muscle activations when compared to the scapular upward rotators. This can cause a disparity in scapular orientation and coordination of muscles. A shorter levator scapulae may lead to reduced neck flexion and contralateral rotation, abnormal scapular elevation, and increased shear force and compressive stresses in the cervical region.[33] By applying MET, through the PIR method, the shortened levator scapulae relaxed, facilitating a better length and extensibility, thereby improving the posture.

Another neck muscle related to the cervical area is the anterior scalene, the tightness of which can influence the development of a forward head position. The present study showed an improvement in cervical proprioception and the CVA when administered with MET to the anterior scalene. The anterior scalene overcompensates to maintain the head's weight by keeping it in flexion in those where deep cervical flexors or other posterior neck muscles are weak or inhibited. This excessive exercise might cause persistent stiffness and exacerbate FHP. Tightness or hypertonicity in the anterior scalene may exacerbate the forward head position by creating an imbalance in the tension in the muscles surrounding the neck and shoulders.[7] Hence, by applying MET to anterior scalene muscles, the flexibility increased, easing the maintenance of the neck in a neutral position.

When compared with MET to anterior scalene muscles, MET to levator scapulae muscles showed better improvement with reference to the mean difference values. Clinically, a reduction in flexibility is nearly always indicative of levator scapulae dysfunction. Since it is a posterior axio-scapular

muscle, it may cause or exacerbate shoulder girdle and cervical spine dysfunctions. Its distinct "twist" of fibers provides it with anatomical mechanical benefits that can have varying effects on the C1–C4 cervical spine vertebrae and associated joints. As the entire cervical area is functionally interdependent, failure of the levator scapulae may cause or overload the upper cervical segments, resulting in localized involvement of the muscles and/or joints.[34]

FHP results from an imbalance of muscle weakness and muscle tightness. By correcting the flexibility of tight muscles and improving the strength of weak muscles, the posture at the neck can be maintained. In combination with MET, the conventional protocol also was given with progression which might have improved the muscle recruitment of the weak muscles. This might also be the reason for an improvement in FHP and indirectly the joint position sense in both the groups.[35,36] Adding an MET technique will not only improve the posture but also help in restoring the proprioceptive function of the neck which is important in maintaining balance and equilibrium. Furthermore, the effectiveness of MET in releasing the tightened cervical muscles may also influence cervical headache complaints and increase the range of motion of the neck.

The current study demonstrated the effectiveness of MET to levator scapulae and anterior scalene muscles by improving FHP and cervical joint position sense. The strengths of this study lie in its study design being a single-blinded randomized controlled trial, adequate sample size, and structured protocol showing improvement in the comprehensive outcome measures.

CONCLUSION

Levator scapulae and anterior scalene flexibility should also be considered in managing FHP. Applying an MET to these two muscles is not only beneficial in realigning the FHP but also in improving the cervical joint position sense.

LIMITATIONS

Pain associated with FHP was not considered in this study. Although, on comparison, MET to both the muscles did not show any statistically significant difference; clinically, levator scapulae showed a better improvement in the outcome measures. Further analysis in this aspect was not considered. As this is a single-center study, generalizability of results cannot be done. The short-term effects of FHP and cervical joint position sense only were observed.

FUTURE SCOPE

A study can be conducted to observe the effect of different scapular muscles on FHP. The association of FHP with the respiratory system involving treatment of different postural muscles can also be studied. The long-term effects and carryover effects of the MET techniques on cervical proprioception or neck pain related to diverse occupation groups can be further explored. Other cervical muscles that are shortened in FHP can also be considered and the muscle activity can be studied post-MET.

CONFLICT OF INTEREST NOTIFICATION

The authors declare there are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Neha Kulkarni: conception and planning of work, writing and reviewing of the article, and final approval of the version. Riddhi Bhandari: conception and planning of work, and writing and reviewing of the

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