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Attentional focus strategies alter muscle activation during combined chin tuck and prone T exercise in individuals with forward head posture: a cross-over pilot study

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ABSTRACT

Aims: This pilot study aims to assess the feasibility and preliminary effects of external versus internal attentional focus cues on cervical muscle activation during combined chin tuck and prone T exercises.

Methods: This cross-over, prospective, and pilot study included 15 individuals with forward head posture (FHP). Photographic analysis using Kinovea software was performed to identify individuals with FHP. Surface EMG system (Noraxon, USA, Inc., Scottsdale, AZ) was used to assess the activation of the sternocleidomastoid (SCM), upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA) during a combined chin tuck and prone T exercise. Exercises were performed under three attentional focus conditions: unguided, internal, and external. Friedman and Wilcoxon signed-rank tests with Bonferroni correction were used to analyse differences.

Results: Friedman analysis revealed significant differences in SCM ($p=0.008$), UT ($p=0.012$), MT ($p=0.013$), and LT ($p=0.017$) activation across focus conditions, but not for SA ($p>0.05$). Pairwise comparisons showed that internal and external focus both increased SCM activation compared to unguided ($p=0.004$ and $p=0.008$), while internal focus significantly increased UT and MT activation ($p=0.013$ and $p=0.002$). LT activation showed an upward trend under internal focus but did not reach Bonferroni-corrected significance ($p=0.02$). No significant changes were observed in UT/MT and UT/LT ratios, although a decreasing (favorable) trend was noted under guided conditions ($p>0.05$).

Conclusion: This pilot study provides preliminary evidence that internal attentional focus cues may selectively enhance cervical and scapular muscle activation, particularly for the SCM, UT, and MT, with a similar trend noted for the LT during combined chin tuck and prone T exercises. These findings could support the potential role of attentional cueing in postural rehabilitation and guide the development of more targeted exercise protocols.

Keywords: Attention, neck muscles, electromyography, exercise therapy, posture

INTRODUCTION

Forward head posture (FHP) is defined as the forward protrusion of the head in the sagittal plane and is a common postural deformity among adults.[1] FHP leads to excessive extension of the upper cervical spine and flexion of the lower cervical spine. It is also recognized as a potential risk factor for neck and shoulder pain and abnormal scapular movement.[2]

Prolonged forward displacement of the head-neck complex causes cervical and scapular muscle imbalance and weakness. In individuals with FHP, the forward displacement of the head leads to shortening and weakening of the deep neck flexor muscles.[3] A key issue in individuals with FHP is compensatory hyperactivation and shortening of the sternocleidomastoid (SCM) muscle, resulting from deep neck flexor weakness.[4] Similarly, individuals with FHP show increased upper trapezius (UT) activation to counteract the heightened tension in the levator scapulae and support the weight of the head.[3] In individuals with FHP, shoulder isometric flexion was accompanied by greater activation of the UT and lower trapezius (LT) compared to performing the same exercises in a neutral head position.[5] Several studies have also demonstrated decreased serratus anterior (SA) activation in FHP, which is important for muscle scapular movement control.[1,5]

Numerous corrective exercises have been proposed to address the abnormal sagittal alignment in FHP. Among these, scapular retraction and craniocervical flexion have strong

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evidence for effectiveness in individuals with FHP without underlying musculoskeletal disorders.[6] Particularly the prone T exercise are widely used to minimize mechanical stress from altered scapular and cervical kinematics. The prone T exercise effectively strengthens scapular retractors, particularly the middle trapezius (MT) and LT, while limiting UT activation, supporting better muscle balance in FHP.[6,7]

In clinical practice, combining the chin tuck position with the prone T exercise may maximize postural correction outcomes, as it reduces cervical protraction and addresses related muscle imbalances;[6,8] however, maintaining correct cervical alignment consistently throughout the exercise remains challenging. Verbal cues directing attention either toward specific body movements (internal focus) or external targets related to task performance (external focus) have been frequently used to enhance motor learning and enhance muscle imbalances, particularly in lower extremity exercises.[9] Evidence suggests that internal attentional focus promotes heightened conscious control, increasing activation of task-specific muscles. In contrast, external attentional focus facilitates automatic movement control, reducing unnecessary muscle recruitment, and enhancing motor learning and athletic performance, such as vertical jump performance.[9-11] Verbal cues are commonly recommended to facilitate correct alignment during therapeutic exercises;[10,11] however, the effectiveness of internal versus external attentional strategies on cervical and scapular muscle activation, specifically in individuals with FHP, remains unclear.[9] Investigating how different attentional focus cues influence muscle activation during the chin-tuck position may help clinicians determine more effective approaches, enhancing outcomes for postural correction. However, to date, no research has investigated how these different attentional focus strategies influence neck and scapular muscle activation during combined chin tuck and prone T exercises in individuals with FHP.

Therefore, this pilot study aims to assess the feasibility and preliminary effects of external versus internal attentional focus cues on cervical muscle activation during combined chin-tuck and prone T exercises. Results from this pilot study will inform the methodology and sample size for the larger project.

METHODS

Study Design

This cross-over, prospective, and pilot study was conducted at the Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Gazi University between August 2024 and February 2025. This pilot study was conducted as part of a larger research project approved by the Gazi University Rectorate Ethics Committee (Date: 06.08.2024, Decision No: 2024/1260) in accordance with the principles of the 2018 Helsinki Declaration. Written informed consent was obtained from each of the participants at the beginning of the study.

Participants

This pilot study included 15 individuals with FHP who had a craniovertebral angle of less than 50 degrees. The study included individuals aged 18-35 who agreed not to participate in any other treatment or evaluation during the study period, were able to perform the exercises appropriately, and voluntarily consented to participate.

Participants were excluded from the study if they met any of the following criteria; experiencing pain in the neck, spine, upper extremities, or lower extremities within the last three months; having a body-mass index (BMI) greater than 25 kg/m^2; a history of intervertebral disc herniation, spondylosis, or neck injuries such as whiplash, or having undergone surgical intervention in the cervical region; the presence of visual or auditory impairments; neurological and orthopedic symptoms; any condition affecting muscle control; dermatological issues at electrode placement sites; hypersensitivity to adhesives; a history of recent surgery involving the measured muscles that could impair EMG quality. A sample size of 15 participants was selected to assess feasibility and effect size for future sample size calculation, in line with methodological recommendations suggesting a minimum of 12 participants per group in pilot trials.[12] Participants with FHP were recruited via convenience sampling through social media and university email announcements.

Measurement of the Craniovertebral Angle

The craniovertebral angle (CVA) was measured using lateral digital photogrammetry, a reliable and valid method supported by Kinovea Video Analysis Software.[13,14] Participants were photographed from their dominant side while standing naturally with their feet shoulder-width apart. A smartphone mounted on a tripod, positioned 1.5 meters away and adjusted to shoulder height, was used for imaging. The tragus and C7 spinous process were marked with visible markers, and participants wore tight-fitting clothing to ensure accurate marker placement. Participants were asked to stand in a comfortable position with their feet shoulder-width apart and to look straight ahead. To capture natural posture, participants marched in place five times before a lateral photograph was taken within the first five seconds.[13] The captured images were then transferred to Kinovea Video Analysis Software (version 8.15).[14]

Electromyography Measurements

Surface electromyography (EMG), a non-invasive method for measuring muscle activity, was performed using an 8-channel Noraxon MiniDTS system (Noraxon, USA, Inc., Scottsdale, AZ). Muscle activation was assessed in SCM, UT, MT, LT, and SA muscles.

Surface EMG signals were recorded using disposable, self-adhesive Ag/AgCl electrodes (Noraxon Dual EMG Electrode, U.S.A). To minimize skin impedance (<5 kΩ), the skin was shaved, lightly abraded with fine sandpaper, and cleaned with 70% isopropyl alcohol. Electrodes were secured with double-sided tape to ensure stability during the session. Electrode placement followed the recommendations of the European Recommendations for Surface Electromyography (SENIAM), with electrodes positioned parallel to the muscle fibers.[4,7] Measurements were taken unilaterally from the dominant side of each participant. Following electrode placement, skin impedance was measured using an ohmmeter and ensured to be below 5 kΩ.[2]

Electrodes were placed as follows: SCM one-third of the distance between the sternal notch and the mastoid process;[15,16] UT midway between the acromion and the seventh cervical vertebra; MT midway between the medial scapular border and the third thoracic vertebra; LT twothirds along the line from the trigonum spinae to T8;[7] and SA at the level of the fifth rib.[15]

Measurement of maximal voluntary isometric contractions (MVICs): Participants performed MVICs for each of the five muscles. Based on established protocols, each muscle was tested in postures designed to elicit maximal isometric activity. After the familiarization trials, participants performed three repetitions of MVIC measurements, each lasting 5 seconds, with 30-second rest periods between individual measurements and 1-minute rest intervals between repetitions. All MVIC measurements were conducted by the same investigator, who provided strong verbal encouragement to ensure maximal effort.[2]

The positions for measuring MVIC are standardized as follows: (1) for SCM, the subject is in a supine position, performing cervical flexion and rotation;[15,16] (2) for UT, the shoulder is positioned at 90° of abduction, combined with lateral flexion of the head to the same side and contralateral rotation;[7] (3) for MT, the arm is placed in a pronated T-position, ensuring the thumb points upward;[17] (4) for LT, the arm is positioned in a prone V-position, with the thumb directed upward;[17] (5) for SA, the shoulder is positioned at 125° of flexion.[15] These standardized positions ensure consistent and accurate measurement of muscle activation during MVIC testing.

Exercise procedures: Muscle activations were measured during the prone T exercise under three distinct conditions: unguided (without any corrective cues or adjustments to the cervical region), external focus, and internal focus (Figure 1). To ensure consistency, all participants received standardized instructions before testing.

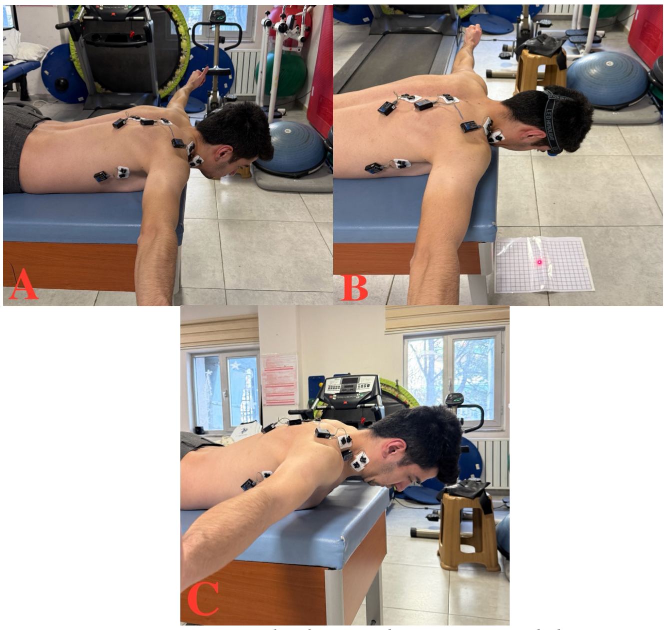

Figure 1. Prone T exercises under three conditions. A: Unguided prone T; B: External focus; C: Internal focus

Unguided (control) condition: Participants were instructed to perform the prone T exercise without any corrective cues or adjustments to the cervical region. In this position, participants performed prone horizontal abduction with the arm abducted, elbow extended, and humerus externally rotated. They lifted their hand toward the ceiling while retracting the scapula.[6] No additional instructions were provided during the control condition to record baseline muscle activation patterns without external influence and ensure result reliability (Figure 1A).[9]

Following the unguided condition, to ensure standardization of the exercises and achieve proper postural alignment prior to the exercises, participants were instructed on how to perform the craniocervical flexion through a gentle chin-tuck maneuver. The chin-tuck position was performed in supine position, and participants were instructed to maintain this position throughout exercise.[18] These focus instructions were provided in accordance with established guidelines from previous studies and relevant literature in the field.[9]

External focus condition: A headband with a laser pointer was placed on the participant's forehead, with the laser positioned between and slightly above the eyebrows. A flat wall was placed in front of the participant to project the laser beam. Participants were instructed: "position your head in the chin-tuck position and focus on the point where the laser hits the wall while performing the exercise" (Figure 1B).

Internal focus condition: Participants were instructed: "Position your head in the chin-tuck position and focus on maintaining the straight alignment of your neck while performing the exercise" (Figure 1C).

The sequence of MVICs and the internal and external focus conditions during the prone T exercise were randomized using "the Sequence Generator" (Random.org) to minimize order bias. To standardize the duration of each exercise phase, a metronome was set at 60 beats per minute, with each phase lasting 3 seconds. Participants performed three repetitions of each exercise to minimize fatigue. A 2-minute rest period was provided between repetitions to ensure adequate recovery.[2]

EMG data analysis: MyoResearch XP software (Noraxon) was used for EMG signal processing. Signals were band-pass filtered (20-450 Hz) and smoothed using a 100-ms RMS window. Muscle activity during prone T was normalized to MVIC, with averages from three repetitions expressed as %MVIC. Muscle activation was categorized as low (0-20%), moderate (21-40%), high (41-60%), or very high (>60%) activity.[2] Additionally, UT/MT, UT/LT, and UT/SA ratios were calculated from average %MVIC values to identify exercises suitable for targeting lower muscle ratios. Ratios were rated as moderate (0.8-1), good (0.6-0.8), or excellent (<0.6) (Figure 2).[7]

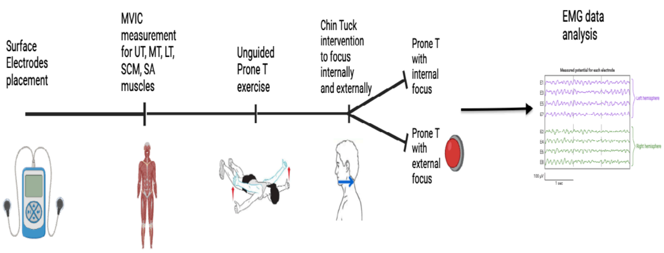

Figure 2. Testing protocol illustration

Statistical Analysis

All data analyses were conducted using SPSS version 24.0 (SPSS 24 for Windows, Armonk, NY: IBM Corp). Normality was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. As data were not normally distributed, values are reported as median and interquartile range (IQR). The Friedman test was used to compare muscle activations (SCM, UT, MT, LT, and SA) across different focus conditions (unguided, internal, and external). Wilcoxon signed-rank tests with Bonferroni correction were performed for pairwise comparisons when significant differences were found. A significance level of 5% was used for statistical tests.

RESULTS

From August to October 2024, 36 individuals were assessed for eligibility. Six had a BMI over 25 kg/m^2, five reported chronic neck and shoulder pain (≥3 months), and 10 had a craniovertebral angle (CVA) greater than 50° based on photogrammetric assessment. Therefore, 15 participants (8 females, 7 males) met the inclusion criteria and were enrolled in this prospective pilot study. All participants were right-handed, with a mean age of 22.2±1.8 years and an average BMI of 21.2±2.2 kg/m^2.

Significant differences in muscle activations between focus conditions were found for SCM (p=0.008), UT (p=0.012), MT (p=0.013), and LT (p=0.017), according to the Friedman test. However, the SA muscle activation did not differ significantly between focus conditions (p=0.074) (**Table 1, 2**). **Figure 3** shows an increasing trend in muscle activation under internal and external focus conditions compared to the unguided condition across all muscles.

Table 1. Normalized activity of each muscle at each focusing condition

Muscles	Maximal voluntary isometric contraction, %, median (IQR) (n=15)			
	Unguided	Internal focus	External focus	p^Y
SCM	3.28 (1.79-6.07)	6.9 (2.5-10.07)	5.7 (4.1-8.2)	0.008*
UT	33.3 (19.02-41)	39.5 (29.75-55.16)	37.2 (23.3-47.5)	0.012*
MT	42.9 (38.9-47.1)	48.1 (41.5-58.4)	48.1 (43.8-52.1)	0.013*
LT	45.4 (34.7-56.2)	56.7 (40.1-67.1)	49.8 (39.6-57.6)	0.017*
SA	11.5 (7.3-13.6)	12.7 (7-16.2)	14 (7.6-16.5)	0.074

IQR: Inter quartile range, SCM: Sternocleidomastoid, UT: Upper trapezius, MT: Middle trapezius, LT: Lower trapezius, SA: Serratus anterior, Y: Friedman test results, *: p>0.05

Table 2. Muscle activation ratios at each focusing condition

Muscles	Muscle activation ratios, median (IQR) (n=15)			
	Unguided	Internal focus	External focus	p^Y
UT/MT	0.8 (0.45-0.89)	0.75 (0.63-1.07)	0.69 (0.49-0.96)	0.368
UT/LT	0.73 (0.36-1.08)	0.69 (0.49-1.1)	0.79 (0.44-1.07)	0.116
UT/SA	3.21 (1.57-4.56)	3.35 (1.87-5.32)	2.8 (1.68-3.44)	0.232

IQR: Inter quartile range, UT/MT: Upper trapezius/middle trapezius, UT/LT: Upper trapezius/lower trapezius, UT/SA: Upper trapezius/serratus anterior, Y: Friedman test results

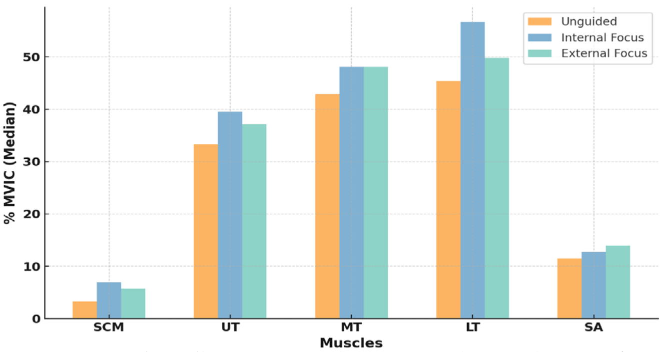

Figure 3. Bar chart illustrating muscle activation (%MVIC) across focus conditions

SCM: Sternocleidomastoid, UT: Upper trapezius, MT: Middle trapezius, LT: Lower trapezius, SA: Serratus anterior

However, when pairwise comparisons were statistically examined, SCM activation was significantly higher in internal and external focus conditions than in the unguided condition (p=0.004 and p=0.008). Nevertheless, no significant difference was found between internal and external focus for SCM muscle activation (p>0.05). While internal focus resulted in higher UT muscle activation compared to the unguided condition (p=0.013), no significant differences were found between external focus and either the unguided or internal focus conditions (p>0.05). MT muscle activation increased significantly with internal focus compared to unguided (p=0.002). However, the increase in MT muscle activity observed with external focus did not reach statistical significance after Bonferroni correction (p=0.03). Similarly, a trend towards higher LT muscle activation in internal focus compared to unguided was observed, but this did not reach the Bonferroni-corrected significance level (p=0.02).

Although no statistically significant differences were observed in the UT/MT, UT/LT, and UT/SA ratios across focus conditions (p>0.05), trends indicated a potential shift towards more favorable (lower) UT/MT and UT/LT ratios in both internal and external focus conditions.

DISCUSSION

The main objective of this study was to investigate cervical and scapular muscle activation levels under different attentional focus strategies during a combined chin-tuck and prone T exercise. According to the preliminary findings of this study, significant differences between conditions were observed for all muscles except the SA. Post-hoc analyses revealed that SCM activation was higher under both internal and external focus than the unguided condition. The internal focus of attention presented greater UT and MT muscle activation. In contrast, LT activation showed a clear upward trend in the internal focus condition but did not reach statistical significance after Bonferroni correction. The changes in muscle activation ratios were not statistically significant.

The chin-tuck maneuver typically is considered to increase the activation of deep cervical flexor muscles while minimizing the activation of superficial muscles such as the SCM.[19] However, this muscle activation pattern is often altered in individuals with neck pain or FHP due to impaired function of the deep cervical flexors and compensatory recruitment of superficial muscles, particularly the SCM.[4,16] Evidence suggests that individuals with neck pain tend to develop compensatory strategies involving increased SCM activation during craniocervical flexion.[16] Similarly in FHP, our pilot study observed significantly increased SCM activation under internal and external attentional focus conditions during the prone T exercise combined with chin-tuck. Dual-task activities are known to challenge the central nervous system (CNS) by simultaneously engaging cognitive and motor processes, often requiring adaptive changes in muscle recruitment to maintain postural control.[20] In our study, combining attentional focus cues with the motor task likely created such a dual-task demand, increasing the complexity of the exercise. Under these conditions, the CNS may prioritize stability by recruiting additional muscle support. While increased SCM activation is commonly observed in individuals with FHP, the additional rise seen during the exercise may raise concerns regarding the potential reinforcement of maladaptive patterns. Instead, the incorporation of attentional focus cues may facilitate controlled and functional activation of the SCM to maintain cervical stability.[21] This approach may be cautiously considered in early rehabilitation, especially when targeted SCM engagement is needed in individuals with FHP.

Previous research demonstrated that increased activation of the UT muscle in individuals with FHP could impair the scapular kinematics and overall postural stability.[2,4] Besides, Cools et al.[22] emphasized the biomechanical advantage of exercises that specifically aim to decrease UT activity, thereby promoting optimal scapular motion and muscle balance in this population. In our pilot study, our preliminary results indicated a significant increase in UT activation during the combined chin-tuck and prone T exercise under internal focus conditions compared to unguided conditions. Conversely, external focus conditions did not result in significantly increased UT activation. This contradictory response may be explained by the motor learning principles outlined by Wulf et al.,[11] suggesting that internal attentional focus promotes heightened conscious control and increased activation of task-specific muscles. In contrast, external focus encourages automatic movement control, reducing unnecessary muscle recruitment. Therefore, if the therapeutic goal specifically includes minimizing or maintaining UT activation during scapular stabilization exercises, external focus cues may be more effective in this population. Besides, despite increased UT activation under internal focus conditions, we found no statistically significant changes in UT/MT and UT/LT activation ratios. Nevertheless, the UT/MT ratio showed a decreasing trend from 0.8 in unguided conditions to 0.75 in internal focus and 0.69 under external focus, indicating a potential shift from moderate to good levels.[7] This suggests that despite increased UT activation, MT and LT engagement might help maintain muscle balance, given that a lower stabilizer-to-UT ratio is considered beneficial in rehabilitation.[23] However, further studies with larger samples are needed to confirm this trend and better understand the clinical relevance of attentional focus on trapezius muscle activation.

Previous research demonstrated increased muscle activation of the pectoralis major, biceps brachii, and triceps brachii under internal focus conditions.[24,25] Consistent with these findings, our pilot study observed significantly increased MT activation under internal focus conditions. Although no statistically significant increase in LT activation was observed, a similar upward trend was noted under internal focus conditions. Conversely, external focus conditions did not significantly enhance activation of either MT or LT, aligning with previous literature that external focus can promote automatic control and reduce unnecessary muscle activation.[11,21] The lack of differences in external focus conditions may be attributed to the small sample size or the increased neuromuscular demands of maintaining a prone position while externally focused. Thereby, to enhance activation of scapular stabilizers such as MT and potentially LT, internal attentional focus during exercises might provide a more effective strategy, especially during early rehabilitation stages that prioritize isolated muscle strengthening.

The lack of significant differences in SA activation across the unguided, internal, and external focus conditions in this study may stem from the muscle's primary role in scapular stabilization. The SA functions to anchor the scapula against the thoracic wall and facilitate controlled protraction,[26] highlighting its relatively constant low-level activation during static tasks such as the prone T exercise. Given its stabilizing function, the SA may be less responsive to short-term attentional focus manipulations compared to more dynamically involved muscles. Additionally, the small sample size might have limited the statistical power to detect subtle variations in SA activation, a common constraint in surface EMG studies.[27] Notably, while UT muscle activation increased significantly, no corresponding change was observed in the UT/SA ratio. This finding aligns with previous research suggesting that the SA maintains consistent activation levels during scapular stabilization, even when UT demand rises.[28] Thereby, to better understand how attentional focus affects SA engagement, future studies should employ dynamic, high-SA-demand tasks.

Limitations

This study has several limitations. First, as a pilot study, the small sample size limits the generalizability of the findings. Additionally, although deep cervical flexors play a key role during chin-tuck, their activation could not be assessed due to the limitations of surface EMG, underscoring the broader importance of evaluating deep stabilizing muscles in postural rehabilitation contexts.[29] Moreover, the study did not include a specific assessment of cervical core stabilization, which may have influenced individual muscle activation responses. Another important limitation is that the study evaluated only acute muscle activation during a single session, which does not allow conclusions about the long-term training or clinical effects of attentional focus strategies. Future studies may benefit from including larger sample sizes, integrating cervical stabilization assessments, and adopting longitudinal designs to examine long-term neuromuscular effects.

CONCLUSION

This pilot study provides preliminary evidence that internal attentional focus cues may selectively enhance cervical and scapular muscle activation, particularly for the SCM, UT, and MT, with a similar trend noted for the LT during combined chin tuck and prone T exercises. External focus cues showed limited effects, possibly due to task-specific stabilization demands or small sample size. Findings suggest attentional cueing may support postural rehabilitation and guide targeted exercises. Beyond postural rehabilitation, the preliminary findings of this study may offer broader insights for neuromuscular retraining in shoulder pathologies characterized by altered cervical-scapular coordination, such as rotator cuff repair or subacromial impingement.[30]

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Gazi University Rectorate Ethics Committee (Date: 06.08.2024, Decision No: 2024/1260).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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