

Weakness and Imbalance of Neck Muscle Groups as Sources of Chronic Neck Pain: A Cross-Sectional Study

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ABSTRACT

Purpose: This study aimed to investigate weakness and strength imbalances of the four principal neck muscle groups and their association with pain intensity in adults with chronic neck pain.

Materials and Methods: This cross-sectional study enrolled 29 patients (22 men, 7 women; aged 20–70 years) with chronic neck pain attending private physiotherapy clinics in Zawia, Libya. The strength of the cervical and capital flexor and extensor groups was graded using manual muscle testing (0–5 scale), and pain intensity was recorded on a 10-point visual analogue scale (VAS). One-sample t-tests compared each muscle group against the normal grade of 5, paired t-tests examined imbalances between and within muscle chains, and Pearson correlations related muscle strength to pain. The significance level was set at $p < 0.05$.

Results: All four muscle groups were significantly weaker than grade 5 ($p < 0.001$). The capital flexors were the weakest group (mean 2.62 ± 0.49). Significant imbalances were found between cervical flexors and capital flexors ($p < 0.001$), between capital flexors and capital extensors ($p < 0.001$), and between the anterior and posterior muscle chains ($p < 0.001$), whereas cervical flexors and extensors were equally affected. Pain intensity correlated significantly with cervical flexor strength ($r = -0.455$, $p = 0.013$), capital extensor strength ($r = -0.406$, $p = 0.029$), and the anterior ($r = -0.400$, $p = 0.031$) and posterior ($r = -0.422$, $p = 0.022$) chain strength.

Conclusion: Chronic neck pain is characterized by pronounced weakness of all neck muscle groups, a selective deficit of the capital flexors, and specific flexor–extensor imbalances. Weaker muscle groups track with higher pain intensity, supporting targeted strengthening of the deep flexors in rehabilitation. (*Open J Biomed Res* 2026;5:147-154)

Keywords: Neck pain, muscle weakness, muscle imbalance, manual muscle testing, visual analogue scale.

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AUDIOABSTRACT



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INTRODUCTION

Neck pain is one of the most common musculoskeletal complaints worldwide and a leading contributor to years lived with disability. The Global Burden of Disease Study estimated

that neck pain affected approximately 222 million people in 2017, with incident cases approaching 47 million annually.¹ Its prevalence continues to rise in parallel with

sedentary occupations and prolonged screen exposure, and it imposes a substantial economic burden through health-care utilization, absenteeism, and reduced productivity.² For many patients the condition becomes chronic and recurrent, considerably diminishing quality of life.

The cervical musculature plays a central role in maintaining segmental stability: the deep flexors and extensors act as dynamic ligaments, controlling the neutral zone of each motion segment. It has been proposed that weakness of these muscles, and imbalances between synergistic and antagonistic groups, predispose the cervical spine to abnormal loading and may perpetuate pain.^{3,4} International guidelines therefore recommend active exercise particularly motor control and strengthening programs as a core component of management.^{3,5}

Despite this evidence base, most studies on cervical muscle weakness and imbalance originate from Europe, North America, and East Asia. Data from North Africa, and from Libya in particular, remain scarce. The present study was designed to quantify strength deficits and imbalances of the four principal neck muscle groups in Libyan patients with chronic neck pain and to examine their relationship with pain intensity.

A growing body of work has focused on the deep cervical flexors the longus colli and longus capitis whose impaired activation and reduced endurance are consistently reported in chronic neck pain. Tsiringakis et al.⁶ demonstrated, in a systematic review and meta-analysis, that motor control training of the deep neck flexors with pressure biofeedback significantly improves pain and disability. Similarly, Garzonio et al.⁷ confirmed that specific exercises targeting the deep cervical muscles are superior to general exercise in reducing pain in nonspecific neck pain. Mueller et al.⁸ extended this evidence by showing that resistance, motor control, and mindfulness-based exercises are all effective, with larger effects for higher training frequencies.

Evidence from occupational populations supports the clinical relevance of these findings. Iqbal et al.⁹ showed that adding deep cervical flexor training to conventional exercises in school teachers produced significantly greater improvements in pain, endurance, and disability than conventional exercise alone, highlighting the consequences of sustained flexed postures.

Beyond isolated weakness, chronic neck pain appears to involve altered motor behavior more broadly. Rampazo et al.⁴ documented sensory, motor, and psychosocial differences between patients with chronic neck pain and asymptomatic controls, while Asiri et al.⁵ reported that kinesiophobia correlates with pain, proprioception, and functional performance, underscoring the multifactorial nature of the condition.

Reliable measurement underpins all of this research. The visual analogue scale has well-established psychometric properties in neck pain, with good-to-excellent test-retest reliability and moderate association with disability questionnaires.¹⁰ Manual muscle testing remains the most accessible clinical measure of strength, and together these instruments allow the relationship between strength, imbalance, and pain to be quantified in routine practice.

Exercise remains the most consistently supported conservative intervention for chronic neck pain, yet the optimal type, dose, and progression of training continue to be debated. Price et al.¹¹ synthesized the available trial evidence and concluded that programs of sufficient duration and moderate frequency produce meaningful reductions in pain and disability, but that benefits attenuate when programs are brief or poorly supervised. Complementing this clinical evidence, Peng et al.¹² in a systematic review and meta-analysis of muscle morphology, confirmed that the longus colli is consistently smaller in patients with chronic nonspecific neck pain than in asymptomatic individuals, providing a structural correlate for the functional weakness

observed at the bedside. Taken together, these dose-response and morphologic data indicate that the muscular deficit in chronic neck pain is both measurable and, at least partly, reversible.

Beyond conventional strengthening, a range of adjunctive approaches has been examined with the aim of enhancing neuromuscular control and addressing psychological barriers to movement. Akodu et al.¹³ showed that combining neck stabilization exercises with Pilates reduced pain, sleep disturbance, and kinesiophobia in patients with non-specific chronic neck pain, suggesting that targeting fear of movement may amplify the benefits of exercise. In a similar vein, Osama¹⁴ reported that muscle energy techniques produced measurable gains in isometric neck muscle strength, indicating that manually guided active techniques may serve as a useful entry point for patients who cannot initially tolerate resisted loading. Collectively, these findings underscore the value of assessing not only strength but also endurance, posture, and psychosocial factors when planning rehabilitation for this population. Therefore, this study aimed to investigate weakness and strength imbalances of the four principal neck muscle groups and their association with pain intensity in adults with chronic neck pain.

MATERIALS AND METHODS

Study Design and Participants

This was a multi-center, cross-sectional, observational study conducted between December 2020 and January 2021 in the physiotherapy departments of two private clinics (Aldeqaa Clinic and Almokhtar Clinic) in Zawia City, Libya. Twenty-nine patients of both sexes (22 men, 7 women), aged 20–70 years, with chronic neck pain were recruited by convenience sampling. Participants were included if they reported persistent neck pain and were under active physiotherapy care. The study protocol, purpose, and procedures were explained to each participant, written informed

consent was obtained, and confidentiality of personal data was guaranteed. Participation was voluntary and participants could withdraw at any time without consequence.

Measurements

Manual muscle testing (MMT) of the four neck muscle groups cervical flexors, capital flexors, cervical extensors, and capital extensors was performed using the standard 0–5 grading scale: 0 = no contraction; 1 = trace contraction; 2 = movement with gravity eliminated; 3 = movement against gravity through full range; 4 = movement against gravity and resistance; 5 = normal power. Capital flexion was tested in supine (chin tuck without lifting the head), cervical flexion in supine (head lift without chin tuck), and capital and cervical extension in prone with the head beyond the end of the table. Pain intensity was measured with a 10-cm visual analogue scale (VAS), where 0 indicated "no pain" and 10 "the worst pain imaginable".

Statistical Analysis

Data were analyzed with SPSS. Descriptive statistics (means, standard deviations, ranges) summarized the sample. One-sample t-tests compared the mean grade of each muscle group against the reference value of 5; paired-samples t-tests compared strength between muscle groups and between the mean anterior (flexor) and posterior (extensor) chains; and Pearson correlation coefficients examined associations between muscle strength and pain intensity. Statistical significance was set at $p < 0.05$.

RESULTS

Twenty-nine patients completed the assessment (22 men, 75.9%; 7 women, 24.1%). Mean pain intensity on the VAS was 6.28 ± 2.03 (range 2–10), indicating moderate-to-severe pain in the majority of participants. The Descriptive statistics are showed in Table 1.

Table 1: Descriptive statistics of neck muscle strength and pain intensity (n = 29).

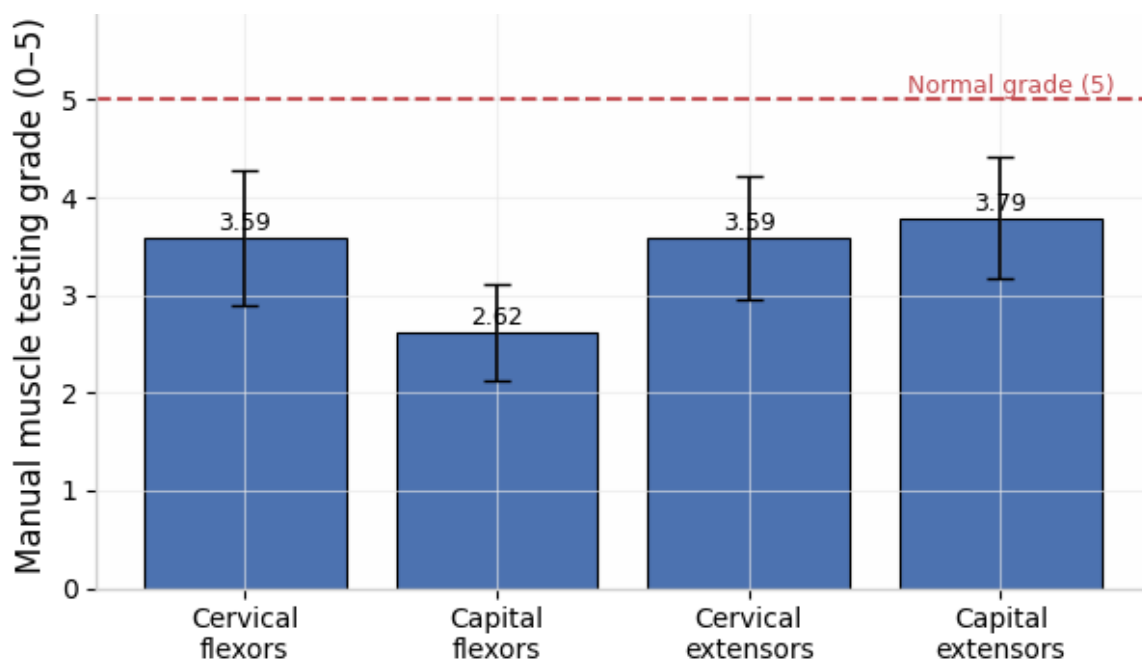
Variable	Minimum	Maximum	Mean	SD
Cervical flexors (grade)	2.00	5.00	3.59	0.68
Capital flexors (grade)	2.00	3.00	2.62	0.49
Cervical extensors (grade)	2.00	5.00	3.59	0.63
Capital extensors (grade)	2.00	5.00	3.79	0.62
Pain intensity (VAS 0–10)	2.00	10.00	6.28	2.03

All four muscle groups were significantly weaker than the normal grade of 5 (all $p < 0.001$) (Table 2). The deficit was largest for the

capital flexors, whose mean grade of 2.62 corresponded to less than 60% of normal strength (Fig 1).

Table 2: One-sample t-tests of muscle strength against the normal grade (test value = 5).

Muscle group	Mean difference vs 5	t (df = 28)	p
Cervical flexors	-1.41	-11.16	< 0.001
Capital flexors	-2.38	-25.95	< 0.001
Cervical extensors	-1.41	-12.13	< 0.001
Capital extensors	-1.21	-10.49	< 0.001


Fig 1: Mean manual muscle testing grades ($\pm$ SD) of the four neck muscle groups. The dashed line marks the normal grade of 5.

Paired comparisons revealed significant imbalances (Table 3). Cervical flexors were significantly stronger than capital flexors ($p < 0.001$), and capital extensors were significantly stronger than capital flexors ($p < 0.001$). In contrast, cervical flexors and cervical extensors

were equally weak ($p = 1.000$), and cervical extensors did not differ significantly from capital extensors ($p = 0.083$). The anterior muscle chain (mean 3.10) was significantly weaker than the posterior chain (mean 3.69; $p < 0.001$).

Table 3: Paired t-tests examining strength imbalances between neck muscle groups.

Comparison	Mean difference	t (df = 28)	p
Cervical flexors – Capital flexors	0.97	10.43	< 0.001
Cervical flexors – Cervical extensors	0.00	0.00	1.000
Capital flexors – Capital extensors	-1.17	-13.49	< 0.001
Cervical extensors – Capital extensors	-0.21	-1.80	0.083
Anterior chain – Posterior chain	-0.59	-7.84	< 0.001

Pain intensity correlated significantly and inversely with cervical flexor strength ($r = -0.455$, $p = 0.013$) and capital extensor strength ($r = -0.406$, $p = 0.029$) (Table 4). Correlations with capital flexor ($r = -0.248$, $p = 0.195$) and cervical extensor ($r = -0.327$, $p = 0.083$) strength were inverse but non-significant. Both the anterior chain ($r = -0.400$, $p = 0.031$) and the posterior chain ($r = -0.422$, $p = 0.022$) correlated inversely with pain, and the two chains correlated strongly with each other ($r = 0.723$, $p < 0.001$). All pairwise correlations among the four muscle groups were positive and significant ($r = 0.420$ – 0.719 , $p < 0.05$), indicating that weakness in one group coexists with weakness in the others.

Table 4: Pearson correlations between muscle strength and pain intensity ($n = 29$).

Variable	r with pain	p
Cervical flexors	-0.455	0.013
Capital flexors	-0.248	0.195
Cervical extensors	-0.327	0.083
Capital extensors	-0.406	0.029
Anterior muscle chain	-0.400	0.031
Posterior muscle chain	-0.422	0.022

DISCUSSION

The main finding of this study is that Libyan patients with chronic neck pain present with widespread, statistically significant weakness of all four neck muscle groups, a selective and pronounced deficit of the capital flexors, and specific imbalances both within the flexor compartment and between the anterior and posterior chains. These findings are consistent with the international literature documenting impaired activation and endurance of the deep cervical flexors in chronic neck pain^{6,7,9} and extend it to a North African population.

The capital flexors (the longus colli and longus capitis, together with the rectus capitis anterior) were the weakest group, averaging only 2.62/5. This is clinically important because these muscles provide fine segmental control of the craniocervical junction; their failure shifts postural demand to the superficial flexors, alters head posture, and may perpetuate pain the rationale for motor control retraining programs that have proven effective in randomized trials and meta-analyses.⁶⁻⁹ The significant anterior–posterior imbalance ($p < 0.001$) further supports the hypothesis that chronic neck pain involves a redistribution of

muscular function rather than uniform weakness alone.

The inverse correlations between pain intensity and the strength of the cervical flexors, capital extensors, and both muscle chains suggest a dose–response element: patients with weaker muscles reported more pain. Although the cross-sectional design precludes causal inference, the direction of association is compatible with the evidence that strengthening reduces pain.⁶⁻⁸ The non-significant correlation for the capital flexors, despite their greatest weakness, may reflect the coarse ordinal nature of MMT, which saturates at the lower end of the scale and may not discriminate well among severely weak patients.

The pattern of weakness observed in our patients aligns closely with recent morphometric evidence. The selective atrophy of the deep cervical flexors documented by Peng et al.¹² mirrors the disproportionate capital flexor deficit identified in the present study, reinforcing the view that the deep flexor compartment is a primary site of pathology in chronic neck pain. Our results are also consistent with the broader treatment literature: Kong et al.¹⁵ reported that traditional Chinese mind-body exercises reduce pain and disability in middle-aged and older adults with neck pain, while Khan et al.¹⁶ demonstrated that post-isometric relaxation and myofascial release techniques improve pain, functional disability, and quality of life. Similarly, Buttayat et al.¹⁷ found Thai massage and muscle energy technique to be comparably effective for chronic neck pain. The convergence of such diverse approaches on pain reduction suggests that several mechanisms mechanical loading, neuromodulation, and reduced muscle guarding may operate simultaneously, and that no single modality holds a monopoly on effectiveness.

From a clinical standpoint, these results argue for incorporating routine strength assessment into physiotherapy practice in settings such as Libya, where access to

advanced instrumentation like dynamometry or ultrasonography is limited. Although manual muscle testing is ordinal and examiner-dependent, it is inexpensive, portable, and was clearly sensitive enough to detect the pronounced deficits observed here; its reliability could be further improved through standardized training and adjunctive measures such as the craniocervical flexion test. Therapeutic strategies that combine active techniques with postural re-education appear particularly relevant: Joshi and Poojary¹⁸ showed that adding posture correction exercises to muscle energy techniques improved pain and function in patients with chronic neck pain and forward head posture, a finding directly pertinent to the capital flexor weakness we describe. Likewise, structured back-school programs that embed postural education into exercise have produced sustained benefits in adults with non-specific neck pain.¹⁹ Future work in this region should adopt prospective designs with asymptomatic controls, larger and sex-balanced samples, and objective strength measures to clarify causal pathways and to define the minimum effective dose of deep flexor training. Finally, a recent network meta-analysis comparing multiple exercise therapies for chronic nonspecific neck pain concluded that no single modality is clearly superior for improving function, reinforcing the case for individualized program selection based on each patient's specific strength deficits and clinical presentation.²⁰

This study has limitations. The sample was small ($n = 29$) and predominantly male, limiting generalizability; a convenience sample from two private clinics in a single city may not represent the broader Libyan population. MMT is an ordinal, examiner-dependent measure with limited sensitivity compared with dynamometry or electromyography. No asymptomatic control group was included, so the comparison against grade 5 relies on the conventional reference rather than matched healthy participants. Finally, the cross-sectional design cannot establish whether

weakness causes pain, pain-driven disuse causes weakness, or both reinforce each other.

CONCLUSION

Patients with chronic neck within this study exhibited significant weakness of all neck muscle groups, a selective deficit of the capital flexors, and clinically relevant flexor–extensor and anterior–posterior imbalances. Weaker muscle groups are associated with higher pain intensity. These results support routine assessment of cervical muscle strength in clinical practice and justify targeted strengthening particularly of the deep capital flexors as part of rehabilitation programs for chronic neck pain in this population.

AUTHOR CONTRIBUTIONS

Mostafa M. ElSoltan: Conceptualization, methodology, writing – original draft, investigation, data curation, and manuscript preparation, validation, critical review, writing – review & editing, and final approval of the manuscript. **Sayfuldeen E. Kushlaf:** Writing – original draft, investigation, data curation, manuscript preparation, and final approval of the manuscript. **Hisham M. Alimrani:** Writing – original draft, investigation, data curation, manuscript preparation, and final approval of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest concerning the research, authorship, and publication of this article.

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REFERENCES

1. Safiri S, Kolahi AA, Hoy D, Buchbinder R, Mansournia MA, Bettampadi D, et al. Global, regional, and national burden of neck pain in the general population, 1990–2017: systematic analysis of the Global

- Burden of Disease Study 2017. *BMJ*. 2020; 26;368:m791. doi: 10.1136/bmj.m791.
2. Kazeminasab S, Nejadghaderi SA, Amiri P, Pourfathi H, Araj-Khodaei M, Sullman MJM, et al. Neck pain: global epidemiology, trends and risk factors. *BMC Musculoskelet Disord*. 2022;23:26. doi: 10.1186/s12891-021-04957-4.
3. Corp N, Mansell G, Stynes S, Wynne-Jones G, Morsø L, Hill JC, et al. Evidence-based treatment recommendations for neck and low back pain across Europe: A systematic review of guidelines. *Eur J Pain*. 2021;25:275-295. doi: 10.1002/ejp.1679.
4. Rampazo ÉP, da Silva VR, de Andrade ALM, Back CGN, Madeleine PM, Arendt-Nielsen L, et al. Sensory, Motor, and Psychosocial Characteristics of Individuals With Chronic Neck Pain: A Case-Control Study. *Phys Ther*. 2021:pzab104. doi: 10.1093/ptj/pzab104.
5. Asiri F, Reddy RS, Tedla JS, ALMohiza MA, Alshahrani MS, Govindappa SC, et al. Kinesiophobia and its correlations with pain, proprioception, and functional performance among individuals with chronic neck pain. *PLoS One*. 2021 16:e0254262. doi: 10.1371/journal.pone.0254262.
6. Tsiringakis G, Dimitriadis Z, Triantafylloy E, McLean S. Motor control training of deep neck flexors with pressure biofeedback improves pain and disability in patients with neck pain: A systematic review and meta-analysis. *Musculoskelet Sci Pract*. 2020;50:102220. doi: 10.1016/j.msksp.2020.102220.
7. Garzonio S, Arbasetti C, Geri T, Testa M, Carta G. Effectiveness of Specific Exercise for Deep Cervical Muscles in Nonspecific Neck Pain: A Systematic Review and Meta-Analysis. *Phys Ther*. 2022;102:pzac001. doi: 10.1093/ptj/pzac001.
8. Mueller J, Weinig J, Niederer D, Tenberg S, Mueller S. Resistance, Motor Control, and Mindfulness-Based Exercises Are Effective for Treating Chronic Nonspecific Neck Pain: A Systematic Review With Meta-Analysis and Dose-Response Meta-Regression. *J Orthop Sports Phys Ther*. 2023 ;53:420–459. doi: 10.2519/jospt.2023.11820.

9. Iqbal ZA, Alghadir AH, Anwer S. Efficacy of Deep Cervical Flexor Muscle Training on Neck Pain, Functional Disability, and Muscle Endurance in School Teachers: A Clinical Trial. *Biomed Res Int*. 2021;2021:7190808. doi: 10.1155/2021/7190808.
10. Modarresi S, Lukacs MJ, Ghodrati M, Salim S, MacDermid JC, Walton DM; CATWAD Consortium Group. A Systematic Review and Synthesis of Psychometric Properties of the Numeric Pain Rating Scale and the Visual Analog Scale for Use in People With Neck Pain. *Clin J Pain*. 2021;38:132-148. doi: 10.1097/AJP.0000000000000999.
11. Price J, Rushton A, Tyros I, Tyros V, Heneghan NR. Effectiveness and optimal dosage of exercise training for chronic non-specific neck pain: A systematic review with a narrative synthesis. *PLoS One*. 2020;15:e0234511. doi: 10.1371/journal.pone.0234511.
12. Peng Q, Zhang Y, Yang S, Meng B, Chen H, Liu X, et al. Morphologic Changes of Cervical Musculature in Relation to Chronic Nonspecific Neck Pain: A Systematic Review and Meta-Analysis. *World Neurosurg*. 2022 Dec;168:79-88. doi: 10.1016/j.wneu.2022.09.057.
13. Akodu AK, Nwanne CA, Fapojuwo OA. Efficacy of neck stabilization and Pilates exercises on pain, sleep disturbance and kinesiophobia in patients with non-specific chronic neck pain: A randomized controlled trial. *J Bodyw Mov Ther*. 2021;26:411-419. doi: 10.1016/j.jbmt.2020.09.008.
14. Osama M. Effects of autogenic and reciprocal inhibition muscle energy techniques on isometric muscle strength in neck pain: A randomized controlled trial. *J Back Musculoskelet Rehabil*. 2021;34:555-564. doi: 10.3233/BMR-200002.
15. Kong L, Ren J, Fang S, He T, Zhou X, Fang M. Traditional Chinese Exercises on Pain and Disability in Middle-Aged and Elderly Patients With Neck Pain: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Front Aging Neurosci*. 2022;14:912945. doi: 10.3389/fnagi.2022.912945.
16. Khan ZK, Ahmed SI, Baig AAM, Farooqui WA. Effect of post-isometric relaxation versus myofascial release therapy on pain, functional disability, rom and qol in the management of non-specific neck pain: a randomized controlled trial. *BMC Musculoskelet Disord*. 2022 Jun 13;23:567. doi: 10.1186/s12891-022-05516-1.
17. Buttagat V, Muenpan K, Wiriyaakunphan W, Pomsuwan S, Kluayhomthong S, Areeudomwong P. A comparative study of Thai massage and muscle energy technique for chronic neck pain: A single-blinded randomized clinical trial. *J Bodyw Mov Ther*. 2021;27:647-653. doi: 10.1016/j.jbmt.2021.05.007.
18. Joshi R, Poojary N. The Effect of Muscle Energy Technique and Posture Correction Exercises on Pain and Function in Patients with Non-specific Chronic Neck Pain Having Forward Head Posture-a Randomized Controlled Trail. *Int J Ther Massage Bodywork*. 2022 ;15:14-21. doi: 10.3822/ijtmb.v15i2.673.
19. Hernandez-Lucas P, Leirós-Rodríguez R, Lopez-Barreiro J, García-Soidán JL. Effects of back school-based intervention on non-specific neck pain in adults: a randomized controlled trial. *BMC Sports Sci Med Rehabil*. 2023 ;15:60. doi: 10.1186/s13102-023-00666-8.
20. Huang M, Liu H, Chen J, Pan R. Comparison of clinical efficacy of different exercise therapies in the treatment of chronic nonspecific neck pain: a network meta-analysis. *Front Neurol*. 2026;17:1781903. doi: 10.3389/fneur.2026.1781903.