Preliminary Effects of Combined Scapular Stabilization Exercise and Myofascial Release on Pain, Proprioception, and Muscle Mechanical Properties in Individuals with Chronic Nonspecific Neck Pain: A Pilot Study

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Abstract
Background: Chronic nonspecific neck pain is commonly associated with pain, functional disability, impaired proprioception, and altered muscle mechanical properties. Although scapular stabilization exercise and myofascial release have each demonstrated therapeutic benefits, evidence regarding their combined effects remains limited.
Objective: This pilot study investigated the feasibility and preliminary effects of a combined scapular stabilization exercise and myofascial release program on pain intensity, neck disability, joint position sense, and upper trapezius muscle mechanical properties in individuals with chronic nonspecific neck pain.
Methods: Eight participants with chronic nonspecific neck pain completed a four-week intervention consisting of scapular stabilization exercises and myofascial release, performed three times per week. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), neck-related disability using the Neck Disability Index (NDI), cervical and shoulder proprioception using joint position sense (JPS) tests, and upper trapezius muscle mechanical properties using the MyotonPRO. Outcome measures were collected before and after the intervention and analyzed using paired statistical comparisons.
Results: Significant improvements were observed in pain intensity (NPRS, $p = 0.003$), neck disability (NDI, $p < 0.001$), cervical flexion joint position sense ($p = 0.010$), and left upper trapezius muscle stiffness ($p = 0.006$). Although shoulder joint position sense, cervical extension proprioception, and the remaining muscle mechanical variables did not show statistically significant changes, all demonstrated favorable improvement trends following the intervention.
Conclusion: The findings of this pilot study suggest that combining scapular stabilization exercise with myofascial release may improve pain, functional disability, cervical proprioception, and muscle stiffness in individuals with chronic nonspecific neck pain. These preliminary results support the feasibility of this multimodal rehabilitation approach and provide a basis for future randomized controlled trials with larger sample sizes.
Keywords: chronic neck pain, scapular stabilization, myofascial release, proprioception, joint position sense
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I. Introduction

Chronic neck pain (CNP) is one of the most prevalent musculoskeletal disorders worldwide and represents a major contributor to disability, healthcare expenditure, and productivity loss. Epidemiological studies have reported that approximately 20–70% of the general population experiences neck pain at least once during their lifetime, while nearly half of affected individuals continue to experience persistent symptoms beyond one year, indicating a substantial risk of chronicity [1,2]. According to the Global Burden of Disease Study, neck pain ranks among the leading causes of years lived with disability (YLDs), particularly in working-age adults, thereby imposing considerable socioeconomic burdens on both individuals and healthcare systems [3].

The rapid expansion of digital technology has further accelerated the prevalence of CNP. Prolonged smartphone use, computer-based occupations, and sustained static postures increase cumulative mechanical loading on the cervical spine and shoulder girdle, resulting in repetitive muscular fatigue, altered postural alignment, and impaired neuromuscular control [4]. Previous systematic reviews have demonstrated a significant association between excessive smartphone use and neck pain, emphasizing that prolonged cervical flexion and forward head posture substantially increase biomechanical stress on cervical structures [5]. Consequently, contemporary rehabilitation strategies have shifted from symptom-oriented approaches toward interventions targeting the underlying neuromuscular dysfunction responsible for persistent pain.

Although chronic neck pain has traditionally been regarded as a localized musculoskeletal disorder, increasing evidence indicates that it involves complex sensorimotor impairments affecting multiple physiological systems. Patients with CNP frequently exhibit deficits in cervical proprioception, impaired postural control, delayed muscle activation, altered motor coordination, and decreased movement accuracy [6–8]. Persistent nociceptive input originating from cervical tissues may disrupt afferent feedback from muscle spindles and joint mechanoreceptors, leading to maladaptive neuroplastic changes within the central nervous system [9]. These alterations contribute not only to pain persistence but also to impaired movement control and functional disability.

Among these sensorimotor deficits, impaired joint position sense (JPS) has emerged as one of the most clinically relevant dysfunctions in individuals with CNP. Cervical proprioception is essential for maintaining postural stability, gaze control, coordinated head movements, and accurate sensorimotor integration [10]. Systematic reviews have consistently reported greater cervical repositioning errors in patients with chronic neck pain than in asymptomatic individuals, suggesting that proprioceptive impairment is closely associated with persistent pain and disability [6,11]. Restoration of proprioceptive function has therefore become an important therapeutic target in contemporary rehabilitation.

Recent investigations have also emphasized that cervical dysfunction cannot be fully understood without considering the functional contribution of the scapulothoracic complex. Anatomically and biomechanically, the cervical spine and scapula function as an integrated kinetic chain connected through the trapezius, levator scapulae, rhomboids, serratus anterior, and deep cervical musculature [12]. Abnormal scapular alignment or dyskinesis may increase cervical loading, alter muscle recruitment patterns, and compromise postural stability, thereby perpetuating neck pain [13]. Consequently, rehabilitation programs focusing on scapular stabilization have received increasing attention as an effective strategy for improving cervical biomechanics and neuromuscular control.

Scapular stabilization exercises aim to restore coordinated activation of the scapular stabilizers, particularly the serratus anterior and lower trapezius muscles, while reducing excessive activity of superficial cervical musculature such as the upper trapezius [14]. Previous randomized controlled trials have demonstrated that scapular stabilization exercise effectively reduces pain intensity, improves cervical function, enhances postural alignment, and restores muscular balance in patients with chronic neck pain [15,16]. Furthermore, recent systematic reviews suggest that scapular-focused rehabilitation may provide superior clinical outcomes compared with conventional cervical exercises alone, particularly for individuals presenting with scapular dyskinesis [17]. Nevertheless, relatively few studies have investigated whether these exercises also improve proprioceptive function or alter muscle mechanical properties.

In addition to exercise-based rehabilitation, manual therapy has been widely incorporated into multimodal interventions for chronic neck pain. Among various manual therapy techniques, myofascial release (MFR) has attracted increasing interest owing to its potential effects on reducing fascial restrictions, improving tissue extensibility, decreasing muscle stiffness, and modulating pain sensitivity [18]. Mechanical stimulation applied during MFR is believed to influence fascial viscoelasticity, local circulation, autonomic nervous system activity, and mechanoreceptor-mediated pain modulation [19]. Randomized controlled trials have reported significant reductions in pain intensity and improvements in cervical range of motion following MFR in patients with chronic neck pain [20]. However, the influence of MFR on cervical proprioception and objective muscle mechanical characteristics remains insufficiently understood.

Muscle mechanical properties have recently emerged as valuable objective biomarkers for evaluating treatment outcomes in musculoskeletal rehabilitation. Devices such as the MyotonPRO enable reliable quantification of muscle tone, stiffness, and elasticity through non-invasive mechanical oscillation measurements [21,22]. Increased upper trapezius stiffness has frequently been reported in individuals with chronic neck pain and is considered to reflect persistent protective muscle guarding and altered neuromuscular regulation [23]. Accordingly, evaluating changes in muscle mechanical properties following rehabilitation may provide additional insight into the physiological mechanisms underlying symptom improvement.

Despite growing evidence supporting scapular stabilization exercises and myofascial release independently, few studies have investigated the combined effects of these interventions on pain, functional disability, cervical and shoulder proprioception, and muscle mechanical properties simultaneously. Moreover, pilot studies exploring the feasibility of such multimodal rehabilitation protocols remain scarce, particularly within Asian populations. Establishing preliminary evidence is essential before conducting adequately powered randomized controlled trials, as pilot investigations allow researchers to evaluate intervention feasibility, estimate effect sizes, refine outcome measures, and optimize study protocols [24].

Therefore, the present pilot study aimed to investigate the feasibility and preliminary effects of a four-week rehabilitation program consisting of scapular stabilization exercises combined with myofascial release in individuals with chronic neck pain. Specifically, changes in pain intensity, neck-related disability, cervical and shoulder joint position sense, and upper trapezius muscle mechanical properties were evaluated before and after the intervention. We hypothesized that the combined intervention would (1) reduce pain intensity and neck disability, (2) improve cervical and shoulder proprioception by decreasing joint position errors, and (3) reduce upper trapezius muscle tone and stiffness, thereby providing preliminary evidence to support the design of future randomized controlled trials.

II. Materials and Methods

2.1 Study Design

This pilot study employed a single-group pretest–posttest design to investigate the feasibility and preliminary therapeutic effects of a combined intervention consisting of scapular stabilization exercise and myofascial release in individuals with chronic nonspecific neck pain. The study was designed to examine changes in pain intensity, neck-related disability, cervical and shoulder joint position sense, and upper trapezius muscle mechanical properties following a four-week intervention program. Because this investigation served as a preliminary study, its primary purpose was not only to evaluate the potential effectiveness of the intervention but also to generate effect size estimates and methodological information for planning future randomized controlled trials. The study protocol was conducted in accordance with the ethical principles of the Declaration of Helsinki, and all participants provided written informed consent prior to participation after receiving a detailed explanation of the study objectives and procedures.

2.2 Participants

Eight adults with chronic nonspecific neck pain voluntarily participated in this study. Chronic neck pain was defined as persistent or recurrent pain in the cervical region lasting for more than three months. Participants were recruited through advertisements distributed at local rehabilitation clinics and community health centers. Individuals were considered eligible if they were between 20 and 60 years of age, reported a Numeric Pain Rating Scale (NPRS) score of at least three points, and were able to understand the study procedures and perform the exercise program independently.

Participants were excluded if they had undergone previous cervical spine surgery, experienced cervical fractures or traumatic injuries, presented with neurological disorders affecting upper-extremity function, had vestibular disorders, inflammatory or rheumatologic diseases, severe shoulder pathology limiting active movement, or had received structured physical therapy for neck pain during the previous three months. Demographic characteristics, including age, sex, height, body weight, pain intensity, and Neck Disability Index (NDI) scores, were collected before the intervention.

2.3 Intervention

The intervention program consisted of scapular stabilization exercises combined with myofascial release therapy. Participants attended supervised treatment sessions three times per week for four consecutive weeks, resulting in a total of twelve treatment sessions. Each treatment session lasted approximately 30 minutes and consisted of 15 minutes of therapeutic exercise followed immediately by 15 minutes of manual therapy. All interventions were administered by a licensed physical therapist with extensive clinical experience in musculoskeletal rehabilitation to ensure consistency throughout the intervention period.

2.3.1 Scapular Stabilization Exercise

The scapular stabilization exercise program was developed based on previously published rehabilitation protocols for chronic neck pain and scapular dysfunction (Im et al., 2015; Andersen et al., 2014; Seo et al., 2019). Each treatment session began with the chin tuck exercise to facilitate activation of the deep cervical flexor muscles while minimizing compensatory activation of the superficial cervical musculature. Participants were instructed to gently retract the chin while maintaining an upright sitting posture, hold the position for three seconds, and then slowly return to the neutral position. This exercise was repeated fifteen times.

Following the chin tuck exercise, participants performed a scapular stabilization program consisting of scapular retraction, protraction, elevation, and depression. Each movement was performed through a pain-free range of motion while emphasizing proper scapular alignment and coordinated muscle activation. Participants completed three sets of fifteen repetitions for each exercise with a one-minute rest period between sets. Throughout the intervention, verbal feedback was provided by the therapist to minimize excessive upper trapezius activation and to facilitate recruitment of the serratus anterior and lower trapezius muscles. Exercise intensity was adjusted individually according to each participant's tolerance while maintaining correct movement quality.

2.3.2 Myofascial Release Technique

Immediately after completing the exercise program, participants received myofascial release therapy targeting the upper trapezius, suboccipital muscles,

and latissimus dorsi. The intervention protocol was based on previously established manual therapy techniques described by Miller et al. (2010) and Rodriguez-Huguet et al. (2018). Participants were positioned comfortably in the prone position throughout the treatment.

The therapist applied sustained low-load manual pressure along the direction of the fascial tissues until a reduction in tissue resistance was perceived. Gentle compression was maintained for approximately 30 seconds before gradually releasing the pressure. The upper trapezius and latissimus dorsi muscles were treated using longitudinal pressure applied with the therapist's forearm along the muscle fibers, whereas the suboccipital muscles were treated using sustained fingertip pressure while maintaining the cervical spine in a neutral position. The intensity of manual pressure was adjusted according to participant comfort to avoid provoking pain while allowing sufficient fascial release.

2.4 Outcome Measures

Outcome measurements were obtained immediately before the first intervention session and again after completion of the four-week intervention program by an examiner who was not involved in delivering the intervention. The primary outcome measures included pain intensity, neck-related disability, cervical joint position sense, shoulder joint position sense, and upper trapezius muscle mechanical properties.

Pain intensity was evaluated using the Numeric Pain Rating Scale (NPRS), an 11-point self-reported scale ranging from 0, indicating no pain, to 10, representing the worst imaginable pain. The NPRS has demonstrated excellent reliability, validity, and responsiveness for evaluating musculoskeletal pain and was therefore selected as the primary pain outcome measure (Mintken et al., 2009; Farrar et al., 2001).

Neck-related disability was assessed using the Neck Disability Index (NDI), which consists of ten items evaluating pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreational activities. Each item is scored on a six-point scale, producing a total score ranging from 0 to 50, with higher scores indicating greater disability. The validated Korean version of the NDI was used in this study (Vernon & Mior, 1991; Song et al., 2010).

Cervical joint position sense was evaluated using a laser-guided repositioning test. Participants wore a lightweight helmet equipped with a laser pointer positioned above the forehead. A circular target with concentric rings was mounted on a wall at eye level approximately 90 cm in front of the participant. After establishing the neutral head position, participants performed active cervical flexion and extension before attempting to return to the initial position while blindfolded. The repositioning error was calculated as the distance between the original target position and the returned laser point. Each movement direction was repeated seven times, and the average repositioning error was used for statistical analysis (Revel et al., 1991; Chen et al., 2013).

Shoulder joint position sense was measured while participants actively reproduced shoulder elevation angles of 40° and 100° in the scapular plane without visual feedback. Joint position error was calculated as the absolute angular difference between the target position and the reproduced position. Each measurement was repeated seven times, and the mean value was used for subsequent analyses (Yang et al., 2008).

Muscle mechanical properties of the upper trapezius were assessed using the MyotonPRO device (Myoton AS, Tallinn, Estonia). Participants remained seated comfortably with both upper extremities resting on their thighs while the midpoint of the upper trapezius muscle was identified using anatomical landmarks. The MyotonPRO quantified muscle tone (frequency), muscle stiffness, and elasticity (decrement) by applying a brief mechanical impulse to the muscle tissue. Measurements were performed twice on both sides, and the mean values were used for statistical analysis. Previous studies have demonstrated excellent reliability and validity of the MyotonPRO for evaluating muscle mechanical characteristics in both healthy individuals and patients with musculoskeletal disorders (Viir et al., 2007; Bailey et al., 2013).

2.5 Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation, whereas categorical variables are summarized as frequencies and percentages. Because this investigation was designed as a pilot study, the primary objective of the statistical analysis was to examine the direction and magnitude of changes following the intervention rather than to draw definitive conclusions regarding treatment efficacy.

The normality of data distribution was assessed using the Shapiro–Wilk test. Pre- and post-intervention differences were analyzed using paired t-tests for normally distributed variables. Statistical significance was established at $p < 0.05$. In addition to significance testing, mean differences and effect sizes were examined to provide preliminary evidence for estimating sample size and determining the feasibility of future large-scale randomized controlled trials.

III. Results

3.1 Participant Characteristics

A total of eight participants completed the four-week intervention program without any dropouts or adverse events. All participants were included in the final analysis. Baseline demographic and clinical characteristics are presented in Table 1.

Table 1. Baseline Characteristics of the Participants (N = 8)

Variable	Total (N = 8)
Age (years)	28.63 ± 6.14
Height (cm)	168.75 ± 8.92
Weight (kg)	64.38 ± 10.15
Sex, n (%)	
Male	3 (37.5)
Female	5 (62.5)
NPRS (score)	3.13 ± 1.96
NDI (score)	9.75 ± 3.92

Values are presented as mean ± standard deviation (SD) or number (percentage). NPRS: Numeric Pain Rating Scale; NDI: Neck Disability Index.

3.2 Changes in Pain Intensity and Neck Disability

Changes in pain intensity and neck-related disability following the intervention are presented in Table 2.

Pain intensity, as measured by the Numeric Pain Rating Scale (NPRS), significantly decreased following the four-week intervention, with mean scores declining from 3.13 ± 1.96 at baseline to 1.13 ± 1.25 after the intervention ($p = 0.003$). The mean reduction in NPRS was 2.00 points, indicating a clinically meaningful improvement in perceived neck pain.

Similarly, neck-related disability, assessed using the Neck Disability Index (NDI), demonstrated a significant reduction following the intervention. The mean NDI score decreased from 9.75 ± 3.92 to 4.25 ± 3.33 ($p < 0.001$), corresponding to a mean improvement of 5.50 points.

Overall, both pain intensity and functional disability showed statistically significant improvements after completion of the combined scapular stabilization exercise and myofascial release program.

Table 2. Changes in Pain and Disability

Variable	Pre (Mean±SD)	Post (Mean±SD)	Mean Difference	p-value
NPRS	3.13 ± 1.96	1.13 ± 1.25	-2.00	.003
NDI	9.75 ± 3.92	4.25 ± 3.33	-5.50	<.001

Values are presented as mean ± standard deviation (SD).

NPRS: Numerical Pain Rating Scale; NDI: Neck Disability Index.

3.3 Changes in Cervical and Shoulder Joint Position Sense

The changes in cervical and shoulder joint position sense are summarized in Table 3.

Shoulder joint position error decreased at both target angles following the intervention. The mean repositioning error at 40° of shoulder elevation decreased from 6.50 ± 6.91° to 3.13 ± 4.39°, whereas the error at 100° of shoulder elevation decreased from 3.63 ± 2.77° to 1.38 ± 1.77°. Although both variables demonstrated improvement, neither reached statistical significance ($p = 0.249$ and $p = 0.097$, respectively).

For cervical proprioception, cervical flexion joint position error significantly decreased following the intervention, with mean values improving from 3.13 ± 1.55° to 1.50 ± 0.93° ($p = 0.010$). In contrast, cervical extension joint position error decreased from 2.88 ± 1.36° to 2.13 ± 1.13°; however, this change did not achieve statistical significance ($p = 0.222$).

Overall, reductions in repositioning error were observed across all joint position sense measurements, with statistically significant improvement observed only during cervical flexion.

Table 3. Changes in Joint Position Sense

Variable	Pre (Mean±SD)	Post (Mean±SD)	Mean Difference	p-value
Shoulder JPS 40°	6.50 ± 6.91	3.13 ± 4.39	-3.37	.249
Shoulder JPS 100°	3.63 ± 2.77	1.38 ± 1.77	-2.25	.097
Cervical Flexion JPS	3.13 ± 1.55	1.50 ± 0.93	-1.63	.010
Cervical Extension JPS	2.88 ± 1.36	2.13 ± 1.13	-0.75	.222

Values are presented as mean ± standard deviation

(SD).
JPS: Joint Position Sense.

3.4 Changes in Upper Trapezius Muscle Mechanical Properties

Changes in the mechanical properties of the upper trapezius muscle are presented in Table 4.
On the right side, muscle tone (frequency) decreased from 18.49 ± 2.30 Hz to 18.00 ± 1.53 Hz, whereas muscle stiffness decreased from 343.13 ± 54.78 N/m to 325.38 ± 34.49 N/m. Muscle elasticity (decrement) showed minimal change, increasing slightly from 1.09 ± 0.14 to 1.11 ± 0.17. None of these changes were statistically significant ($p > 0.05$).
On the left side, muscle tone decreased from 17.69 ± 1.84 Hz to 16.84 ± 1.60 Hz, while muscle stiffness decreased from 324.38 ± 40.42 N/m to 278.38 ± 34.13 N/m. The reduction in left upper trapezius stiffness was statistically significant ($p = 0.006$). Muscle elasticity also demonstrated a slight decrease from 1.11 ± 0.14 to 1.00 ± 0.11, although the difference did not reach statistical significance ($p = 0.091$).
In general, the intervention produced a consistent trend toward reduced muscle tone and stiffness in the upper trapezius bilaterally, with a statistically significant reduction observed only for left-sided muscle stiffness.
Table 4. Changes in Muscle Tone

Variable	Pre (Mean±SD)	Post (Mean±SD)	Mean Difference	p-value
Rt. Frequency (Hz)	18.49 ± 2.30	18.00 ± 1.53	-0.49	.420
Rt. Stiffness (N/m)	343.13 ± 54.78	325.38 ± 34.49	-17.75	.184
Rt. Decrement	1.09 ± 0.14	1.11 ± 0.17	0.02	.717
Lt. Frequency (Hz)	17.69 ± 1.84	16.84 ± 1.60	-0.85	.083
Lt. Stiffness (N/m)	324.38 ± 40.42	278.38 ± 34.13	-46.00	.006
Lt. Decrement	1.11 ± 0.14	1.00 ± 0.11	-0.11	.091

Values are presented as mean ± standard deviation (SD).

IV. Discussion

The present pilot study investigated the feasibility and preliminary therapeutic effects of a four-week intervention consisting of scapular stabilization exercises combined with myofascial release in individuals with chronic nonspecific neck pain. The principal findings demonstrated that the combined intervention significantly reduced pain intensity and neck-related disability while improving cervical joint position sense during flexion and reducing upper trapezius muscle stiffness. Although improvements were also observed in shoulder joint position sense, cervical extension repositioning accuracy, and several muscle mechanical variables, these changes did not reach statistical significance. Collectively, these findings suggest that a multimodal rehabilitation program targeting both neuromuscular control and soft tissue dysfunction may positively influence clinical symptoms and selected sensorimotor impairments associated with chronic neck pain **[4–8]**.
One of the most notable findings of this study was the significant reduction in pain intensity following the intervention. Chronic neck pain is increasingly recognized as a multifactorial condition involving not only peripheral nociceptive mechanisms but also alterations in central pain processing, sensorimotor integration, and muscular coordination **[2,4]**. Persistent nociceptive input originating from overloaded cervical structures can induce maladaptive neuroplastic changes within the central nervous system, resulting in central sensitization, impaired motor control, and sustained muscle hyperactivity **[4,6]**. Consequently, contemporary rehabilitation strategies have shifted from symptom-oriented interventions toward approaches designed to restore normal neuromuscular function rather than merely alleviating symptoms **[5,6]**. The significant decrease in NPRS scores observed in the present study suggests that the combined intervention may have contributed to pain modulation through multiple physiological mechanisms rather than through a single therapeutic pathway.
Scapular stabilization exercises likely played an important role in reducing pain by restoring normal scapulothoracic biomechanics and improving cervical muscle coordination. The cervical spine and scapula function as an integrated kinetic chain in which the scapular stabilizing muscles provide a stable foundation for cervical movement **[5,6]**. Dysfunction of the serratus anterior and lower trapezius muscles is frequently accompanied by excessive activation of the upper trapezius and levator scapulae, thereby increasing compressive loading on cervical structures and perpetuating pain **[5,6]**. Previous investigations have demonstrated that patients with chronic neck pain commonly exhibit delayed activation of the lower trapezius

together with excessive recruitment of superficial cervical muscles, resulting in altered movement patterns and increased mechanical stress on the cervical spine **[5,6]**. By facilitating coordinated activation of the deep cervical flexors, serratus anterior, and lower trapezius while reducing unnecessary upper trapezius activity, scapular stabilization exercises may redistribute mechanical loading more efficiently across the shoulder girdle and cervical region, thereby reducing nociceptive stimulation and improving movement efficiency **[5,6]**.

The contribution of myofascial release should also be considered when interpreting the observed reduction in pain. Increasing evidence suggests that fascial tissues contain abundant mechanoreceptors capable of influencing both peripheral and central pain modulation **[7,8]**. Sustained manual pressure applied during myofascial release is believed to reduce fascial stiffness, improve tissue extensibility, enhance local blood circulation, and normalize abnormal muscle tone through stimulation of fascial mechanoreceptors **[7,8]**. These physiological responses may decrease sympathetic nervous system activity while simultaneously increasing parasympathetic activity, ultimately reducing pain sensitivity and muscle guarding **[7,8]**. Rodriguez-Huguet et al. reported that myofascial release significantly improved pressure pain thresholds and reduced pain intensity in individuals with chronic neck pain **[8]**, whereas Miller et al. concluded that manual therapy combined with therapeutic exercise produced superior clinical outcomes compared with exercise alone **[7]**. The present findings are consistent with these reports and further support the rationale for integrating manual therapy with active rehabilitation to maximize clinical improvement.

Another important finding of this study was the significant improvement in neck-related disability, as evidenced by the reduction in NDI scores. Neck disability reflects the cumulative impact of pain, impaired movement, reduced muscular endurance, and diminished confidence during activities of daily living **[9–13]**. Although pain reduction undoubtedly contributes to functional improvement, disability recovery is often influenced by broader changes in motor performance and movement efficiency. Restoration of coordinated cervical and scapular muscle activation may improve postural stability during occupational and daily functional activities, thereby enabling patients to perform movements with less discomfort and greater confidence **[5,6]**. Furthermore, repeated execution of controlled scapular stabilization exercises may promote motor learning by reinforcing efficient movement strategies and reducing compensatory muscle activity. This process may explain why participants reported meaningful improvements in functional capacity after only four weeks of intervention.

The reduction in disability observed in this study is consistent with previous randomized controlled trials investigating scapular-focused rehabilitation. Javdaneh et al. demonstrated that rehabilitation programs emphasizing scapular stabilization significantly improved both pain and disability in patients with chronic neck pain **[5]**. Similarly, Seo et al. reported in their systematic review that scapular stabilization exercises consistently produced moderate improvements in pain and functional outcomes compared with conventional cervical exercise **[6]**. The present findings extend previous evidence by suggesting that combining scapular stabilization with myofascial release may further enhance functional recovery, although randomized controlled trials are required to determine whether this combined approach is superior to exercise alone.

A particularly interesting finding of this study was the significant improvement in cervical joint position sense during cervical flexion. Proprioceptive deficits are increasingly recognized as a hallmark characteristic of chronic neck pain **[3,4]**. Accurate cervical proprioception depends on the integrity of muscle spindles located within the deep cervical musculature, joint mechanoreceptors, and central sensorimotor integration pathways **[3,4]**. Persistent pain may disrupt afferent input from these receptors, leading to inaccurate movement perception, impaired postural control, dizziness, and reduced movement precision **[3,4]**. Previous systematic reviews consistently reported greater cervical repositioning errors in patients with chronic neck pain than in healthy controls, emphasizing proprioceptive rehabilitation as an essential treatment target **[3,4]**.

Several mechanisms may explain the observed improvement in cervical proprioception. First, activation of the deep cervical flexor muscles during chin tuck exercises may increase muscle spindle sensitivity and improve afferent feedback to the central nervous system **[4,6]**. Second, improved scapular stability may indirectly enhance cervical proprioception by providing a more stable proximal base during head and neck movements **[5,6]**. Finally, repetitive therapeutic exercises may facilitate motor learning and sensorimotor reorganization, resulting in improved movement accuracy and postural control **[4,6]**.

V. Conclusions

This pilot study investigated the preliminary effects of a four-week intervention combining scapular stabilization exercises with myofascial release in individuals with chronic nonspecific neck pain. The findings demonstrated significant improvements in pain intensity, neck-related disability, cervical flexion joint position sense, and upper trapezius

muscle stiffness following the intervention. Although improvements in shoulder joint position sense and other muscle mechanical properties did not reach statistical significance, all outcome measures showed favorable trends.

These findings suggest that the combined intervention may effectively reduce pain and functional disability while enhancing cervical sensorimotor function and normalizing muscle mechanical properties. By addressing both neuromuscular control and soft tissue dysfunction, this multimodal rehabilitation approach may provide greater therapeutic benefits than interventions focusing solely on pain relief.

However, the present study has several limitations, including the small sample size, the absence of a control group, and the short intervention period. Therefore, the findings should be interpreted with caution and cannot be generalized to the broader population of individuals with chronic neck pain.

Future randomized controlled trials with larger sample sizes, longer intervention durations, and long-term follow-up are warranted to confirm the effectiveness of this combined intervention and to further investigate the underlying mechanisms responsible for the observed clinical improvements. Overall, this pilot study provides preliminary evidence supporting the feasibility and potential clinical value of combining scapular stabilization exercises with myofascial release for the rehabilitation of individuals with chronic nonspecific neck pain. These findings may serve as a foundation for future large-scale clinical trials and contribute to the development of evidence-based rehabilitation strategies for chronic neck pain.

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