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Original Article

Effects Of Cervical Muscle Strengthening Exercises On Neck Muscle Function, Tenderness, Headache Intensity, And Disability In Patients With Chronic Tension-Type Headache: A Randomized Controlled Trial

Asma Anwar[1], Amna Qamar[2], Adeena Zaheer[3], Faryal Akhtar[4], Kamran Akbar[5], Hazrat Bilal[6], Nimrah Humayoon[7], Etisam Wahid[8]

[1] MS Scholar, Riphah International University, Islamabad, Pakistan
[2] Riphah International University, Islamabad, Pakistan
[3] Riphah International University, Islamabad, Pakistan
[4] Physical Therapist, Saidu Group of Teaching Hospital, Swat, Pakistan
[5] Lecturer, Institute of Physical Medicine and Rehabilitation, Khyber Medical University, Peshawar, Pakistan
[6] Demonstrator, Institute of Physical Medicine and Rehabilitation, Khyber Medical University, Peshawar, Pakistan
[7] Lecturer, University of Veterinary and Animal Sciences, Swat, Pakistan
8 Lecturer - Department of Physical Therapy, University of Veterinary and Animal Sciences, UVAS SWAT, Pakistan

***Corresponding author: Hazrat Bilal, bilal_kmu02@yahoo.com**

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ABSTRACT

Background: Chronic tension-type headache is frequently associated with cervical muscle dysfunction, increased muscle tenderness, restricted cervical mobility, and headache-related disability. Although physiotherapy is commonly used in conservative headache management, the added value of structured cervical strengthening-centered rehabilitation requires further clarification. Objective: To determine the effects of cervical muscle strengthening exercises on neck muscle function, muscle tenderness, headache intensity, headache frequency, cervical range of motion, and headache-related disability in adults with chronic tension-type headache. Methods: This two-arm randomized controlled trial included 60 participants with chronic tension-type headache who were allocated to an experimental group receiving a structured cervical strengthening-centered rehabilitation program or a control group receiving conventional physiotherapy. Both interventions were delivered three times weekly for eight weeks. Outcomes included cervical flexor and extensor strength, pressure pain threshold, Visual Analogue Scale score, monthly headache frequency, cervical range of motion, and Headache Impact Test-6 score. Data were analyzed using mixed-design repeated-measures ANOVA. Results: The experimental group demonstrated greater improvements than the control group across all outcomes. Cervical flexor strength increased by 5.6 kg, cervical extensor strength by 5.9 kg, pressure pain threshold by 1.6 kg/cm², cervical range of motion by 38.5°, while headache intensity decreased by 4.2 points, headache frequency by 10.2 days/month, and HIT-6 score by 12.8 points. All group × time interaction effects were statistically significant. Conclusion: Structured cervical strengthening-centered rehabilitation produced greater short-term improvements than conventional physiotherapy in muscle function, tenderness, headache symptoms, cervical mobility, and disability among adults with chronic tension-type headache. Keywords: chronic tension-type headache; cervical strengthening; physiotherapy; headache disability; pressure pain threshold; randomized controlled trial.

INTRODUCTION

Chronic tension-type headache is one of the most frequent primary headache disorders and remains a major contributor to persistent pain, impaired function, reduced work productivity, and health-related

disability among adults. It is clinically characterized by bilateral, pressing or tightening headache occurring on at least 15 days per month for more than three months, and although it is often perceived as less severe than migraine, its high prevalence and chronic course create a substantial cumulative burden for patients and healthcare systems. Contemporary epidemiological evidence indicates that tension-type headache affects a large proportion of the global population, with increasing absolute numbers of affected individuals over time, making it an important public health and rehabilitation concern (1–3).

The clinical burden of chronic tension-type headache extends beyond headache pain alone. Patients frequently report reduced participation in occupational, domestic, and social activities, sleep disturbance, psychological distress, increased use of analgesic medication, and diminished quality of life. These consequences are particularly important in patients with persistent headache, in whom recurrent symptoms may contribute to central sensitization, pain-related fear, physical inactivity, and progressive functional limitation. The need for safe, accessible, and non-pharmacological strategies is therefore increasingly recognized, particularly in rehabilitation settings where modifiable musculoskeletal contributors can be assessed and managed alongside symptom control (4,5).

A growing body of evidence suggests that cervical musculoskeletal dysfunction plays an important role in the persistence and clinical expression of chronic tension-type headache. Patients with chronic headache commonly demonstrate reduced cervical muscle strength, impaired endurance of the deep cervical flexors and extensors, altered neuromuscular control, restricted cervical mobility, and postural dysfunction. Increased tenderness of the pericranial and cervical muscles, including the upper trapezius, sternocleidomastoid, suboccipital, and levator scapulae muscles, has also been consistently reported in this population. These impairments may increase mechanical loading of pain-sensitive cervical structures and contribute to recurrent nociceptive input, thereby worsening headache intensity, frequency, and disability (6,7).

The association between cervical dysfunction and headache symptoms is biologically plausible through the trigeminocervical convergence mechanism. Sensory afferents from the upper cervical spine converge with trigeminal nociceptive pathways within the trigeminocervical nucleus, allowing nociceptive input from cervical structures to be perceived as head pain. Persistent dysfunction of cervical muscles may therefore amplify peripheral nociceptive drive, contribute to central sensitization, and increase pressure pain sensitivity in patients with chronic tension-type headache. This mechanism provides a clear rationale for interventions that improve cervical muscle performance, reduce tenderness, and restore neuromuscular control rather than relying exclusively on passive modalities or pharmacological symptom suppression (8,9).

Physiotherapy has become an important component of conservative headache management, with interventions such as therapeutic exercise, manual therapy, stretching, postural correction, relaxation training, and patient education showing potential benefits for headache intensity, headache frequency, and disability. However, previous studies have used heterogeneous treatment protocols, varied diagnostic criteria, inconsistent outcome measures, and different intervention dosages, limiting the certainty with which specific rehabilitation components can be recommended. Exercise-based rehabilitation appears particularly promising, but the relative contribution of structured cervical strengthening to improvements in muscle function, tenderness, and headache-related disability remains insufficiently defined in patients with chronic tension-type headache (10–12).

Cervical muscle strengthening is clinically relevant because it directly targets neuromuscular impairments frequently observed in this population. Strength deficits in the deep cervical flexors, cervical extensors, and scapular stabilizers may reduce cervical stability, alter head-neck posture, increase compensatory activity of superficial muscles, and perpetuate pericranial tenderness. Strengthening-centered rehabilitation may improve load tolerance, enhance postural control, reduce fatigue-related nociceptive input, and support better functional performance. Previous exercise studies

have reported reductions in headache intensity, frequency, and duration following strength-based neck and shoulder interventions; however, many available trials have not simultaneously evaluated cervical strength, pressure pain threshold, headache intensity, headache frequency, cervical range of motion, and headache-related disability within a single randomized controlled design (13–16).

This evidence gap is clinically important because chronic tension-type headache is multidimensional, and improvement in pain alone may not adequately represent recovery. A comprehensive evaluation should include both impairment-based outcomes, such as cervical flexor and extensor strength, pressure pain threshold, and cervical range of motion, and patient-reported outcomes, such as headache intensity, headache frequency, and disability. Establishing whether a structured cervical strengthening-centered program produces superior short-term outcomes compared with conventional physiotherapy would help guide rehabilitation decision-making and improve the specificity of exercise prescription for patients with chronic tension-type headache.

Therefore, the present randomized controlled trial was conducted to determine the effects of a structured cervical muscle strengthening program on neck muscle function, muscle tenderness, headache intensity, headache frequency, cervical range of motion, and headache-related disability in adults with chronic tension-type headache. Using a PICO framework, the study evaluated adults diagnosed with chronic tension-type headache, compared supervised cervical strengthening-centered rehabilitation with conventional physiotherapy, and assessed changes in cervical muscle strength, pressure pain threshold, Visual Analogue Scale score, monthly headache frequency, cervical range of motion, and Headache Impact Test-6 score after eight weeks of treatment. It was hypothesized that participants receiving the structured cervical strengthening program would demonstrate greater improvements in neck muscle function, reduced muscle tenderness, lower headache intensity and frequency, increased cervical range of motion, and reduced headache-related disability compared with participants receiving conventional physiotherapy.

MATERIALS AND METHODS

This study was conducted as a two-arm, parallel-group randomized controlled trial designed to evaluate the short-term effects of a structured cervical muscle strengthening program compared with conventional physiotherapy in adults with chronic tension-type headache. The trial followed the principles of randomized comparative intervention research and was prepared in accordance with CONSORT reporting standards for randomized trials. The study was conducted in the outpatient rehabilitation facilities of the Department of Physical Therapy, Afridi Medical Complex, Peshawar, between August 2024 and February 2025. All recruitment, eligibility screening, baseline assessment, intervention delivery, treatment monitoring, and post-intervention assessment were performed within the same clinical setting to maintain procedural consistency.

Participants were recruited through referrals from neurologists, physiotherapists, and outpatient clinics. Adults aged 18 to 65 years were screened for eligibility and included if they had a diagnosis of chronic tension-type headache according to the International Classification of Headache Disorders, 3rd edition, had experienced headache symptoms for at least three months, reported headache occurrence on 15 or more days per month, were able to understand the study procedures, and provided written informed consent. Participants were excluded if they had cervicogenic headache, migraine as the primary diagnosis, secondary headache disorders, previous cervical spine surgery, neck trauma or whiplash injury within the preceding six months, neurological conditions affecting cervical muscle performance, severe cervical musculoskeletal pathology, inflammatory disease, systemic illness limiting participation, concurrent physiotherapy or exercise treatment for headache management, or contraindications to therapeutic exercise.

After baseline eligibility confirmation and informed consent, participants underwent initial demographic and clinical assessment. Baseline data included age, sex, body mass index, headache

duration, headache frequency, headache intensity, and headache-related disability. Outcome assessments were performed at baseline and immediately after completion of the eight-week intervention by an assessor blinded to group allocation. Participants were randomly allocated in a 1:1 ratio to either the experimental group or the control group using a computer-generated random sequence prepared by an independent researcher who was not involved in recruitment, intervention delivery, outcome assessment, or data analysis. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes that were prepared before enrollment and opened only after completion of baseline assessment. Because of the nature of the exercise and physiotherapy interventions, participants and treating physiotherapists could not be blinded; however, outcome assessors and data analysts remained blinded to group assignment to reduce assessment and analytical bias.

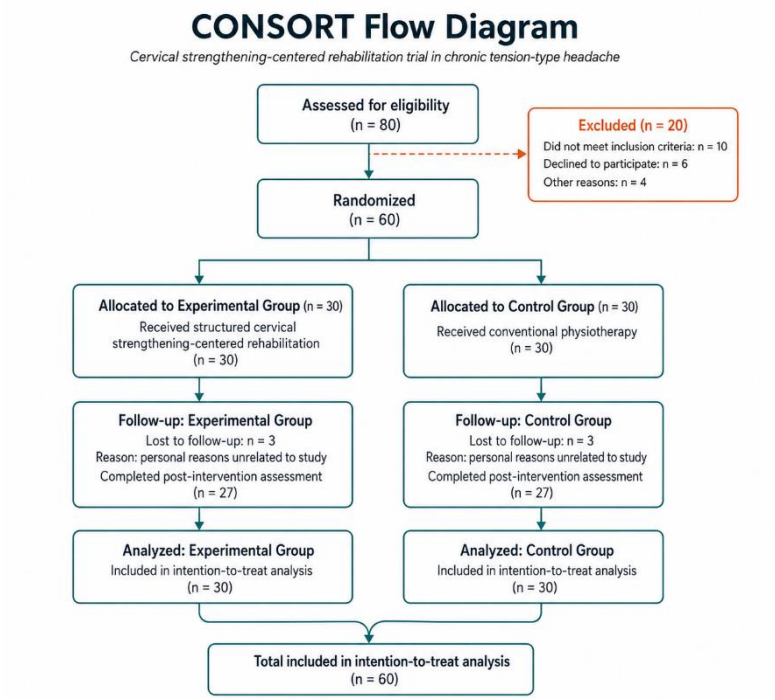

Figure 1 CONSORT Flowchart

The sample size was calculated a priori using G*Power software version 3.1 for repeated-measures analysis of variance with two groups and two measurement points. The calculation was based on an expected moderate effect size of 0.25 derived from previous exercise-based intervention studies in chronic headache populations, with statistical significance set at $p < 0.05$. The analysis indicated that a minimum sample of 54 participants was required. To compensate for an anticipated attrition rate of approximately 10%, the final target sample was increased to 60 participants, with 30 participants allocated to each group.

Participants in the control group received a conventional physiotherapy program consisting of moist heat application to the cervical region for 15 minutes, conventional transcutaneous electrical nerve stimulation using a frequency of 80–100 Hz and pulse width of 100 μs for 20 minutes, active cervical range-of-motion exercises in flexion, extension, rotation, and lateral flexion, stretching of the upper trapezius, levator scapulae, sternocleidomastoid, and pectoralis muscles, and postural education addressing neutral head posture, workstation ergonomics, and sleeping posture. Range-of-motion exercises were performed for 10 repetitions in each movement direction, and each stretch was performed for three repetitions with a 30-second hold. The intervention was delivered three sessions per week for eight weeks, with session duration matched as closely as possible to the experimental group.

Participants in the experimental group received a supervised cervical strengthening-centered rehabilitation program targeting the deep cervical flexors, cervical flexors and extensors, lateral flexors, and scapular stabilizing muscles. Each session began with a warm-up consisting of cervical range-of-

motion exercises and shoulder rolls. The strengthening program included craniocervical flexion or chin-tuck training, isometric resisted cervical flexion, extension, and lateral flexion, elastic-band resisted cervical flexion, extension, and lateral flexion, scapular retraction, theraband rows, resisted shoulder external rotation, prone Y exercises for lower trapezius strengthening, and prone T exercises for middle trapezius strengthening. Deep cervical flexor and isometric exercises were performed for three sets of 10 repetitions with 10-second holds, dynamic elastic-band exercises were performed for three sets of 12 repetitions, scapular retraction was performed for three sets of 15 repetitions, and prone Y and T exercises were performed for three sets of 10 repetitions. The intervention was supervised by a licensed physiotherapist three times per week for eight weeks. Exercise intensity was progressed every two weeks by increasing resistance, hold duration, or repetitions according to participant tolerance, technique quality, and symptom response.

The primary outcomes were neck muscle function and headache-related disability. Neck muscle function was assessed using cervical flexor and extensor strength measured with a handheld dynamometer according to standardized testing procedures. Three trials were performed for each movement, and the mean value was used for analysis. Headache-related disability was assessed using the Headache Impact Test-6, with higher scores indicating greater headache-related impact. Secondary outcomes included muscle tenderness, headache intensity, headache frequency, and cervical range of motion. Muscle tenderness was assessed using pressure pain threshold measurements obtained with a digital pressure algometer at predefined cervical and pericranial muscle sites. Headache intensity was measured using a 10-cm Visual Analogue Scale, where 0 represented no pain and 10 represented the worst imaginable pain. Headache frequency was recorded as the number of headache days per month using a headache diary. Active cervical range of motion was measured using a cervical range-of-motion device according to standardized procedures.

Treatment adherence was monitored by recording attendance at each scheduled treatment session. Participants were instructed to report any discomfort, symptom aggravation, adverse events, or unusual responses during or after treatment sessions. Reported events were documented and reviewed by the research team. To improve reproducibility and intervention fidelity, the same standardized treatment protocols, dosage schedules, progression rules, and outcome assessment procedures were used throughout the trial. Treating physiotherapists followed predefined intervention procedures, and outcome assessors used consistent measurement methods at baseline and post-intervention.

Data were analyzed using IBM SPSS Statistics version 27. Continuous variables were summarized as mean ± standard deviation, and categorical variables were summarized as frequencies and percentages. Baseline comparability between groups was evaluated using independent-samples t-tests for continuous variables and chi-square tests for categorical variables. Data normality was assessed using the Shapiro–Wilk test. Intervention effects were evaluated using two-way mixed-design repeated-measures analysis of variance, with group as the between-subject factor and time as the within-subject factor. The primary inferential focus was the group × time interaction, which assessed whether change from baseline to post-intervention differed between the experimental and control groups. Effect sizes were reported using partial eta squared. Statistical significance was set at $p < 0.05$. All randomized participants were included in the intention-to-treat analysis. For participants with missing post-intervention data due to loss to follow-up, missing outcome values were handled using a conservative baseline-observation-carried-forward approach, and available-case findings were reviewed as a sensitivity check to assess whether attrition influenced the direction of treatment effects.

The study was conducted in accordance with ethical principles for human participant research. Written informed consent was obtained from all participants before enrollment. Participants were informed about the study purpose, intervention procedures, potential risks and benefits, voluntary participation, confidentiality of data, and their right to withdraw at any stage without affecting their routine care.

Participant information was anonymized before analysis, and study data were stored securely with access restricted to the research team.

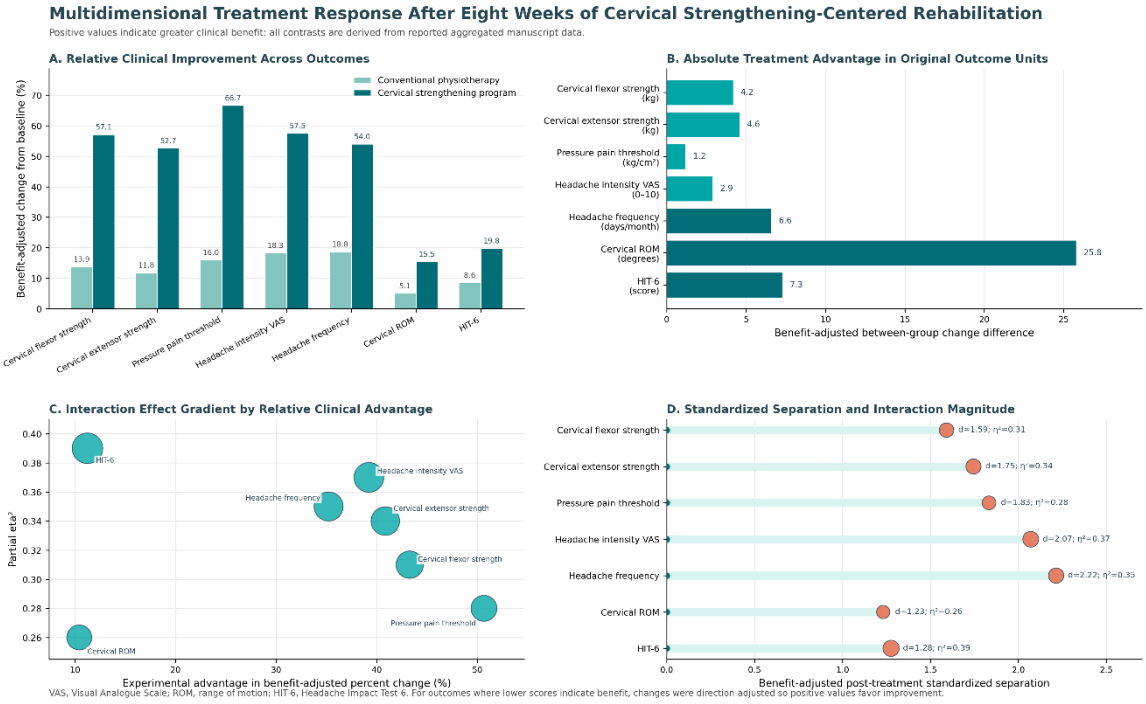

Figure 2 Multidimensional Treatment Response After Eight Weeks of Cervical Strengthening-Centered Rehabilitation

The panelled figure summarizes the comparative treatment response across cervical strength, pressure pain threshold, headache intensity, headache frequency, cervical range of motion, and HIT-6 disability score after eight weeks of intervention. Panel A shows that the cervical strengthening group achieved larger benefit-adjusted relative improvements than conventional physiotherapy across all outcomes, with the greatest relative advantages observed for pressure pain threshold, headache intensity, and headache frequency. Panel B demonstrates consistent absolute treatment advantages favoring the experimental group, including 4.2 kg greater cervical flexor strength gain, 4.6 kg greater cervical extensor strength gain, 1.2 kg/cm² greater pressure pain threshold improvement, 2.9-point greater VAS reduction, 6.6 fewer headache days per month, 25.8° greater cervical ROM gain, and 7.3-point greater HIT-6 reduction. Panel C shows that larger benefit-adjusted percent advantages aligned with moderate-to-large group × time interaction effects, with partial eta-squared values ranging from 0.26 for cervical ROM to 0.39 for HIT-6. Panel D demonstrates favorable standardized post-treatment separation for all outcomes, supporting a broad multidimensional response pattern rather than improvement limited to pain intensity alone.

DISCUSSION

The present randomized controlled trial evaluated the effects of an eight-week structured cervical strengthening-centered rehabilitation program on neck muscle function, muscle tenderness, headache intensity, headache frequency, cervical range of motion, and headache-related disability in adults with chronic tension-type headache. The findings demonstrated that participants receiving the experimental intervention achieved greater improvements than those receiving conventional physiotherapy across all measured physical and patient-reported outcomes. These improvements were observed in cervical flexor and extensor strength, pressure pain threshold, headache intensity, monthly headache frequency, cervical mobility, and HIT-6 score, suggesting that a supervised program targeting cervical muscle performance and scapular stabilization may provide clinically meaningful short-term benefits in this population.

A key finding of the study was the greater improvement in cervical flexor and extensor strength in the experimental group compared with the control group. This finding is consistent with the proposed role of cervical neuromuscular dysfunction in chronic tension-type headache. Reduced performance of the deep cervical flexors and extensors may compromise cervical stability, increase reliance on superficial muscles, and contribute to sustained mechanical loading of pain-sensitive cervical structures. The strengthening-centered program used in the present study specifically targeted craniocervical flexion, resisted cervical flexion, extension, lateral flexion, and scapular stabilizer activation, which may have improved load tolerance, postural control, and coordination of the cervical musculature. These effects support previous evidence indicating that strength-based rehabilitation can improve neck muscle function in patients with chronic headache and neck-related pain conditions (13–16).

The improvement in pressure pain threshold observed in the experimental group indicates a reduction in cervical and pericranial muscle tenderness. Muscle tenderness is a common clinical feature of chronic tension-type headache and is considered relevant to both peripheral nociceptive input and central sensitization. Regular strengthening and stabilization exercise may reduce tenderness through improved local muscle conditioning, decreased fatigue-related nociceptive drive, enhanced circulation, and exercise-induced hypoalgesia. The present findings are consistent with previous work reporting reductions in muscle tenderness following strengthening and posture-focused rehabilitation in patients with chronic headache (15,16). However, because the experimental program included cervical strengthening, scapular stabilization, and stretching, the reduction in tenderness should be interpreted as the effect of a multimodal strengthening-centered rehabilitation package rather than isolated cervical strengthening alone.

Headache intensity and headache frequency also decreased more substantially in the experimental group. The reduction in Visual Analogue Scale scores and monthly headache days suggests that improving cervical muscle performance may influence headache symptoms beyond local neck function. One possible explanation is the trigeminocervical convergence mechanism, in which nociceptive input from upper cervical structures converges with trigeminal pathways and contributes to headache perception. By improving cervical stability and reducing abnormal mechanical stress, the experimental intervention may have reduced nociceptive input from cervical tissues and contributed to improved pain modulation (8,9). These findings support earlier physiotherapy and exercise-based literature indicating that non-pharmacological rehabilitation may reduce headache intensity, frequency, and disability in chronic tension-type headache (10–13).

The greater improvement in cervical range of motion in the experimental group further supports the relationship between muscle performance and functional cervical mobility. Restricted cervical motion in chronic headache may result from pain-related guarding, muscle tightness, reduced neuromuscular control, and avoidance of movement. The combination of progressive strengthening, active range-of-motion exercise, scapular control, and stretching may have improved movement efficiency and reduced protective muscle activity. This finding is clinically relevant because improved cervical mobility may reduce mechanical triggers during daily activities and improve tolerance to sustained postures, particularly in patients whose headaches are aggravated by prolonged sitting, computer use, or poor head-neck alignment.

Headache-related disability, measured using the HIT-6, showed the largest treatment effect among the reported outcomes. This finding is important because disability reflects the broader impact of headache on daily functioning, work productivity, social participation, and quality of life. A reduction in HIT-6 score indicates that the benefits of the intervention extended beyond impairment-level changes and were reflected in patient-perceived functional improvement. The observed pattern suggests that improving cervical strength, reducing tenderness, decreasing headache symptoms, and enhancing range of motion may collectively contribute to lower disability. This multidimensional response is particularly relevant

for chronic tension-type headache, where symptom persistence is often associated with both musculoskeletal dysfunction and reduced functional capacity.

The superiority of the experimental intervention may be explained by several interacting mechanisms. First, progressive strengthening likely improved the capacity of cervical muscles to maintain stable head and neck posture during functional activities. Second, improved activation of the deep cervical flexors and scapular stabilizers may have reduced compensatory overactivity of superficial cervical muscles, thereby decreasing tenderness and fatigue. Third, repeated exercise exposure may have promoted exercise-induced hypoalgesia and improved descending pain modulation. Fourth, the supervised and progressive nature of the intervention may have improved adherence, movement confidence, and treatment engagement. These mechanisms are plausible but should be interpreted cautiously because the present study did not directly measure neuromuscular activation patterns, central sensitization, medication use, or psychosocial mediators.

The findings have practical implications for physiotherapy management of chronic tension-type headache. Conventional physiotherapy modalities such as heat, TENS, stretching, range-of-motion exercise, and postural education may provide symptomatic benefit, but the present results suggest that adding a structured strengthening-centered cervical and scapular program may produce broader improvements in muscle function, tenderness, headache symptoms, mobility, and disability. The intervention is low-cost, feasible in outpatient rehabilitation settings, and associated with minimal adverse effects in the present study. Clinicians may therefore consider incorporating progressive cervical strengthening, deep cervical flexor training, and scapular stabilization into rehabilitation plans for appropriately screened patients with chronic tension-type headache.

Several limitations should be acknowledged. The study was conducted at a single clinical center, which may limit generalizability to other healthcare settings and patient populations. The follow-up period was limited to immediate post-intervention assessment after eight weeks; therefore, the durability of treatment effects remains unknown. Participant and therapist blinding was not feasible because of the nature of the intervention, creating a possible risk of performance or expectation bias. Although outcome assessors and data analysts were blinded, subjective outcomes such as VAS and HIT-6 may still be influenced by participant expectations. The study also did not include long-term follow-up, medication-use monitoring, psychosocial covariates, or objective assessment of cervical muscle activation. In addition, because the experimental intervention included cervical strengthening, scapular stabilization, and stretching, the independent contribution of each component cannot be isolated.

Future research should include larger multicenter randomized trials with longer follow-up periods to evaluate the sustainability of treatment effects. Further studies should compare different strengthening dosages, progression strategies, and combinations of strengthening with manual therapy, motor control training, or behavioral interventions. Future trials should also report between-group mean differences with 95% confidence intervals, prespecified primary endpoints, trial registration, and detailed missing-data procedures to improve transparency and reproducibility. Investigations incorporating objective measures of neuromuscular control, central sensitization, medication use, and psychosocial factors may help clarify the mechanisms through which cervical strengthening-centered rehabilitation improves outcomes in chronic tension-type headache.

CONCLUSION

A structured eight-week cervical strengthening-centered rehabilitation program was more effective than conventional physiotherapy in improving cervical flexor and extensor strength, reducing muscle tenderness, decreasing headache intensity and frequency, increasing cervical range of motion, and reducing headache-related disability in adults with chronic tension-type headache. The findings suggest that supervised rehabilitation targeting cervical muscle performance and scapular stabilization may provide meaningful short-term clinical benefits when incorporated into physiotherapy management for

this population. However, because the intervention was multimodal and follow-up was limited to the immediate post-treatment period, further multicenter trials with longer follow-up and more detailed reporting of treatment mechanisms are required before definitive conclusions can be made regarding long-term effectiveness and optimal exercise dosage.

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