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Original Article

Effect of Deep Neck Flexor Activation on Upper Trapezius Muscle Tightness in Individuals with Forward Head Posture: A Randomized Controlled Trial

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ABSTRACT

Background: Forward head posture is associated with impaired deep cervical flexor function, altered cervical muscle recruitment, neck pain, and disability. Evidence regarding the specific effect of deep cervical flexor activation on upper trapezius tightness remains limited. Objective: To determine the effect of a structured deep cervical flexor activation programme on upper trapezius tightness and secondary cervical outcomes in individuals with forward head posture. Methods: This parallel-group randomized controlled trial included 70 participants allocated to deep cervical flexor activation or general postural education groups, with 35 participants per group. Outcomes assessed at baseline and postintervention included upper trapezius tightness, craniovertebral angle, deep cervical flexor endurance, Numeric Pain Rating Scale score, and Neck Disability Index score. Between-group effects were estimated from differences in change scores with 95% confidence intervals. Results: Compared with the control group, the intervention group demonstrated greater reductions in upper trapezius tightness (mean difference, −1.55; 95% CI, −1.92 to −1.18; $p<0.001$; $d=1.99$), pain (−2.15; 95% CI, −2.56 to −1.74; $p<0.001$), and disability (−14.50 percentage points; 95% CI, −16.06 to −12.94; $p<0.001$). Craniovertebral angle increased by an additional 3.00° and deep cervical flexor endurance by 8.30 seconds. Improvements in endurance were negatively correlated with changes in upper trapezius tightness in the intervention group ($r=-0.68$; $p<0.001$). Conclusion: Deep cervical flexor activation was associated with greater short-term improvements in upper trapezius tightness, cervical posture, muscle endurance, pain, and disability than postural education alone. Keywords: Deep cervical flexor activation; forward head posture; upper trapezius tightness; craniovertebral angle; neck pain.

INTRODUCTION

Forward head posture is a common postural alteration characterized by anterior displacement of the head relative to the trunk and is generally identified by a reduction in the craniovertebral angle on lateral photographic assessment. Prolonged computer use, smartphone exposure, sustained sitting, and other activities requiring continued visual concentration may contribute to the development or persistence of this postural pattern. Forward head posture has been associated with neck pain, functional limitations, altered cervical muscle performance, and impaired neuromuscular control of the cervical and scapular regions (1–3). Although postural alignment varies among individuals and cannot be interpreted independently of symptoms and function, a reduced craniovertebral angle may increase the mechanical demand placed on the cervical musculature and contribute to persistent neck and shoulder discomfort.

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The deep cervical flexors, principally the longus capitis and longus colli, provide segmental support and facilitate controlled craniocervical flexion. Individuals with forward head posture and chronic neck symptoms frequently demonstrate reduced activation or endurance of these muscles, accompanied by greater recruitment of superficial cervical and scapular muscles (4–6). The upper trapezius may consequently contribute to compensatory stabilization of the head and shoulder girdle, particularly during sustained postures and repetitive upper-limb activities. Prolonged or excessive recruitment of this muscle may be accompanied by increased perceived tightness, fatigue, tenderness, and pain. This altered coordination between the deep cervical flexors and superficial muscles is frequently described within models of impaired cervical motor control and upper-quarter muscle imbalance.

Targeted deep cervical flexor training has been investigated as a strategy for restoring cervical motor control. Craniocervical flexion exercises, particularly when performed with pressure biofeedback, can improve deep cervical flexor activation and endurance while limiting substitution by superficial cervical muscles. Previous controlled studies have reported improvements in deep cervical flexor endurance, neck pain, disability, and, in some populations, craniovertebral angle following structured deep cervical flexor training (1,2,7). Cervical stabilization programmes containing deep cervical flexor exercises have also been associated with improvements in cervical posture, headache-related outcomes, pain, and functional performance (8). However, changes in static postural alignment have not been consistent across studies, suggesting that the effects of deep cervical flexor training may be more pronounced for neuromuscular control and symptoms than for structural posture alone.

Exercise programmes directed at cervical and scapular muscle imbalance may also influence upper trapezius characteristics. Corrective exercise has been associated with improvements in forward head posture and reductions in upper trapezius stiffness, while neck stabilization exercises have been reported to reduce upper trapezius tone and improve cervical alignment (9–11). These findings support a possible relationship between improved deep cervical stabilization and reduced reliance on the upper trapezius. Nevertheless, upper trapezius activity, stiffness, tightness, and pain represent related but distinct constructs, and evidence regarding the effect of an isolated deep cervical flexor activation programme on clinically assessed upper trapezius tightness remains limited.

Most previous deep cervical flexor training studies have primarily evaluated pain, disability, deep cervical flexor endurance, or craniovertebral angle. Direct assessment of upper trapezius tightness has been less common, while electromyographic investigations have generally described altered muscle-activation patterns without determining whether deep cervical flexor training reduces clinically perceived tightness (5,12). Furthermore, studies have frequently involved selected populations such as adolescents, teachers, medical students, excessive screen users, or patients with headache, limiting the transferability of their findings to other individuals with forward head posture. A controlled investigation in which upper trapezius tightness is treated as the primary outcome may therefore provide clinically relevant information regarding the broader neuromuscular effects of deep cervical flexor activation.

The primary objective of this study was to determine the effect of a structured deep cervical flexor activation programme on upper trapezius muscle tightness in individuals with forward head posture. The secondary objectives were to evaluate changes in craniovertebral angle, deep cervical flexor endurance, neck pain intensity, and neck-related disability and to examine the relationship between changes in deep cervical flexor endurance and upper trapezius tightness. It was hypothesized that participants receiving deep cervical flexor activation would demonstrate greater reductions in upper trapezius tightness and greater improvements in cervical posture, deep cervical flexor endurance, pain, and disability than participants receiving general postural education.

MATERIALS AND METHODS

A prospective, parallel-group randomized controlled trial was conducted among individuals with forward head posture in Karachi, Pakistan. Seventy participants were recruited through convenience sampling from an academic or clinical population and allocated in a 1:1 ratio to an intervention group or a control group, with 35 participants assigned to each group. Individuals were eligible when they were adults with forward head posture identified through a reduced craniovertebral angle on lateral photographic assessment. Individuals with recent cervical surgery, acute cervical trauma, or severe neurological disorders that could affect cervical movement, posture, or participation in exercise were excluded. Eligible individuals received information regarding the study procedures before providing written informed consent.

After completion of the baseline assessment, participants were randomly allocated to the study groups. The intervention group received a structured deep cervical flexor activation programme over a six-to-eight-week period. The programme included craniocervical flexion exercises performed with pressure biofeedback and sustained deep cervical flexor holding exercises performed in supine and sitting positions. The exercises were intended to facilitate controlled activation and endurance of the deep cervical flexors while minimizing compensatory activity by superficial cervical muscles. Participants allocated to the control group received general education regarding cervical posture. Outcome measurements were completed at baseline and repeated at the end of the intervention period using the same assessment procedures.

The primary outcome was upper trapezius muscle tightness, assessed using a 0–10 clinical stiffness rating scale, with higher scores indicating greater perceived or clinically assessed tightness. The score was recorded at baseline and after completion of the intervention. The same scoring direction and assessment procedure were applied at both measurement points to permit evaluation of within-group and between-group changes.

Forward head posture was evaluated through measurement of the craniovertebral angle. A lateral photograph was obtained while each participant stood in a relaxed position. The craniovertebral angle was defined as the angle formed between a horizontal line passing through the spinous process of the seventh cervical vertebra and a line connecting the seventh cervical vertebra to the tragus of the ear. A smaller craniovertebral angle represented a greater degree of forward head posture, whereas an increase in the angle following treatment represented improvement in cervical alignment. Standardized lateral photographic assessment has been used in previous investigations of forward head posture and deep cervical flexor training (1,10).

Deep cervical flexor endurance was assessed using the craniocervical flexion test with a pressure biofeedback unit. Participants performed controlled craniocervical flexion while attempting to maintain the required pressure level without substituting with superficial cervical flexion. Endurance was recorded in seconds according to the duration for which the required position and pressure could be maintained. Participants were familiarized with the procedure before baseline testing, and the same assessment method was used at follow-up. Pressure-biofeedback assessment has previously been used to evaluate deep cervical flexor activation and endurance in individuals with neck pain and forward head posture (2,13).

Neck pain intensity was measured using the 11-point Numeric Pain Rating Scale, ranging from 0, representing no pain, to 10, representing the greatest pain intensity. Neck-related functional disability was assessed using the Neck Disability Index. Neck Disability Index scores were expressed as percentages, with higher values indicating greater disability. Both measures were administered at baseline and after the intervention and have been used extensively in clinical research involving neck pain and cervical rehabilitation (2,3,8).

The sample-size calculation was based on a two-group comparison using a two-sided significance level of 0.05, statistical power of 80%, and an anticipated standardized effect size of 0.70 for the primary outcome. The final recruitment target was set at 70 participants, comprising 35 participants in each group, to provide adequate group sizes and allow for potential attrition. The anticipated effect was selected because the primary outcome was upper trapezius tightness rather than craniovertebral angle, for which smaller effects had been reported in previous deep cervical flexor training research (1).

Baseline and postintervention measurements were collected using consistent procedures. Lateral photographs were obtained according to the same positioning protocol, and craniovertebral angle measurements were performed consistently to minimize measurement variability. Participants were familiarized with the craniocervical flexion test before formal recording. Study data were recorded using participant identification codes rather than personal identifiers, and access to identifiable information was restricted to maintain confidentiality.

Data were analysed using IBM SPSS Statistics version 28.0. Continuous variables were summarized using means and standard deviations, while categorical variables were summarized using frequencies and percentages. Independent-samples t-tests were used to compare continuous outcome measurements between the intervention and control groups at baseline. Paired-samples t-tests were used to evaluate changes between baseline and postintervention measurements within each group. A two-way mixed analysis of variance, incorporating group as the between-participant factor and time as the within-participant factor, was used to evaluate whether changes over time differed between the intervention and control groups. Pearson correlation coefficients were calculated to examine the relationship between changes in deep cervical flexor endurance and changes in upper trapezius tightness. Cohen's d was used to quantify the magnitude of key between-group differences. Statistical significance was established at a two-sided p-value of less than 0.05. Complete baseline and postintervention data were available for all 70 participants; therefore, no outcome-data imputation was required.

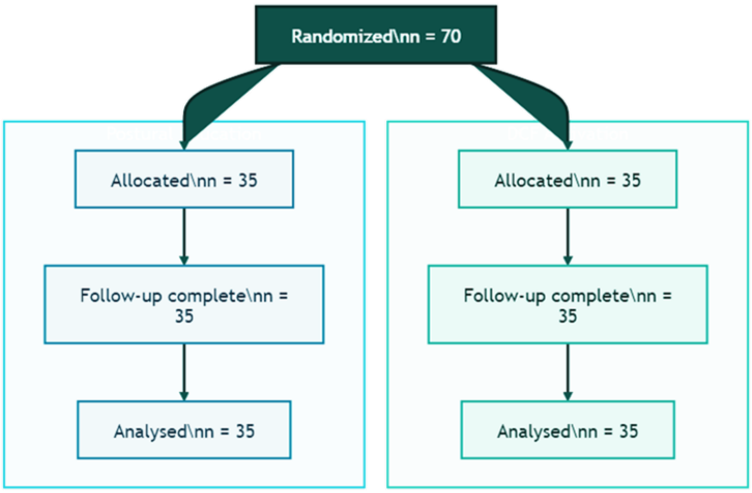

Figure 1 CONSORT Flowchart

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation was voluntary, and written informed consent was obtained before enrolment. Participants were informed of the study purpose, procedures, potential benefits, and possible discomfort associated with exercise and were permitted to withdraw without penalty. Participant information was treated confidentially, and study identification codes were used during analysis and reporting. Participants were instructed to report pain, dizziness, neurological symptoms, or other adverse responses during exercise so that treatment could be modified or discontinued when clinically necessary.

RESULTS

All 70 participants, comprising 35 participants in the intervention group and 35 in the control group, had complete baseline and postintervention outcome data. The groups had similar descriptive baseline values for upper trapezius tightness, craniovertebral angle, deep cervical flexor endurance, pain intensity, and neck-related disability. Baseline significance testing was not used to determine the adequacy of randomization.

Table 1. Outcome Measures at Baseline and Postintervention

Outcome	Intervention baseline, mean ± SD	Intervention postintervention, mean ± SD	Control baseline, mean ± SD	Control postintervention, mean ± SD
Upper trapezius tightness, 0–10	7.20 ± 1.10	4.90 ± 0.95	7.15 ± 1.05	6.40 ± 1.00
Craniovertebral angle, degrees	42.30 ± 5.20	45.80 ± 4.80	42.10 ± 5.40	42.60 ± 5.30
Deep cervical flexor endurance, seconds	18.50 ± 6.20	28.40 ± 7.10	18.20 ± 6.40	19.80 ± 6.50
Numeric Pain Rating Scale, 0–10	5.60 ± 1.40	2.80 ± 1.10	5.55 ± 1.35	4.90 ± 1.30
Neck Disability Index, %	42.00 ± 8.50	22.00 ± 6.80	41.50 ± 8.70	36.00 ± 8.00

Higher upper trapezius tightness, pain, and disability scores represent poorer status. A greater craniovertebral angle and longer deep cervical flexor endurance represent improvement.

Table 2. Within-Group Changes and Between-Group Intervention Effects

Outcome	Intervention change, mean ± SD	Control change, mean ± SD	Between-group difference in change, mean (95% CI)	F(1,68)	p-value	Cohen's d	Partial η^2
Upper trapezius tightness, 0–10	−2.30 ± 0.85	−0.75 ± 0.70	−1.55 (−1.92 to −1.18)	69.35	<0.001	1.99	0.505
Craniovertebral angle, degrees	3.50 ± 1.20	0.50 ± 1.00	3.00 (2.47 to 3.53)	129.10	<0.001	2.72	0.655
Deep cervical flexor endurance, seconds	9.90 ± 2.30	1.60 ± 2.00	8.30 (7.27 to 9.33)	259.54	<0.001	3.85	0.792
Numeric Pain Rating Scale, 0–10	−2.80 ± 0.90	−0.65 ± 0.80	−2.15 (−2.56 to −1.74)	111.58	<0.001	2.53	0.621
Neck Disability Index, percentage points	−20.00 ± 3.50	−5.50 ± 3.00	−14.50 (−16.06 to −12.94)	346.29	<0.001	4.45	0.836

Between-group differences were calculated as intervention-group change minus control-group change. Negative differences favour the intervention for upper trapezius tightness, pain, and disability; positive differences favour the intervention for craniovertebral angle and deep cervical flexor endurance. The group-by-time effect for two assessment points was evaluated through the between-group comparison of change scores. Cohen's d was calculated using the pooled change-score SD and is presented as an absolute magnitude. CI, confidence interval.

Table 3. Correlation Between Changes in Deep Cervical Flexor Endurance and Upper Trapezius Tightness

Group	n	Pearson r	95% CI	p-value
Intervention	35	−0.68	−0.83 to −0.45	<0.001
Control	35	−0.12	−0.44 to 0.22	0.48

Confidence intervals for Pearson correlation coefficients were calculated using Fisher's z transformation. Negative values indicate that greater gains in deep cervical flexor endurance were associated with greater reductions in upper trapezius tightness.

The primary outcome improved in both groups, although the reduction was substantially greater after deep cervical flexor activation. Upper trapezius tightness decreased by 2.30 ± 0.85 points in the intervention group and by 0.75 ± 0.70 points in the control group. The adjusted contrast represented a 1.55-point greater reduction in the intervention group (95% CI, 1.18–1.92 points; $F[1,68]=69.35$; $p<0.001$; $d=1.99$).

Cervical posture and deep cervical flexor endurance also improved more in the intervention group. The craniovertebral angle increased by 3.50 ± 1.20° in the intervention group and 0.50 ± 1.00° in the control group, producing a between-group difference of 3.00° (95% CI, 2.47–3.53°; $p<0.001$). Deep cervical flexor endurance increased by 9.90 ± 2.30 seconds in the intervention group compared with 1.60 ± 2.00 seconds in the control group. The resulting between-group difference was 8.30 seconds (95% CI, 7.27–9.33 seconds; $p<0.001$).

Pain intensity decreased from 5.60 ± 1.40 to 2.80 ± 1.10 in the intervention group and from 5.55 ± 1.35 to 4.90 ± 1.30 in the control group. The intervention produced a 2.15-point greater reduction in pain (95% CI, 1.74–2.56 points; $p<0.001$; $d=2.53$). Neck Disability Index scores decreased by 20.00 ± 3.50 percentage points in the intervention group and by 5.50 ± 3.00 percentage points in the control group, corresponding to a between-group difference of 14.50 percentage points (95% CI, 12.94–16.06; $p<0.001$; $d=4.45$).

Within the intervention group, greater improvement in deep cervical flexor endurance was associated with a greater reduction in upper trapezius tightness ($r=-0.68$; 95% CI, −0.83 to −0.45; $p<0.001$). No corresponding association was observed in the control group ($r=-0.12$; 95% CI, −0.44 to 0.22; $p=0.48$).

DISCUSSION

This study found that a structured deep cervical flexor activation programme produced greater short-term improvements in upper trapezius tightness, craniovertebral angle, deep cervical flexor endurance, neck pain, and neck-related disability than general postural education. The principal finding was a 1.55-point greater reduction in upper trapezius tightness in the intervention group. The concurrent improvement across muscle endurance, posture, pain, and disability suggests that deep cervical flexor activation may influence several related components of cervical musculoskeletal function rather than producing an isolated change in a single outcome.

The reduction in upper trapezius tightness is consistent with evidence that forward head posture may alter the spatial recruitment and mechanical behaviour of the descending portion of the trapezius and other cervical muscles (5,6). Park et al. found that adding craniocervical flexion exercise to cervical stretching influenced upper trapezius and suboccipital muscle characteristics and improved craniovertebral alignment in patients with cervicogenic headache (11). Similarly, a supervised corrective exercise programme improved cervical alignment and the biomechanical properties of cervicothoracic muscles in medical students with forward head posture (10). The present findings extend this evidence by treating upper trapezius tightness as the primary clinical outcome. Nevertheless, stiffness, muscle tone, electromyographic activity, perceived tightness, and palpation-based tightness are distinct constructs. The observed change should therefore be interpreted specifically in relation to the 0–10 clinical stiffness scale used in this study.

Deep cervical flexor endurance increased by 8.30 seconds more in the intervention group than in the control group. This result agrees with controlled studies showing that pressure-biofeedback training improves deep cervical flexor endurance and cervical motor control (2,3). Iqbal et al. reported greater improvements in endurance, pain, and disability when deep cervical flexor training was added to conventional exercise among school teachers with neck pain (2). Improvements in pain and posture have also been reported after pressure-biofeedback training in teachers and after structured cervical stabilization programmes in patients with headache (8,13). The consistency of these findings supports the clinical relevance of targeting deep cervical flexor performance within cervical rehabilitation.

The intervention group also demonstrated a 2.15-point greater reduction in pain and a 14.50-percentage-point greater reduction in neck-related disability. Previous trials have generally reported more consistent benefits of deep cervical flexor training for pain and function than for static postural alignment. Sikka et al. observed improvements in pain and functional status among adolescent computer users, although changes in forward head posture were limited (1). The present findings therefore support the symptomatic and functional benefits reported previously, but the magnitude of the standardized effects in the current study was substantially larger than that commonly reported in rehabilitation trials. These estimates should be interpreted in the context of the modest sample size, short assessment period, and clinical measurement approach.

The 3.00° between-group difference in craniovertebral-angle change indicates improvement in cervical alignment. This finding is consistent with the overall direction of evidence from therapeutic-exercise studies and systematic review findings suggesting that strengthening, stretching, and multicomponent corrective exercise can improve forward head posture (9,10). However, changes in craniovertebral angle have not been uniform across previous studies. A four-week deep cervical flexor programme did not produce a significant postural advantage in adolescent computer users, while a pilot trial among individuals with excessive screen exposure found that both neck-retraction and deep cervical flexor exercises improved posture, with somewhat greater postural change after neck-retraction exercise (1,7).

Differences in participant characteristics, baseline postural impairment, intervention dosage, comparator treatment, and photographic methods may contribute to variation across studies.

The negative correlation between deep cervical flexor endurance and upper trapezius tightness supports an association between improvement in deep cervical muscle performance and reduction in clinically assessed trapezius tightness. Experimental and electromyographic studies indicate that forward head posture may alter cervical and trapezius recruitment, while craniocervical flexion exercises are intended to facilitate deep cervical activation with reduced superficial-muscle substitution (4–6,12). The correlation observed in this study does not, however, demonstrate that improvement in endurance caused the reduction in upper trapezius tightness. Direct measurement of muscle activation and formal mediation analysis would be required to establish the proposed neuromuscular pathway.

The study's strengths include its two-group randomized design, complete outcome data for all 70 participants, assessment of a prespecified primary outcome, and simultaneous evaluation of posture, muscle endurance, pain, and disability. Reporting between-group differences with confidence intervals and standardized effect sizes improves interpretation beyond reliance on p-values alone.

Several limitations should be considered. Participants were recruited through convenience sampling from a single setting, limiting external validity. Demographic and clinical baseline characteristics were not available for detailed assessment of sample representativeness. The sequence-generation process, allocation concealment, assessor blinding, treatment adherence, protocol fidelity, and exposure to co-interventions were not sufficiently documented. The primary outcome was assessed with a clinical 0–10 stiffness scale rather than myotonometry, elastography, or electromyography, and its measurement properties and clinically important difference were not established. The control intervention may not have matched the intervention for therapist contact and treatment expectations. Adverse events were not reported, and the absence of longer-term follow-up prevents conclusions regarding the persistence of treatment effects. The large effect estimates should therefore be confirmed in prospectively registered, assessor-blinded, multicentre trials using objectively validated measurements and prespecified statistical analyses.

CONCLUSION

A structured deep cervical flexor activation programme was associated with greater short-term reductions in clinically assessed upper trapezius tightness, neck pain, and neck-related disability and greater improvements in craniovertebral angle and deep cervical flexor endurance than general postural education. Improvements in deep cervical flexor endurance were also associated with reductions in upper trapezius tightness. These findings support deep cervical flexor activation as a potentially useful component of rehabilitation for individuals with forward head posture, although confirmation using objectively validated muscle-stiffness measures, clearly documented trial procedures, and longer follow-up is required.

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