Original Article

Effects of Cervical Proprioception Training Versus Strengthening Exercise of the Deep Neck and Lower Trapezius Muscle Combined with Cranio-Cervical Flexion Training (CCFT) to Improve Postural Control of the Neck in Office Workers with Chronic Neck Pain: A Single-Blind, Parallel-Group Randomized Controlled Trial

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ABSTRACT

Objectives: To compare the effects of cervical proprioception training versus strengthening exercises of the deep cervical flexor and lower trapezius muscles, each combined with cranio-cervical flexion training (CCFT) on postural control of the neck in office workers with chronic neck pain

Study design: A single-blind, parallel-group randomized controlled trial

Setting: Outpatient Department (OPD), Physical Therapy Clinic, Ramathibodi Chakri Naruebodindra Hospital, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Thailand

Subjects: Thirty-three office workers with neck pain lasting more than 3 months were included. After three participants were excluded prior to the first assessment, twenty-eight people remained in the study (average age 31.2 years; 11 men, 17 women).

Methods: All treatments lasted 45-60 minutes per session, twice a week for 6 weeks (total of 12 sessions). Group 1 did CCFT plus neck position training (n = 10). Group 2 did CCFT plus neck and shoulder muscle strength training (n = 9). The control group did only CCFT (n = 9). Cervical joint position error (JPE), cervical range of motion (ROM), pain intensity (VAS), and the Neck Disability Index (NDI). Outcomes were assessed at baseline, at 4- and 6-weeks post-intervention, and at the 12-week follow-up.

Results: All groups showed significant within-group reductions in mean JPE error angles across all directions by T3 ($p < 0.05$). Group 2 exhibited the earliest improvement, with a significant reduction in JPE at T1 (week 4), whereas Group 1 reached significance at T2 (week 6). Between-group comparisons revealed that both intervention groups (groups 1 and 2) demonstrated significantly greater improvements in JPE than the control group. Cervical ROM increased over time in all groups. group 1 showed greater improvements in right/left lateral flexion than group 2, with no differences compared to the control group. Pain intensity (VAS) and NDI scores decreased significantly from baseline in every group ($p < 0.05$). However, the magnitude of reduction did not differ significantly between groups for VAS, while NDI reduction was greatest in Group 2.

Conclusions: Combining CCFT with deep cervical flexor and lower trapezius strengthening exercises yielded the most rapid and pronounced improvements in proprioceptive accuracy, postural control (ROM), and neck disability. All combinations of interventions were more effective than CCFT alone in reducing JPE, pain, and disability.

Keywords: chronic neck pain, cervical proprioception, strength training, cranio-cervical flexion training, lower trapezius

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Introduction

According to studies on musculoskeletal disorders among the working-age population in Thailand, the three most common complaints are neck pain, low back pain, and upper back pain, in that order. These conditions are largely attributed to inappropriate work environments, including prolonged sitting and a lack of postural variation during work hours.[1] With the increasing use of electronic devices and computers in modern workplaces, the prevalence of work-related musculoskeletal disorders has risen significantly. Risk factors include individual characteristics such as general health status, stress, anxiety, and underlying medical conditions, as well as occupational factors, including duration of work, nature of tasks, posture, and workplace ergonomics. These factors can contribute directly or indirectly to the development of musculoskeletal symptoms.[2,3]

Neck pain is commonly observed among working individuals, particularly those who also experience shoulder and upper back pain due to prolonged poor posture.[4] Chronic neck pain is a form of work-related musculoskeletal disorder that often results from repetitive strain on muscles, ligaments, joints, and nerves due to the continuous use of the same muscle groups.[5]

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Dysfunction in the control system of the cervical spine and deep neck muscles may lead to impaired joint control and repeated injuries to bones, muscles, and joints, which in turn contributes to the chronicity of neck pain.[6]

Ravi Shankar Reddy and colleagues found that patients with chronic neck pain and cervical spondylosis demonstrated deficits in joint position sense and movement control compared to healthy individuals. These patients also showed impaired function of deep neck muscles. In some cases, chronic neck pain can affect postural stability, in addition to the neuromuscular control of the cervical spine.[6,7] Sremakaew. et al. reported that patients with cervicogenic headache associated with upper cervical dysfunction exhibited postural instability during standing on unstable surfaces and tandem gait tasks.[8] Moreover, a systematic review by de Vries et al. indicated that joint position error tests could effectively differentiate patients with neck pain (whether traumatic or non-traumatic) from healthy controls, though differences among neck pain subgroups were not statistically significant.[9]

Various physical therapy interventions exist for managing chronic neck pain, including cervical mobilization and manipulation, neuromuscular exercises, stretching and strengthening of cervical muscles, cranio-cervical flexion exercises, thermotherapy, laser therapy, transcutaneous electrical nerve stimulation (TENS), and ergonomic education. The primary goals of these treatments are to reduce pain and improve cervical neuromuscular function.[10] While many interventions focus on short-term pain relief, specific muscle training, particularly targeting the deep neck flexors, has shown promise for long-term improvement and is recommended for physical therapy patients with chronic neck pain.[10,11]

Schomacher, J. and colleagues found that training the deep cervical extensor muscles can enhance coordination with the deep cervical flexors, improving muscle function and reducing overactivity of the extensors, ultimately leading to pain reduction in patients with chronic neck pain.[12] This form of training enhances sensorimotor control and proprioception of the cervical spine.[6] Similarly, research by O'Leary et al. highlighted the specificity and effectiveness of deep cervical flexor training, recommending this method for strengthening and endurance enhancement in patients with chronic neck pain.[13]

Gallego Izquierdo et al. compared cranio-cervical flexion training (CCFT) with joint position sense training in patients with chronic neck pain. CCFT, a low-intensity exercise, activates the motor control of deep neck flexors in coordination with deep neck extensors. Both types of training were found to improve deep neck flexor function, reduce pain, and enhance functional outcomes in terms of disability indices and daily activities.[14]

In another study by Shannon M. Petersen et al., patients with unilateral neck pain were found to have weakness in the lower trapezius muscle. Strengthening exercises targeting both the ipsilateral and contralateral lower trapezius muscles resulted in significant pain reduction, indicating the therapeutic potential of this approach for managing neck pain.[15,16]

Despite the growing evidence, research focusing on postural control in individuals with chronic neck pain remains limited. This randomized controlled trial aims to compare the effects of two protocols in working-age adults with chronic neck pain and investigate the effects of joint position sense training compared to lower trapezius strengthening exercises combined with CCFT on cervical postural control in working-age individuals with chronic neck pain. The findings from this study could help to inform and enhance physical therapy practices for this patient population in the future.

Methods

Study design

This randomized controlled trial was prospectively registered at the Thai Clinical Trials Registry (TCTR20230124005). Ethical approval was obtained from the Institutional Review Board, Faculty of Medicine Ramathibodi Hospital, Mahidol University (approval No. COA-MURA2021/361; approved on May 14, 2021). All participants provided written informed consent prior to enrollment. The study complied with the Declaration of Helsinki.

Participants

The study population comprised working-age patients presenting with chronic neck, shoulder, and scapular pain lasting for more than 3 months who sought treatment at the Outpatient Department (OPD) of the Physical Therapy Clinic, Ramathibodi Chakri Naruebodindra Hospital. All patients underwent a comprehensive evaluation by a physician specializing in rehabilitation medicine.

Eligibility screening

Potential participants were screened for eligibility based on predefined inclusion and exclusion criteria. To be included, individuals had to be office workers aged 20-50 years whose occupation involved computer- or desk-based tasks for more than 4 hours per day who reported chronic neck pain persisting for over 3 months; an average neck pain intensity of at least 30 millimeters on a 100-millimeter Visual Analog Scale (VAS) over the past week demonstrating a cervical joint position error (JPE) of more than 4.5 degrees, and be willing to provide written informed consent. Participants were excluded if they had any history of cervical spine or spinal cord injury or surgery, had been diagnosed with vestibular disorders (e.g., vertigo, BPPV), neurological sensory deficits or central nervous system disorders, circulatory disorders affecting the cervical region (e.g., migraine, vertebrobasilar insufficiency), musculoskeletal or neurological conditions impairing movement, inflammatory arthropathies of the cervical joints (e.g., rheumatoid arthritis), having received physical therapy for the neck and shoulder or upper back within the previous 6 months, a lower back condition such as scoliosis or lumbar disc herniation with nerve root compression or had been pregnant within the past 12 months, used analgesic, anti-inflammatory or steroid medications regularly, had communication difficulties preventing cooperation with study procedures, or declined or withdrew consent to participate.

All inclusion criteria and none of the exclusion criteria underwent a comprehensive medical assessment and diagnosis conducted by a rehabilitation medicine physician prior to enrollment. The study procedures and objectives were thoroughly explained to eligible participants, who then provided written informed consent to confirm their voluntary participation. At baseline, enrolled participants completed detailed history taking and physical examination in accordance with the research protocol. This assessment included evaluation of cervical JPE in multiple directions, measurement of pain intensity, cervical range of motion (ROM) testing, and completion of the Neck Disability Index (NDI) questionnaire. All outcome measurements were performed by an independent physical therapist who was not involved in delivering the interventions and who was blinded to group allocation (Figure 1).

Outcomes

Primary outcome measurement

Joint position error: Cervical joint position sense was assessed using the JPE test. Participants were seated in an upright position with their feet flat on the floor and wore a laser pointer mounted on a headband, aimed at a target placed on the wall at eye level. With eyes closed, participants were instructed to actively rotate or move their head in one of the tested directions: flexion, extension, left rotation, or right rotation, and then attempt to return to the starting (neutral) position. The deviation from the original target was measured in degrees and recorded as the JPE. Each direction was tested three times, and the mean error was calculated for each trial.

Secondary outcome measurement

VAS was measured using a 100-millimeter VAS consisting of a single horizontal line anchored at 0 representing no pain and 100 representing the worst pain imaginable. Participants were instructed to mark a point on the line that best reflected their average pain over the past seven days. This continuous scale was used to reduce score clustering and enhance measurement sensitivity.

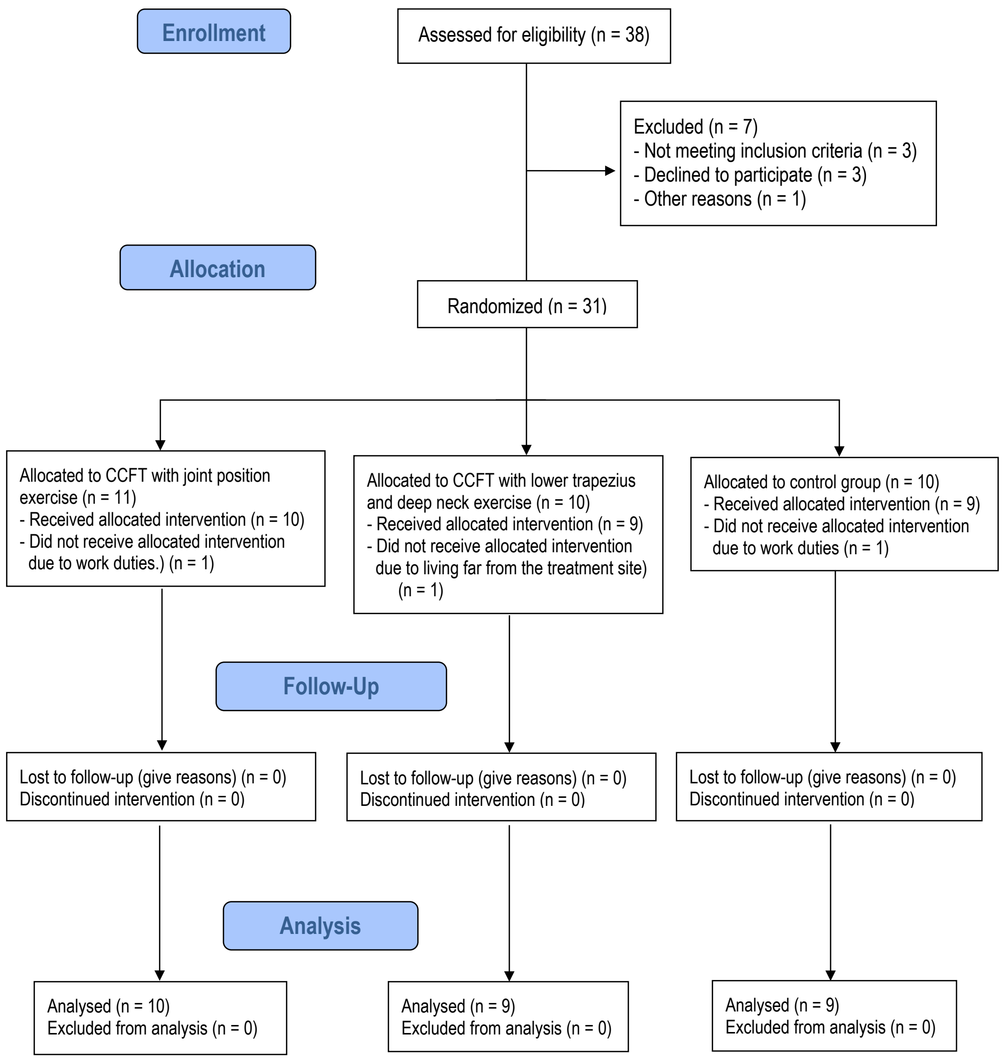

Figure 1. CONSORT flow diagram

Range of motion

Cervical range of motion was assessed in six directions (flexion, extension, left and right lateral flexion, left and right rotation). A digital inclinometer was mounted on a head strap to measure angular displacement. Participants were seated upright with both feet flat on the floor and head in a neutral position. Each movement was performed three times, and the average value was recorded as the representative range of motion for each direction.

Neck disability index

Neck-related disability was assessed using the Thai version of the NDI, a validated questionnaire commonly used in Thailand for evaluating patients with neck pain. The NDI consists of items related to activities of daily living and functional tasks, providing a comprehensive measure of the impact of neck pain on daily activities.

Statistical analysis

Descriptive statistics were used to summarize baseline characteristics. Categorical variables were presented as frequencies and percentages, and continuous variables as mean (SD) or medians (range), depending on distribution. Between-group comparisons were analyzed using Chi-square or Fisher's exact test for categorical variables and ANOVA or Kruskal-Wallis test for continuous variables. Changes in outcomes (JPE, ROM, Pain Score, %NDI) over time were analyzed using mixed-effects models with time, group, and their interaction as fixed effects and subjects as random effects. Results were reported as least-squares means (95%CI). Statistical significance was set at $p < 0.05$. Analyses were performed using Stata version 18 (Stata Corp LLC, College Station, TX, USA).

Sample size calculation

The sample size was calculated based on previous literature by Gallego Izquierdo et al. (2016), using pooled data from all directions of JPE, with a standard deviation of 15 degrees. This corresponds to a large effect size (Cohen's f = 0.7). Using one-way ANOVA with three groups, a significance level of 0.05, and a power of 80%, the required sample size was 30 participants (10 per group).[14]

Intervention

All programs were delivered at the hospital OPD physical therapy twice weekly for 6 weeks (12 sessions total). Outcome assessments were conducted at T0 (baseline, week 0), T1 (week 4, mid-intervention), T2 (week 6, post-intervention), and T3 (week 12, follow-up). Eligible participants were randomly assigned to one of three physical therapy intervention groups using sealed opaque envelopes containing the group allocation. Group 1 received CCFT combined with cervical joint position sense training designed to improve proprioceptive accuracy through JPE exercises. Group 2 participated in CCFT along with strengthening exercises targeting the deep cervical flexor muscles and the lower trapezius muscle. Group 3, the control group, performed CCFT exclusively. Throughout the study, participants were informed of their right to withdraw at any time without consequence. Outcome assessments were conducted at four times: T0 (baseline), T1 (week 4 intervention), T2 (week 6 intervention), and T3 (week 12 follow-up). These follow-up evaluations aimed to monitor progress and treatment effectiveness over the course of the intervention period. (Figures 2-5)

Supine with sub-occipital cuff starting at 20 mmHg at baseline; gentle nodding to targets 22, 24, 26, 28, and 30 mmHg while keeping neutral alignment and avoiding superficial substitution. Dose: hold 10 seconds, 10 repetitions per target.

Seated with a headband-mounted laser aimed at a target 90 cm away at eye level, starting position, eyes closed. Move flexion, extension, and left/right rotation then return to perceived neutral. Each direction had 3 trials.

Supine chin-tuck (with/without slight head lift) on towel roll, emphasizing gentle deep flexor activation and neutral cervical alignment. Dose: 10 repetitions, 3 sets.

Results

A total of 31 participants were randomized to one of three groups (group 1 CCFT with joint position error training, n = 11; group 2 CCFT with deep cervical flexor and lower trapezius strengthening, n = 10; control group CCFT alone, n = 10). One participant per group withdrew during the intervention, and 28 participants were included in the final analysis (group

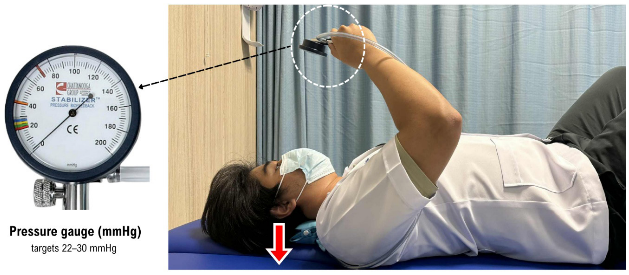

Figure 2. Cranio-cervical flexion training (CCFT)

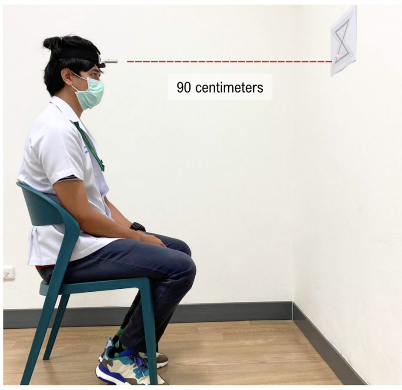

Figure 3. Joint position error (JPE)

Figure 4. Deep neck exercise

1, n = 10; group 2, n = 9; Control, n = 9; 11 males and 17 females; mean age, 31.2 years). The most frequently reported occupational activities were desk-based work, followed by computer use and smartphone use. Baseline characteristics showed no statistically significant differences among groups (Table 1). No adverse events or increases in neck pain were reported in any group during the intervention period.

All groups demonstrated a statistically significant reduction in mean JPE error angles across all directions at the 12-week follow-up (T3) ($p < 0.05$). Within-group analysis showed that Group 2 exhibited a significant reduction in JPE at week 4 (T1), while Group 1 demonstrated significant improvement at week 6 (T2). These findings suggest that group 2 experienced earlier improvement in proprioceptive accuracy compared to the other groups (Table 2).

Between-group comparisons revealed statistically significant improvements in JPE for both group 1 and group 2 compared to the control group, with no significant difference observed between the two intervention groups (Table 5).

Direction-specific intra-group analysis showed the following statistically significant reductions in JPE relative to baseline (T0):

- Right rotation: Significant reduction in the control group at T3.
- Left rotation: Significant reductions in groups 1 and 2 at T2 and T3; the control group showed significant reductions at T1 and T3.

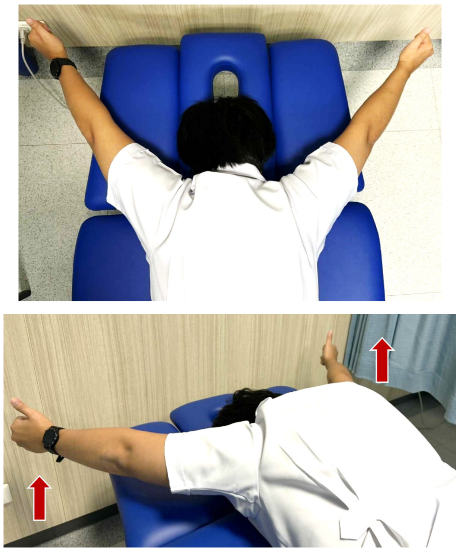

Figure 5. Lower trapezius exercise
Exercises in position "Y", prone horizontal abduction with external rotation. Dose: 10 repetitions, 3 sets

- Flexion: Significant improvements in groups 1 and 2 at T1 and T3; no significant changes in the control group.
- Extension: Significant reduction observed only in group 1 at T1.

Between-group comparisons indicated statistically significant differences in flexion and extension directions between each intervention group and the control group.

Cervical ROM: statistically significant increases in cervical ROM were observed in various directions over time:

- Extension: Increased ROM at T1 in the control group; at T2 in both group 1 and the control group; and at T3 in all three groups.
- Right Lateral Flexion: Increased ROM at T1 in the control group; at T2 in group 1 and the control group; and at T3 in all groups.
- Left lateral flexion: No significant changes at T1; increased ROM at T2 in the control group; and at T3 in all groups.

Table 1. Baseline characteristics of the participants (n = 28)

Baseline characteristics	Group 1 (n = 10)	Group 2 (n = 9)	Control group (n = 9)	*p*-value
Gender (n %)				
Male[1]	3 (27.3)	3 (27.3)	5 (45.5)	0.621[a]
Female[1]	7 (41.2)	6 (35.3)	4 (23.5)	
Age (years)[1]	30.2 (5.2)	32.2 (7.3)	31.3 (5.4)	0.763
BMI (kg/m^2)[1]	24.9 (9.4)	22.4 (10.2)	23.7 (4.0)	0.798[b]
Duration of neck, shoulder, scapular pain (months)[2]	12 (12, 24)	7 (6, 24)	12 (12, 12)	0.712[c]
Usage activities (hours)				
Computer[1]	4.5 (2.6)	4.0 (2.9)	5.3 (3.3)	0.626[b]
Desk[1]	4.1 (1.5)	7.7 (5.2)	7.7 (5.4)	0.136[b]
Smartphone[2]	2 (0, 2)	1 (0, 3)	2 (2, 8)	0.116[c]
Driving a car, motorcycle[2]	1 (1, 2)	1 (0.5, 3)	0 (0, 2)	0.354[c]
Heavy lifting[2]	0.5 (0, 1)	0.5 (0, 1)	0 (0, 1)	0.977[c]

[1]Mean (SD), [2]Median (p25, p75);
[a]*p*-value from Chi-square test, [b]*p*-value from One-way ANOVA, [c]*p*-value from Kruskal–Wallis test

Table 2. Joint position error (JPE)

	Group	Degrees[1]				p- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Mean JPE error angle	CCFT (JPE)	4.9 (4.3, 5.6)	4.4 (3.7, 5.2)	3.7 (2.8, 4.7)*	4.0 (3.0, 5.0)*	
	CCFT (LTE)	4.9 (3.9, 5.9)	4.0 (3.1, 5.0)*	4.0 (3.2, 4.8)*	4.1 (3.4, 4.8)*	0.009**
	Control	5.2 (4.6, 5.9)	5.2 (4.7, 5.8)	5.2 (4.1, 6.3)	4.2 (3.4, 4.9)*	
Right rotation	CCFT (JPE)	5.3 (4.9, 5.7)	6.1 (4.7, 7.6)	4.2 (2.9, 5.6)	4.4 (2.5, 6.3)	
	CCFT (LTE)	5.5 (3.8, 7.2)	4.3 (2.8, 5.8)	4.8 (3.2, 6.4)	4.9 (3.6, 6.2)	0.467
	Control	5.6 (4.4, 6.8)	6.3 (5.0, 7.5)	5.2 (3.9, 6.6)	3.9 (3.1, 4.7)*	
Left rotation	CCFT (JPE)	5.4 (4.0, 6.8)	4.7 (3.4, 5.9)	3.9 (2.4, 5.5)*	4.0 (3.1, 5.0)*	
	CCFT (LTE)	5.4 (4.2, 6.6)	4.2 (3.1, 5.3)	4.0 (3.0, 5.0)*	3.6 (2.5, 4.8)*	0.454
	Control	5.7 (4.4, 7.0)	4.6 (3.2, 6.0)*	4.9 (3.5, 6.4)	3.2 (1.9, 4.5)*	
Flexion	CCFT (JPE)	4.6 (3.4, 5.8)	3.4 (2.5, 4.3)*	3.4 (2.2, 4.5)	3.5 (2.6, 4.4)*	
	CCFT (LTE)	4.5 (3.8, 5.1)	3.1 (2.1, 4.0)*	3.5 (2.6, 4.4)	3.0 (1.9, 4.1)*	0.002**
	Control	4.8 (4.0, 5.6)	4.7 (3.7, 5.7)	4.8 (3.6, 6.0)	4.9 (4.2, 5.6)	
Extension	CCFT (JPE)	4.5 (3.6, 5.4)	3.4 (2.7, 4.1)*	3.3 (2.3, 4.3)	4.1 (3.2, 5.0)	
	CCFT (LTE)	4.5 (3.1, 5.8)	4.4 (3.4, 5.4)	3.3 (2.9, 4.0)	4.6 (3.9, 5.3)	< 0.001**
	Control	4.9 (4.0, 5.7)	5.5 (4.6, 6.4)	5.9 (3.9, 7.9)	4.8 (3.5, 6.1)	

[1]Mean (95% confidence interval); Mean JPE error angle, difference in angle compared with the initial angle before treatment;
CCFT, cranio-cervical flexion training; JPE, joint position error;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2);
Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups;
**Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 3. Range of motion of neck (ROM)

ROM	Group	Mean (95 % confidence interval)				p- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Flexion	CCFT (JPE)	43.7 (39.4,47.9)	46.0 (39.8, 52.1)	47.7 (41.8, 53.5)	50.9 (44.8, 56.9)*	
	CCFT (LTE)	42.4 (32.9, 52.0)	44.0 (36.8, 51.2)	44.0 (35.1, 52.9)	45.5 (36.1, 54.9)	0.009**
	Control	40.5 (35.9, 45.2)	39.4 (32.8, 46.0)	41.5 (35.4, 47.6)	42.7 (38.6, 46.8)	
Extension	CCFT (JPE)	47.6 (43.6, 51.6)	53.2 (48.1, 58.4)	58.5 (54.2, 62.8)*	55.5 (48.4, 62.5)*	
	CCFT (LTE)	50.5 (44.3, 56.7)	49.1 (40.7, 57.5)	51.0 (40.2, 61.8)	48.8 (41.2, 56.4)	0.467
	Control	43.8 (32.0, 55.5)	52.0 (43.6, 60.5)*	55.5 (48.7, 62.3)*	57.1 (52.1, 62.1)*	
Right lateral flexion	CCFT (JPE)	31.1 (27.3, 34.8)	32.6 (29.1, 36.1)	39.8 (36.8, 42.9)*	39.6 (35.4, 43.8)*	
	CCFT (LTE)	29.5 (25.6, 33.4)	30.5 (25.8, 35.1)	31.5 (26.9, 36.1)	31.3 (26.9, 35.7)	0.454
	Control	27.3 (23.6, 30.9)	32.9 (29.0, 36.8)*	35.5 (28.7, 42.2)*	35.4 (30.8, 39.9)*	
Left lateral flexion	CCFT (JPE)	32.1 (27.8, 36.4)	33.2 (28.2, 38.2)	38.7 (34.3, 43.1)	40.4 (34.7, 46.1)*	
	CCFT (LTE)	31.4 (28.9, 34.0)	31.4 (28.3, 34.5)	31.7 (28.6, 34.9)	30.4 (27.9, 32.8)	0.002**
	Control	31.7 (28.5, 34.8)	32.7 (27.9, 37.5)	36.5 (30.6, 42.5)*	36.9 (33.6, 40.1)*	
Right rotation	CCFT (JPE)	59.2 (51.9, 66.6)	70.2 (65.7, 74.7)*	70.5 (62.6, 78.4)*	67.1 (60.5, 73.6)	
	CCFT (LTE)	59.0 (50.3, 67.8)	64.2 (52.8, 75.6)	69.8 (57.9, 81.6)*	69.2 (59.1, 79.3)*	
	Control	55.7 (48.2, 63.3)	64.6 (58.1, 71.0)	64.0 (60.3, 67.6)*	62.6 (58.9, 66.3)	0.002**
Left rotation	CCFT (JPE)	60.5 (53.5, 67.5)	69.1 (63.6, 74.5)*	73.1 (68.0, 78.2)*	71.7 (66.7, 76.7)*	
	CCFT (LTE)	59.4 (52.7, 66.1)	65.2 (54.0, 76.5)	71.6 (63.4, 79.9)*	69.7 (61.4, 77.9)*	
	Control	57.6 (49.9, 65.2)	64.5 (58.5, 70.6)	65.4 (59.9, 70.8)*	65.5 (61.2, 69.8)*	

CCFT, cranio-cervical flexion training; JPE, joint position error; CCFT, cranio-cervical flexion training;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups; **Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 4. Pain score and Neck Disability Index (NDI)

ROM	Group	Mean (95 % confidence interval)				*p*- value
		Baseline	Follow-up			
		T0	T1	T2	T3	
Pain score	CCFT (JPE)	6.5 (6.0, 6.9)	2.2 (1.3, 3.1)*	1.1 (0.4, 1.9)*	1.9 (1.0, 2.8)*	
	CCFT (LTE)	5.7 (4.9, 6.6)	1.3 (0.8, 1.7)*	0.5 (0.2, 0.9)*	0.6 (0.2, 1.0)*	0.346
	Control	6.4 (5.5, 7.3)	2.0 (1.0, 2.9)*	1.2 (0.4, 2.1)*	1.6 (0.4, 2.7)*	
	CCFT (JPE)	24.9 (19.6, 30.1)	12.5 (9.9, 15.1)*	8.1 (5.1, 11.1)*	11.8 (7.5, 16.2)*	
% NDI	CCFT (LTE)	20.2 (14.7, 25.8)	5.0 (1.8, 8.2)*	2.2 (-0.4, 4.9)*	2.2 (-0.6, 5.0)*	0.017**
	Control	23.3 (15.8, 30.9)	12.2 (7.9, 16.5)*	9.2 (4.7, 13.6)*	8.2 (2.6, 13.8)*	

CCFT, cranio-cervical flexion training; JPE, joint position error; CCFT, cranio-cervical flexion training;
CCFT (JPE), CCFT with joint position exercise (Group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (Group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$) compared with baseline (T0) within groups; **Statistical significance ($p < 0.05$) in ANOVA analysis between groups

Table 5. Multiple pairwise comparisons of study results (Bonferroni test)

Outcome	Mean (SD)			*p*-value
	CCFT (JPE)	CCFT (LTE)	Control	
Joint position error (degree)				
Mean JPE error angle	4.3 (1.4)	4.1 (1.3)	5.1 (1.2)	0.009*
Right rotation	5.0 (2.2)	4.7 (2.3)	5.4 (1.9)	0.467
Left rotation	4.6 (2.2)	4.2 (1.8)	4.8 (2.2)	0.454
Flexion	3.7 (1.7)	3.5 (1.5)	4.8 (1.4)	0.002*
Extension	3.8 (1.5)	4.1 (1.5)	5.3 (2.0)	< 0.001*
ROM (degree)				
Flexion	46.5 (8.9)	43.6 (13.1)	41.0 (8.1)	0.082
Extension	53.7 (9.0)	50.3 (12.3)	53.3 (13.7)	0.425
Right lateral flexion	35.6 (7.0)	31.0 (6.5)	32.9 (7.9)	0.028*
Left lateral flexion	35.8 (8.3)	31.2 (4.2)	34.7 (6.9)	0.016*
Right rotation	66.3 (11.3)	65.3 (16.4)	62.1 (9.3)	0.370
Left rotation	68.1 (10.1)	65.4 (13.4)	63.7 (9.8)	0.253
Pain (score)	3.0 (2.5)	2.2 (2.4)	2.8 (2.6)	0.346
NDI (%)	14.6 (9.1)	8.0 (9.5)	12.9 (10.6)	0.017*

JPE, joint position error; ROM, range of motion of neck; NDI, Neck Disability Index; CCFT, cranio-cervical flexion training; CCFT (JPE), CCFT with joint position exercise (group 1); CCFT (LTE), CCFT with lower trapezius and deep neck exercise (group 2); Control, CCFT alone (control group); T0 = baseline; T1 = follow-up week 4; T2 = follow-up week 6; T3 = follow-up week 12;
*Statistical significance ($p < 0.05$)

- Right rotation: Increased ROM at T1 in group 1; at T2 in all groups; and at T3 in control group only.
- Left rotation: Increased ROM at T1 in group 1; at T2 in all groups; and at T3 in the control group and group 1.

Between-group comparisons revealed no significant differences in lateral flexion ROM between the intervention groups and the control group. However, group 1 exhibited significantly greater improvement in both right and left lateral flexion compared to group 2 (Table 3, Table 5).

Pain Scores decreased over time in all groups. Although between-group comparisons showed no statistically significant differences, within-group comparisons revealed significant reductions from baseline (T0) in all groups (Table 4). NDI scores significantly decreased in all groups both within and between time points. There was no significant difference in NDI reduction between the intervention groups and the control group. group 1 demonstrated significantly greater improvement than group 2 in both pain score and NDI and multiple pairwise comparisons of study results (Bonferroni test). (Table 4, Table 5)

Discussion

The findings of this study demonstrate that supplementing CCFT with either JPE training or lower trapezius exercises (LTE) produces greater pain relief, increases cervical ROM, enhances cervical postural control, and lowers NDI scores in patients with chronic neck, shoulder and scapular pain than CCFT alone.

Both the CCFT plus JPE and the CCFT plus LTE groups showed similar improvements in the measured outcomes, suggesting that combining specific muscle training with proprioceptive exercises is key to enhancing motor control and modulating pain.

Chronic neck pain reflects not only deficits in cervical proprioception but also impaired motor control of the neck, shoulder, and scapula. These impairments often manifest as inappropriate activation patterns, such as overuse of the upper trapezius and levator scapulae muscles which can exacerbate pain and further disrupt joint proprioception and postural stability.

CCFT effectively activates the deep cervical flexors, including the longus capitis and longus colli muscles, by stimulating proprioceptive receptors such as muscle spindles and golgi tendon organs. These receptors drive neuromuscular adaptations that improve cervical joint-position sense. Falla et al. (2004) reported that patients with chronic neck pain tend to overuse superficial muscles, namely the sternocleidomastoid and anterior scalene muscles, underscoring the necessity of deep cervical flexor training for sustained functional recovery.[17]

The CCFT plus LTE group showed the earliest improvements in mean JPE angle error, with significant changes by week 4. This likely reflects the role of the lower trapezius muscle in optimizing scapular alignment and maintaining cervical posture. These biomechanical gains may reduce inflammation and improve mechanoreceptor sensitivity. Juerjan et al. (2021) similarly found that targeted scapular exercises significantly reduced pain, increased muscle strength, and lowered NDI scores[18], underscoring the importance of scapular stabilizers in maintaining cervical posture and controlling movement.

Cervical range of motion improved in all groups, with the largest improvements in lateral flexion attributed to stretching of the upper trapezius and levator scapulae muscles. The CCFT plus JPE group achieved greater lateral flexion improvements than the CCFT plus LTE group, suggesting enhanced central nervous system processing and sharper kinesthetic awareness. These results align with those of Winter et al. (2022), who reported a 46% increase in joint position sense and a 45% improvement in motor system function following proprioceptive training.[19]

All three groups showed significant post-intervention improvements in NDI scores. The CCFT plus LTE group achieved the greatest reduction in disability. This finding is consistent with Park and Lee (2020), who found that lower trapezius training improves both the craniovertebral and cranial rotation angles, increases muscle thickness, and reduces pain.[20] All interventions reduced neck pain and improved cervical function; however, the CCFT plus LTE intervention produced the fastest recovery. Both joint position error training and lower trapezius exercises served as effective adjuncts to CCFT in office workers with chronic neck, shoulder, and scapular pain.

Conclusions

In this randomized three-arm trial of office workers with chronic neck pain, adding either proprioception training targeting joint position error or targeted strengthening of the deep cervical flexors and lower trapezius to cranio-cervical flexion training produced greater improvements in cervical sensorimotor control than cranio-cervical flexion training alone over a six-week period, with benefits observed at short-term follow-up. Targeted strengthening tended to yield larger reductions in pain and disability, whereas proprioception training appeared to produce the greatest gains in joint position accuracy. These findings suggest that combining cranio-cervical flexion training with a goal-matched adjunct can enhance clinical outcomes in practice. Clinicians can prioritize strengthening when pain and disability predominate, and focus on proprioception drills when sensorimotor inaccuracy is the primary deficit. Confirmation in larger, multi-center cohorts with longer follow-up and cost-effectiveness evaluation is warranted, along with optimization of dose and training duration, as well as stratified analyses to identify patients most likely to benefit.

Limitations

This study has several limitations. Daily loading and use of neck-shoulder-scapular muscles likely varied across participants, and some may have had undiagnosed early-stage cervical spondylosis which could have affected joint position sense and training response. The sample was small and single-center, and, although outcome assessors were blind, participants and physical therapists were not, introducing potential performance bias. Long-term follow-up was not conducted, and workplace ergonomics were not assessed. Future studies should utilize larger, multi-center cohorts with extended follow-up and incorporate ergonomic assessments and interventions to provide more durable outcomes.

Conflict of interest declaration

The authors declare that they have no conflicts of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript. Grammarly was used solely to check and refine grammar throughout the manuscript prior to submission. All content was fully written, organized, and reviewed by the authors.

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Data availability

All relevant data and materials are available from the corresponding author upon reasonable request.

Author contributions

Peerapong Wongsawan: conceptualization, methodology, data collection, formal analysis, writing - original draft,

Thanit Veerapong: supervision, methodology, resources, validation, writing - review & editing,

Supinda Rattanawihok: investigation, data curation, visualization, writing - review & editing.

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