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Research Article

The Effectiveness of Craniocervical Flexor Exercise on Craniovertebral Angle in Subjects with Forward Head Posture a Systematic Review

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Abstract

Background: The effectiveness of craniocervical flexor exercise on the craniovertebral angle in Subjects with forward head posture is a field that has drawn a lot of research interest. Therefore, this study aimed to conduct, for the first time, a systematic review to investigate the short-term effect of craniocervical flexor exercise on the craniovertebral angle of individuals with forward head postures.

Purpose: To explore the effect of craniocervical flexor exercise on forward head posture and investigate the short-term effect of deep cervical flexor exercise to increase the craniovertebral angle.

Design: Systematic review.

Methods: This systematic was performed based on PRISMA guidelines. Related resources about this topic were collected from different databases, which are: (PubMed, PEDRo, and Google Scholar). PEDro scale was used for examining methodological quality.

Results: Eight studies were included in our qualitative research. Craniocervical flexion exercise with pressure biofeedback was found to have different effects among studies on the craniovertebral angle compared with control or other interventions.

Conclusions: The current study's findings suggested that craniocervical flexion exercise may improve craniovertebral angle in subjects with forward head posture.

Keywords: Craniocervical Flexor Exercise; Deep Cervical Flexor Exercise; Pressure Biofeedback; Craniovertebral Angle; Forward Head Posture

Introduction

In general, forward head posture (FHP) refers to the posture that accompanies the forward bending of the lower cervical vertebrae and excessive extension of the upper cervical vertebrae [1]. FHP happens while the head moves anterior to a vertical line out of the individual's center of gravity [2]. Factors influence this posture in modernistic people to contain careers and habits [3,4], and most cases except the occupational factor are primarily influenced by the habit of using electronic devices such as computers and smartphones [5]. The use of optical display stations like smartphones for long hours can cause inappropriate positions such as FHP [6,7].

FHP can contain both upper cervical extension and lower cervical flexion [8]; it can involve weakness and lengthening of the cervical flexor muscles and shortening of the extensor cervical muscles [2]. If this dysfunction in the joints and muscles of the cervical region is prolonged, it may cause decreased muscular performance and delimit cervical mobility. The craniovertebral angle (CVA) is a simple and convenient descriptor of this aspect of natural head posture. CVA was recognized at the overlap of a horizontal line crossing through the C7 spinous process and a line connecting in the middle of the tragus of the ear to the skin overlying the C7 spinous process.

The head position angle evaluates the head situation in relevance to the trunk and indicates the vertical distance between the chin and sternum. It is the angle between the tragus manubrium line and the line passing from the center point of the chin to the tragus. Similar to the CVA, there is no standard cut-off point for this value, but a larger head position angle may be associated with a longer FHP. On the photographic image, a line was drawn through these points. A plumb line (gravity line) suspended from the ceiling in proximity to the Subject and captured in the photograph provided the means to draw a horizontal line through C7. The angle made between these two lines, i.e., the CVA (Figure 1), was gauged from the photograph with a protractor, using the Coutts overlay sheet technique [9].

Figure 1: CVA angle.

In the rehabilitation of FHP, methods for stretching the pectoralis, upper cervical extensors, strengthening the scapular retractors, and deep cervical flexors (DCF) are generally used [10]. Craniocervical flexors exercises (CCFE) a low-load exercise of the craniocervical flexors (CCF) that includes contracting the DCF of the upper cervical part (longus capitis and longus colli) without enrollment of the superficial flexors (sternocleidomastoid and anterior scalene). The program for CCFE was based on the previous studies [11,12]. DCF muscles act over the anterior aspect of the upper and middle parts of the cervical region [13]. DCF muscles are small stabilizing muscles located on the anterior and anterior-lateral surface of the cervical spine and are deep to the sternocleidomastoid muscle [14].

A previous study on FHP recommended that DCF play a major role in supporting and straightening the cervical spine [15]. In an early study, activation of the DCF was increased, and muscle activity of the superficial cervical flexors was decreased with significant devaluation in neck pain after CCFE in patients with chronic neck pain [12]. Additionally, (Rizo AM., *et al*. 2012) reported that suboccipital release (SR) promptly improved FHP in asymptomatic subjects, showing a significant increase in the CVA in both sitting and standing positions [16].

Materials and Methods

Protocol and registration

This qualitative study is based on PRISMA guidelines [20], with registration in PROSPERO (CRD42020223312).

Justification of systematic review

The main weaknesses of qualitative research are its time-consuming nature, the difficulty of generating generalizable results, and the increased risk of bias. In contrast, quantitative researchers rely on a positivist approach to social science. However, a shortage of data and resources can fail to provide an in-depth description of the experience [21]. (Parahoo (2014) defined systematic review as "the rigorous and systematic search, selection, appraisal, synthesis and summary of the findings of primary research studies to answer a specific question." It can be identified as "research on research" [22].

We agreed to use this kind of research based on some factors. First, Systematic reviews aim to identify, evaluate and summarise the findings of all relevant individual studies, thereby making available evidence more accessible to decision-makers [23]. Second, a systematic review demonstrates what was done, and this information can be used to direct future research [24]. Third, this type of research is concerned with the quality of included studies by providing systematic appraising of internal and external validity while restricting bias and enhancing accuracy and reliability.

To solve the research question, quantitative research studies consist of the sample in this review; consequently, the review compromised randomized controlled trials (RCTs). Other studies as such designs have less bias in the internal validity [25]. The ontological assumption in quantitative research is objectivist or realist, which means that facts have an objective reality [25]. The author assumes that some realities, i.e., CCFE, may affect the craniovertebral angle of individuals with forward head postures.

Eligibility criteria

Search process and strategies

The starting point was the review question, which was formulated by using PICO or PICOS, which is intended for questions of therapeutic interventions [25]. This study was conducted based on literature that investigates the effectiveness of craniocervical flexor exercise on forward head posture, which is measured by craniovertebral angle. Related resources about this topic were collected from different databases, which are: (PubMed, PEDro, and Google Scholar).

Our research question is.

What's the effectiveness of craniocervical flexor exercise on the craniovertebral angle in subjects with forward head posture?

We used the following terms

- **Search word 1:** (Craniocervical flexor exercise - deep cervical flexor exercise).
- **Search word 2:** Pressure biofeedback - craniovertebral angle.
- **Search word 3:** Forward head posture.

Initially, all titles and abstracts of the studies were screened. Then, studies included in this research were randomized control trials and non-randomized control trials. Also, any articles that contained craniocervical flexor exercise or deep cervical exercise as an intervention and craniovertebral angle as the measurement in the study were included.

Selection process

Two authors (AJ/MH) explored specific articles separately and then investigated and clarified specific studies for inclusion, simplified by grading each eligibility criterion as eligible/not eligible/might be eligible [26]. full articles were revised, and the article counted as potentially related to our interest when it cannot be excluded based on its Title and Abstract [23] following discussion between the two separated authors. The full texts were acquired for abstracts with incomplete information or in case of disagreement. When both authors agreed and were satisfied separately with an article, then it was included in our study. In the condition of any conflict between authors on that occasion, a consensus method was used, or an expert was aided to solve disagreements between the two authors concerning the inclusion of articles [27,28].

Data collection process

Using a standardized form, (AJ/MH) were elicited the data separately [23]. For matchmaking and distinctness, a third expert inspected the elicited data.

Inclusion criteria

Study design

Randomized control trials were included in the study. Also, non-randomized control clinical trials (CCTs) were included because RCTs were less than five [26].

Participants

We included articles that inspected general subjects (13 years or older) who had forward head postures (CVA <53). We also included studies on people who were diagnosed with neck pain or not. Furthermore, we excluded studies of populations restricted to specific diseases or obesity, as determined by body mass index >30 kg/m^2 [29]. Every article defined the Subject's characteristics (age - sex - Weight – height - timescales to appear disorder phases) at the baseline and after the intervention.

Intervention

We are concerned about craniocervical flexor exercise as an intervention. CCFE was described in detail in type, duration, intensity, frequency, and Specifics of control or comparison interventions, whether the exercises were under the oversight of the therapist or self-supervision in a home exercise program. We excluded articles that combined our intervention with manual therapy or other modalities in the same group.

Outcomes measure

We included any studies that measured Craniovertebral angle by taking a lateral photograph of subjects and then made a line that connects the 7th cervical vertebra with the tragus and a horizontal line from a standing position; this approach was reported to have high reliability (intraclass correlation coefficient 0.94) [32]. This measurement was included in the study, with consideration of validity, reliability, and clarification of the measurement [26].

On the other hand, pain associated with CVA was included in the study with different pain scales used such as VAS, and NRPS.

Data items

The elicited articles consisted of sample characteristics, sample size, outcome measure, and timescales to reflect disorder state, acute, subacute, and chronic, outcomes. Otherwise, we excluded gray literature and other languages except for English and Arabic.

Data synthesis and analysis

Data were analyzed using mean difference (MD) that was converted into a standardized mean difference (SMD) with a confidence interval (CI) of 95%. A random-effects model was used to determine the effect size. The large effect size was considered to be 0.8 or more; medium between 0.5 and < 0.8; and small when 0.2 to < 0.5 [46]. Statistical significance was set at $p < 0.05$.

Effect size and its calculation for the outcome CVA were presented using a forest plot. The test of heterogeneity was analyzed using the I [2] statistic [47].

Studies were blinded and analyzed by an independent reviewer. Data were analyzed using the software Review Manager 5.3.

Risk of bias in individual studies

Bias refers to systematic deviations from the true underlying effect brought about by poor study design or conduct in the collection, publication, or review of data [23]. In our study, we considered the minimum criteria for the assessment of the risk of bias in RCTs as described in (CRD., 2008) [23]. The risk of bias for each included study was independently assessed by the same initial reviewers.

Rigour

To perform a high-quality study, the author considered three important notions during the evaluation of the articles: integrity, transparency, and accountability [30]. For the first one, the researchers used an appropriate assessment tool for appraising the articles (PEDro scale) [31]. Furthermore, to achieve transparency, and accountability the reviewers debated the inclusions and exclusions criteria with their supervisor in detail.

Results and Discussion

Search results

One hundred thirty-four studies were collected from different databases, and then screening records were excluded after exclusion criteria examination and duplication checked 96 articles. After prolonged examining and checking for full-text articles, 38 articles were recorded. In the final stage, eight studies were eligible in our review (Figure 2).

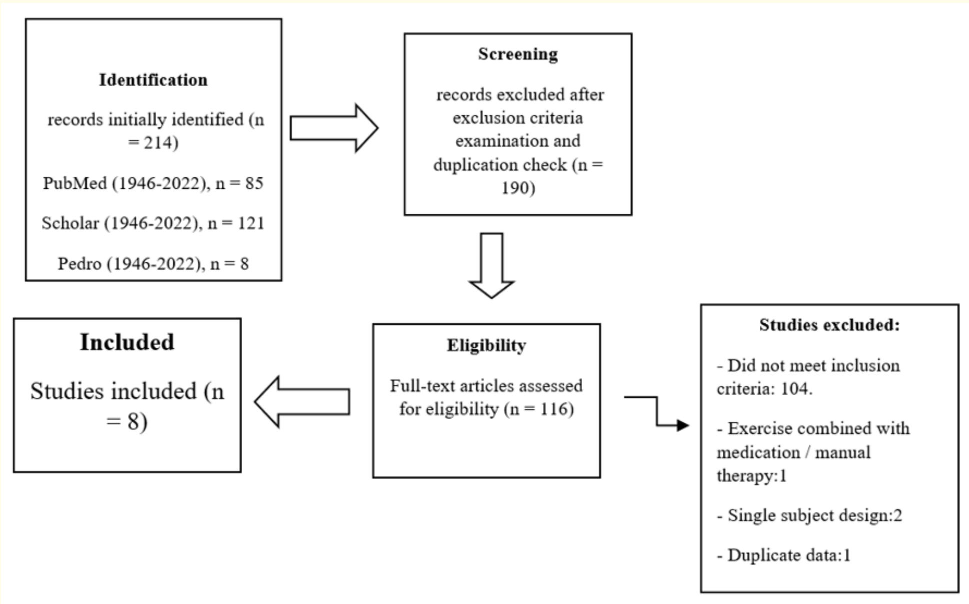

Figure 2: Flow diagram for eligible studies.

Studies characteristics

Quality of studies

Five studies out of 7 included studies were RCTs [15,37-38], whereas two studies were non-RCTs [33,34].

Based on the PEDro scale, four studies were of fair quality [15,34,36,38], three studies were of high quality [13,35,37].

Participant

Five studies included patients with chronic NP [15,34,35,37], one of these studies were for chronic mechanical NP [37]. Only one study was for chronic cervicogenic headaches [38]. Two studies out of 8 included patients with mechanical NP [33,37]. One study out of 8 included asymptomatic forward-head posture subjects (Chodankar A., *et al*. 2022).

Four studies only included specific participants; two studies included students [35,36], one study included Dentists [35], one study included Nurses [34]. All studies included adult participants, except one included participants below 18 years [35].

All studies included at least a minimum size of a valid generalization, except one study [36] included only twenty participants.

Intervention

The craniocervical flexion exercise with pressure biofeedback was compared with various interventions across several studies. Some of these studies included multiple groups; therefore, the intervention of interest was compared with more than one intervention [34,37].

The craniocervical flexion exercise was compared with different strengthening exercises in four studies [15,34,36,37], in one study was compared with stretching exercise [38], in one study was compared with mobilization treatment [33], in one study was compared with postural education [35], in one study the craniocervical flexion exercise with pressure biofeedback was compared with craniocervical flexion exercise without pressure biofeedback [36].

Outcome measures

All the studies included an assessment of CVA. FHP was assessed with CVA in all included studies. Five studies included pain neck assessment [15,33-35,37].

Effectiveness of the intervention

All the studies showed that craniocervical flexion exercise effectively reduces FHP except for three studies [33,35,36]. The duration of the intervention ranged from 3 to 6 weeks across studies. CCFE with pressure biofeedback (PB) was compared with the control group [15,35-38], all six studies showed improvement in CVA except [35,36].

In our review CCFE with PB was compared with several interventions [15] CCFE had a significant difference compared with isometric neck exercise, both [36,37]. CCFE had similar effectiveness when compared with conventional deep cervical flexor exercise [36] and semispinalis cervicis isometric exercise [34,37] showed CCFE had more effectiveness than endurance strengthening exercise, in [38]. CCFE had a significant difference compared with cervical stretching exercise, but [33,37] showed no significant improvement in CVA compared with upper cervical, and thoracic spine mobilization, Postural education, and Bruegger's exercises.

Five out of eight studies had a significant difference in CVA [15,34,37,38]. Table 1.

Authors	Sample size	Characteristics of participants	Duration and Doses of CCFE	Intervention	Control group	Outcome measure	Results	PEDro Scores
Gupta., *et al.* 2013 [15]	30 CCFE:15 C:15	Dentist with chronic neck pain (>3 months)CVA: 40-42NDI: (<24) Age: 20-40Y	Four weeks	Deep cervical flexion exercises with a pressure biofeedback	Conventional isometrics exercise	VAS NDI CVA	Significance Reduction in FHP in DCFE group.	4/10
Kang DY. 2015 [36]	20 DCFE with PU: 10 CDCFE: 10	College Students with FHP.Chronic neck pain. (>3 months)CVA:40-56VAS: >3/10. NDI: (<15) Age: 20-27 Y.	Experimental group: stretching (10 minutes) + Convention-al DCF exercise (15-20 minutes, 10-16 repetitions × 1-2 sets) + PBU exercise (5-10 minutes, 10-16 repetitions × 1-2 sets), three times a week for six weeks. Control group: stretching (10 minutes) + conventional DCF exercise (20-30 minutes, 10-16 repetitions × 1-4 sets), three times a week for six weeks.	Stretching exercises + conventional deep cervical flexion exercises with a pressure biofeedback	Stretching exercises + conventional deep cervical flexion exercises	CVA. Muscular endurance of deep cervical flexors. Cervical ROM.	Significant improvement in craniovertebral angle in both groups but more in the experimental group. No significant difference between both groups.	4/10
Karthikeyan M 2014 [34]	60 CCFE:20 CG1:20 CG2:20	Nurses with chronic, non-severe neck pain(>3 months) CVA: 38-50NDI: (5-15).craniocervical flexion test: (< 24 mmhg).Age: 20-30 years.	Five times a week for five weeks, 30 minutes per session. CCFE: Ten repetitions.	Craniocervical flexion exercise	CG1: endurance-strength training, progressing to resistance exercise.Repetitions:12-15. CG2: using both(CCFE+ CG1) programs.	CVA NRS NDI	a significant difference between CCFE and CG1. Significant improvement in CG2 more than in other groups.	4/10

Suvarnnato., *et al.* 2019 [37]	54 CCFE:18 CG1:18 CG2:18	Adults with chronic mechanical neck pain (>3 months) NDI: (≥10/100) CVA: 43-52 degrees. NPS:3-5/10. Age: 18-60 years.	Six weeks twice per week under supervision. Home exercises twice per day. Repetitions: ten times per set.	Deep cervical flexor exercise.	CG1: (semispinalis cervicis isometric exercise) Six weeks twice per week Repetitions: 10 times per set, Three sets per day. CG2: (usual care programs without CCFE and SCT) 10-12 sessions for six weeks, 20-30 minutes for each session.	CVA NPS NDI	significant improvement in CVA in CCFE and SCT groups compared to the control group immediately after training and at one-month follow-up, but at three months follow-up, the CCFE group showed better than the SCT group.	7/10
Park., *et al.* 2017 [38]	30 CCFE:15 C:15	Adults with chronic cervicogenic headache. (4-24 months) CVA: 48-50 degrees. Age:20-42 years.	CCFE: 10 repetitions Stretching exercise: 5-6 repetitions Duration: 3 weeks	Craniocervical flexion exercise + cervical stretching exercise.	cervical stretching exercise (5-6 repetitions) For three weeks	CVA So, Tone. SO, Stiffness. UT Tone. UT Stiffness.	There is improvement in craniovertebral angle in both groups but more in the CCFE group.	4/10
Sikka., *et al.* 2020 [35]	30 CCFE:15 C:15	Students with FHP and chronic neck pain. (3-18 months) NDI: (<24) CVA: 34-51 degrees. Age: 13-17.	Three sets, ten repetitions, four times per week for four weeks	Deep cervical flexor exercise + postural education.	Postural education for four weeks.	CVA VAS NDI	There is no significant improvement in CVA in both group.	6/10
Cho J., *et al.* 2019 [33]	31 CCFE:16 CG:15	Adult with FHP and mechanical neck pain NPRS:4-6/10. CVA:45-53 degree. Age:20-29	Less than 10 minutes, ten repetitions per set, ten sessions for four weeks.	Deep cervical flexor exercise.	CG: upper cervical and upper thoracic spine mobilization. Less than 10 minutes, ten sessions for four weeks.	CVA NPRS FVC FEV1 PIP (HH2O) PIF (L/s) PIV (L)	There is no significant improvement in CVA in the CCFE group. Significant improvement in CVA in CG at four weeks and six weeks.	8/10

Ashma 2022	51 BE and ERB: 17 CCFE: 17 CG: 17	Adults with asymptomatic FHP CVA: >53 Age: 18- 40	Session: 15-20 min. 15 sessions per week 1st week: 10 rep. 2nd week: 15 rep. 3rd week: 20 rep. With 20 sec. hold	BE and ERB: Bruegger's exercise and elastic resistance band CCFE: deep cervical flexor exercise with a pressure biofeedback	CG: neck isometric exercise with chin tucks, side flexion, and rotation.	CVA CCET Pectoralis minor index	There is a significant improvement in CVA in all groups. In BE Group Meanwhile, the craniovertebral angle correction was maintained for a longer duration in Bruegger's exercise group.	8/10

Table 1: A Description of Eligible Studies.

Abbreviations: CCFE: Craniocervical Flexor Exercise; DCFE: Deep Cervical Flexor Exercise; CVA: Craniovertebral Angle; FHP: Forward Head Posture; CG: Comparison Group; C: Control Group; VAS: Visual Analog Scale; NDI: Neck Disability Index; NPRS: Neck Pain Rating Scale; SCT: Semispinalis Cervicis Training; SO: Suboccipital; UT: Upper Trapezius; FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume In One Second; PIP: Peak Inspiratory Pressure; PIF: Peak Inspiratory Flow; PIV: Peak Inspiratory Volume

All studies showed CCFE with PB is effective in reducing NP intensity (4 - 6 weeks). The duration of the intervention ranged from 4 to 6 weeks across studies. In terms of comparisons with other interventions, in two studies [33] the other intervention is more effective than CCFE. in (Suvarnnato., *et al*. 2019) there is no significant difference between CCFE and other treatments. in 2 studies the CCFE with PB was more effective in pain reduction in comparison with the control condition. In (Sikka., *et al.* 2020) there is no significant difference compared with the control group.

Discussion

The results of this review showed that CCFE was effective in improving CVA in subjects with FHP. A search of the literature from 2013 to 2020 was done, and eight articles were finally included.

The treatment of FHP by CCFE is based on the rationale that the deep cervical flexor plays a major role in straightening and supporting cervical lordosis and improving postural function [15]. Facilitation of deep cervical muscles contributes to improving its ability and neuromuscular control [41,42].

[34] was founded that CCFE with cervical flexor exercises better combination in treating FHP than CCFE alone; this can be explained due to the effectiveness of cervical flexor exercises in increasing cervical flexion strength and reducing the myoelectrical manifestation of superficial superficiality muscle fatigue in individuals with chronic non-severe neck pain [44]. Another explanation is that cervical flexor exercises improve the endurance of DCF and superficial neck muscles. According to [37], deep cervical extensor muscles was important as deep cervical flexor muscles in the treatment program due to the results of recent studies that showed impairment in semispinalis cervicis and cervical multifidus muscles and stabilization of the cervical spine in individuals with chronic mechanical neck pain [43].

In (Ashma 2022), The craniovertebral angle was more easily maintained the improvement by Bruegger's exercises at weeks 6 and 9, both at the post-intervention and follow-up evaluations. Because of three factors, the deep cervical flexor training group's deep cervical muscular endurance improved more than the other two groups did. First, the exercises involve holding a position that stretches the pectorals and strengthens the scapular retractors. Second, the use of an elastic resistance band allows the pectoral and scapular retractor muscles to contract simultaneously, improving eccentric control and aiding in postural balance correction. Third, the exercises inhibit and relax the shortened muscles while simultaneously strengthening weak cervical and scapular muscles.

When the effect of CCFE is compared with other treatments (conventional isometric training [15] - cervical stretching [38] - usual care [37] 0 cervical flexion exercise [34]) the difference in CVA improvement is statistically significant with moderate to large effect size, respectively. In this review, comparing the mean change (MC) of CVA between those with or without neck pain showed better improvement than those without neck pain (with neck pain MC = 2.22 °, without neck pain MC = 4.6 °), and it is not obvious what level of change would be clinically meaningful. This difference in MC may be due to motor output defects and a decrease in the EMG amplitude of the painful muscle [39].

The CCFE in [33,35,36] showed no effect on CVA; two possible factors may explain this issue one mentioned by [40], CVA is a result of shortness of sternocleidomastoid cervical extensor muscles or even weakness of deep cervical flexor muscles. Another cause that may disturb the improvement of CVA is not addressing the bad posture in ADL activity or focusing on a single group of muscles (deep cervical flexor muscles) and over side muscles imbalance around the cervical spine [35].

In [36] When compared to the CCFE without PBU group, the CCFE with PBU group improved the craniovertebral angle right after the intervention, but the effect was lost at the 6-week checkup (week 9). This can be linked to the maintenance of a particular stance; the participant's head posture during exercise was aligned by maintaining the chin-tuck position while training with the pressure biofeedback unit.

Only [45] did a systematic review of craniovertebral angle, which analyzed the effect of therapeutic exercises on FHP. In contrast, our review was concerned with a specific type of exercise (CCFE). Our study was the first systematic review of craniocervical flexor exercise's effectiveness on the craniovertebral angle in subjects with forward head posture.

Limitations

Several limitations were found in this review: firstly: in study selection: no research on grey literature was done in this review, and only articles published in English or Arabic were reviewed. Secondary: most studies had limited data points, and the analysis of CVA outcome was measured from immediate to short-term. Otherwise, two studies were non-RCTs.

An important clinical inference was obtained from the results of this review. CCFE with PB seems to be an effective intervention for improving CVA in subjects with FHP. The CCFE is also preferable to strength-endurance training of deep cervical flexor muscles. Therefore, it is not suggested as monotherapy, but it should be a part of the rehabilitation program. Additionally, take into consideration the musculoskeletal imbalance in the cervical region to get better findings. Future studies should include large sample size, static and dynamic measurement of FHP, moderate to long-term follow-up period, and Randomized Controlled Trails design.

Conclusions

The results of this study demonstrated that CCFE may play a role in decreasing CVA in subjects with FHP. furthermore, high-quality RCTs should be conducted on this topic.

Data Availability

The data supporting this [SYSTEMATIC REVIEW] are from previously reported studies and datasets, which have been cited. The processed data are available [from the corresponding author upon request].

Conflicts of Interest

There is no conflict of interest regarding the publication of this paper.

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Bibliography

1. Hanten WP., *et al*. "Total head excursion and resting head posture: normal and patient comparisons". *Archives of Physical Medicine and Rehabilitation* 81.1 (2000): 62-66.
2. Lee MY., *et al*. "Characteristics of cervical position sense in subjects with forward head posture". *Journal of Physical Therapy Science* 26.11 (2014): 1741-1743.
3. Berg HE., *et al*. "Dynamic neck strength training effect on pain and function". *Archives of Physical Medicine and Rehabilitation* 75.6 (1994): 661-665.
4. Cailliet R. "Neck and Arm Pain (Pain Series)". Philadelphia: FA Davis and Co (1999).
5. Salahzadeh Z., *et al*. "Assessment of forward head posture in females: observational and photogrammetry methods". *Journal of Back and Musculoskeletal Rehabilitation* 27.2 (2014): 131-139.
6. Janwantanakul P., *et al*. "Risk factors for the onset of nonspecific low back pain in office workers: a systematic review of prospective cohort studies". *Journal of Manipulative and Physiological Therapeutics* 35.7 (2012): 568-577.

7. Szeto GP and Lee R. "An ergonomic evaluation comparing desktop, notebook, and subnotebook computers". *Archives of Physical Medicine and Rehabilitation* 83.4 (2002): 527-532.

8. Iqbal ZA., *et al*. "Effect of deep cervical flexor muscles training using pressure biofeedback on pain and disability of school teachers with neck pain". *Journal of Physical Therapy Science* 25.6 (2013): 657-661.

9. Dalton M. "The effect of age on cervical posture in a normal population". Grieve's modern manual therapy: the vertebral column (1994).

10. Roddey TS., *et al*. "The effect of pectoralis muscle stretching on the resting position of the scapula in persons with varying degrees of forward head/rounded shoulder posture". *Journal of Manual and Manipulative Therapy* 10.3 (2002): 124-128.

11. Jull G., *et al*. "A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache". *Spine* 27.17 (2002): 1835-1843.

12. Jull GA., *et al*. "The effect of therapeutic exercise on activation of the deep cervical flexor muscles in people with chronic neck pain". *Manual Therapy* 14.6 (2009): 696-701.

13. Basmajian JV. "Muscle Alive". Baltimore: Williams and wilkins Co (1979): 175-293.

14. Mayoux-Benhamou MA., *et al*. "Longus colli has a postural function on cervical curvature". *Surgical and Radiologic Anatomy* 16.4 (1994): 367-371.

15. Gupta BD., *et al*. "Effect of deep cervical flexor training vs. conventional isometric training on forward head posture, pain, neck disability index in dentists suffering from chronic neck pain". *Journal of Clinical and Diagnostic Research: JCDR* 7.10 (2013): 2261.

16. Rizo AMH., *et al*. "Immediate effects of the suboccipital muscle inhibition technique in craniocervical posture and greater occipital nerve mechanosensitivity in subjects with a history of orthodontia use: a randomized trial". *Journal of Manipulative and Physiological Therapeutics* 35.6 (2021): 446-453.

17. Falla D and Farina D. "Neural and muscular factors associated with motor impairment in neck pain". *Current Rheumatology Reports* 9.6 (2007): 497-502.

18. Quek J., *et al*. "Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults". *Manual Therapy* 18.1 (2013): 65-71.

19. Kim KH., *et al*. "The effects of horse-riding simulator exercise and Kendall exercise on the forward head posture". *Journal of Physical Therapy Science* 27.4 (2015): 1125-1127.

20. Moher D., *et al*. "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement". *PLOS Medicine* 6.7 (2009): e1000097.

21. Carr LT. "The Strengths and Weaknesses of Quantitative and Qualitative Research: What Method for Nursing?" *Journal of Advanced Nursing* 20.4 (1994): 716-721.

22. Parahoo K. "Nursing Research: Principles, Process, and Issues. 3rd edition". Basingstoke: Palgrave Macmillan (2014).

23. CRD. "Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care". York: University of York NHS Centre for Reviews and Dissemination (2008).

24. Cynthia D Mulrow. "Rationale for Systematic Reviews". *BMJ: British Medical Journal* 309.6954 (1994): 597-599.

25. Saini M and Shlonsky A. "Systematic Synthesis of Qualitative Research". US: Oxford University Press (2012).

26. Van Tulder M., *et al*. "Updated method guidelines for systematic reviews in the cochrane collaboration back review group". *Spine* 28.12 (2003): 1290-1299.

27. Furlan AD., *et al*. "2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group". *Spine* 34.18 (2009): 1929-1941.

28. Edwards P., *et al*. "Increasing response rates to postal questionnaires: a systematic review". *BMJ* 324.7347 (2002): 1183.

29. Kilpeläinen TO., *et al*. "Physical activity attenuates the influence of FTO variants on obesity risk: a meta-analysis of 218,166 adults and 19,268 children". *PLoS Medicine* 8.11 (2011): e1001116.

30. Siu C and Comerasamy H. "Doing a Research Project in Nursing and Midwifery: A Basic Guide to Research Using the Literature Review Methodology". *Sage* (2013).

31. de Morton NA. "The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study". *Australian Journal of Physiotherapy* 55.2 (2009): 129-133.

32. Lee CH., *et al*. "Reliability of forward head posture evaluation while sitting, standing, walking, and running". *Human Movement Science* 55 (2017): 81-86.

33. Cho J., *et al*. "Upper cervical and upper thoracic spine mobilization versus deep cervical flexors exercise in individuals with forward head posture: A randomized clinical trial investigating their effectiveness". *Journal of Back and Musculoskeletal Rehabilitation* 32.4 (2019): 595-602.

34. Karthikeyan M. "Effect of Craniocervical Flexor Training and Cervical Flexor Training on Sitting Neck Posture in Patients with Chronic Neck Pain; comparative study". *Indian Journal of Physical Therapy* 2.1.

35. Sikka I., *et al*. "Effects of Deep Cervical Flexor Training on Forward Head Posture, Neck Pain, and Functional Status in Adolescents Using Computer Regularly". *BioMed Research International* (2020).

36. Kang DY. "Deep cervical flexor training with a pressure biofeedback unit is an effective method for maintaining neck mobility and muscular endurance in college students with forward head posture". *Journal of Physical Therapy Science* 27.10 (2015): 3207-3210.

37. Suvarnnato T., *et al*. "Effect of specific deep cervical muscle exercises on functional disability, pain intensity, craniovertebral angle, and neck-muscle strength in chronic mechanical neck pain: a randomized controlled trial". *Journal of Pain Research* 12 (2019): 915.

38. Park SK., *et al*. "Effects of cervical stretching and cranio-cervical flexion exercises on cervical muscle characteristics and posture of patients with cervicogenic headache". *Journal of Physical Therapy Science* 29.10 (2017): 1836-1840.

39. Gizzi L., *et al*. "Experimental muscle pain impairs the synergistic modular control of neck muscles". *PloS One* 10.9 (2015): e0137844.

40. Janda V. "Muscles and motor control in cervicogenic disorders: assessment and management". *Physical Therapy of the Cervical and Thoracic Spine* (1994).

41. O'Leary S., *et al*. "Specificity in retraining craniocervical flexor muscle performance". *Journal of Orthopaedic and Sports Physical Therapy* 37.1 (2007): 3-9.

42. O'Leary S., *et al*. "Training mode-dependent changes in motor performance in neck pain". *Archives of Physical Medicine and Rehabilitation* 93.7 (2012): 1225-1233.

43. O'leary S., *et al*. "Muscle dysfunction in cervical spine pain: implications for assessment and management". *Journal of Orthopaedic and Sports Physical Therapy* 39.5 (2009): 324-333.

44. Mayoux-Benhamou MA., *et al*. "Longus colli has a postural function on cervical curvature". *Surgical and Radiologic Anatomy* 16.4 (1994): 367-371.

45. Sheikhhoseini R., *et al*. "Effectiveness of therapeutic exercise on forward head posture: a systematic review and meta-analysis". *Journal of Manipulative and Physiological Therapeutics* 41.6 (2018): 530-539.

46. Ferguson CJ. "An effect size primer: A guide for clinicians and researchers". *Professional Psychology: Research and Practice* 40.5 (2009): 532-538.

47. Higgins JP., *et al*. "Measuring inconsistency in meta-analyses". *BMJ* 327.7414 (2003): 557-560.