

Effect of deep neck flexor strengthening on forward head posture: A systemic review and meta-analyses

Deep neck flexor strengthening and forward head posture

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Abstract

Aim: This study aimed to systematically review and summarize the best evidence of the efficiency of deep neck flexor (DNF) strengthening for forward head posture (FHP).

Material and Methods: A literature search from January 2000 to 2020 was performed using PubMed, Cochrane Library, Science Direct, and PEDro by two authors who independently selected studies. The methodological quality of studies was assessed using the PEDro scale. The primary outcomes were pain, disability, and cervicovertebral angle (CVA), and the secondary outcomes were forced vital capacity and forced expiratory volume in 1 second.

Results: A total of 7 randomized controlled trials of low-to-moderate quality evidence that compared the short-term effect of DNF strengthening on pain, disability, CVA, and respiratory function with that of another treatment; 4 studies were enrolled in the meta-analyses. In 3 studies that investigated the effect of DNF strengthening on the cervicovertebral angle, the overall effect was statistically insignificant in patients with FHP (mean difference [MD], 0.23; 95% confidence interval [CI], -2.58 to 3.04; $P=0.23$). In 2 studies that examined the effect of DNF strengthening on pain, the overall effect was statistically insignificant (MD, -0.07; 95% CI, -1.77 to 1.62; $P=0.87$).

Discussion: The findings of this review suggest that the evidence of DNF strengthening in FHP is not sufficient.

Keywords

Deep neck flexor muscle; Forward head posture; Systematic review

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Introduction

Forward head posture (FHP) is the anterior positioning of the head relative to the line of gravity in the sagittal plane, which results from habitual postures adopted over time. FHP is associated with weakness of the deep cervical short flexors and mid-thoracic scapular retractors [1]. Symptoms of FHP include forward head position, chronic pain, temporomandibular joint dysfunction, teeth clenching, fatigue, arthritis, pinched nerves, decreased range of motion, headaches and migraines, numbness or tingling in the arms and hands, muscular spasms, sore and tight chest and neck muscles, asthma, impaired athletic performance, poor sleep or insomnia, and disk degeneration [2]. In a cross-sectional study on 62 subjects with neck pain and 52 healthy subjects, a significantly smaller craniocervical angle (CVA) was found in the neck pain group. Moreover, the subjects with smaller CVA scored higher in the Northwick Park Neck Pain Questionnaire and Numeric Pain Rating Scale [3], which is caused by several factors such as sleeping with head, elevated too high, extended use of computers, and lack of the developed back muscle strength [4].

The deep cervical flexor (DCF) muscles consist of the longus colli and longus capitis muscles. In the comparison with muscular activation levels, DCF muscles were less activated than the superficial sternocleidomastoid muscles. Therefore, maintaining the DCF muscular strength is critical for controlling neck posture and stability [4].

There was a review that compared different corrective treatments in FHP [1]. We performed a systematic review with a meta-analysis to evaluate the effect of deep neck flexor (DNF) strengthening on CVA and pain in patients with FHP. The difference between our review and the previous review is the type of exercise that was applied. Our review discussed DNF strengthening but the previous review discussed corrective exercises like stretching and general strengthening exercises of the spine and hamstrings but not including DNF strengthening as the sole group.

Material and Methods

Inclusion and exclusion criteria

All the randomized controlled trials selected in our review compared DNF strengthening with no treatment or conventional therapy in patients with FHP. Studies included patients >18 years of age and with FHP. Duplicated publications were excluded. Abstracts without full reports were also excluded. We excluded articles published in a language other than English; articles without baseline data or without clear data, and articles that compared DNF with another treatment in 1 group or another type of stabilization exercise rather than DNF.

Search methods

Electronic searches were performed in the Cochrane Library (CENTRAL), PubMed, PEDro, and Science Direct.

Database and search strategies

Targeted searches were between 2000 and 2020 and limited to studies published on December 2018. The search terms and combination used were “forward head posture,” “conservative treatment,” “craniocervical flexor strengthening,” “deep neck flexor strengthening,” and “stabilization exercise.”

Data extraction and methodological quality assessment

Two authors collected data independently according to the inclusion and exclusion criteria. The inclusion data included the year of publication (2000–2020), average age and symptom duration, treatment process, details of the intervention, treatment duration, and outcome measurement. Randomized controlled studies and quasi-experimental studies were included in this systematic review. The quality of randomized controlled trials in this study was assessed independently using the PEDro scale (physiotherapy evidence database) [5].

Study screening and selection

First, all studies were obtained from all databases exported to Mendeley, and duplicates were removed. Second, 2 independent reviewers screened the title and abstract of all studies and finally the full texts. Investigators independently extracted the name of authors and year of publication, study design, study population, sample size, and procedure of intervention exercise. Studies with no follow-up and with incomplete data were excluded.

Data synthesis

Continuous outcomes were expressed as mean difference (MD) with 95% confidence interval (CI). The MD values between the end of the final intervention and the baseline were used to assess the difference among the groups. Heterogeneity was assessed using both the chi-square test and the statistic with an I² value of >50% indicative of substantial heterogeneity. The Review Manager (RevMan 5.2.0) software provided by the Cochrane collaboration for data analysis was used [6].

Strength of evidence

The quality of evidence was evaluated using the Physiotherapy Evidence Database (PEDro) scale developed to rate the quality of RCTs evaluating physical therapist interventions [5].

Results

Description of included trials

The study selection process is presented in Figure 1 (details of the included and excluded studies). The search in electronic databases was performed until December 2018. A total of 3234 articles were identified by the initial search. Duplicates were removed and 1453 articles were screened. After reading the titles, 1418 articles were excluded, and after reading the abstracts, 20 articles were excluded. Full texts of 15 articles were retrieved, and finally, 7 randomized controlled trials were included. Only 4 studies were enrolled in the meta-analyses.

Participant

The 7 randomized studies included 196 patients aged between 18 and 40 years.

Exercise protocol

The exercise protocol was the same in all the studies that included DNF strengthening using pressure biofeedback from the supine position.

Interventions and control interventions

The first study compared between mobilization to cervical and thoracic and deep neck strengthening [8]. The second study compared between DNF with pressure biofeedback and electrotherapy modalities [9]. DNF strengthening with pressure biofeedback was also compared with DNF strengthening [10]. Mackenzie neck exercises were performed and compared with DNF in another study [11]. One study compared DNF

Table 1. Summary of study results(data extraction)

	Juchul Cho et al.,2018[8]	SaadAmmar and Shaik Husain, 2017[9]	Dong Yeon Kang,2015[10]	EunYoung Kim et al.,2015[11]	Nezamuddiet al.,2015[12]	Bhuvan Deep Gupta et al.,2013[13]	VamsiGanna-maneni2005[14]	
Research design	RCT	Quasi-experimental research	RCT	RCT	RCT	RCT	RCT	
Level of evidence	II	III	II	II	II	II	II	
No of participants	Treatment group	16	10	10	12	15	15	20
	Control group	15	10	10	13	15	15	20
	Forward head posture without any degenerative changes		Forward head posture	Forward head posture	Forward head posture	Forward head posture	Forward head posture	Forward head posture
Age range	20–29	18–29	18–28	21–23	20–35	20–40	20–22	
Intervention	DCFE: The participants at crook lying position and then, inflatable air-filled pressure biofeedback sensor placed at the suboccipital area. For 4 weeks 3 times/week. Three sets performed; 1set consisted of 10 times for 10 seconds. The break time 5 seconds per 1movement and 30 seconds per 1set.	Performed deep neck flexor by using PBU; the subjects maintain the static contraction for 10 seconds and then took a rest for 5 seconds, 5 sets each set consists of 10 repetitions.	Craniocervical flexion exercise using PBU was conducted for 4 weeks and then for 6 weeks, 3 times per week. 3 sets performed. One set consists of 10repetitions, each time from 5 to 10 sec. This exercise is performed to reach 5target pressures in 2 mmHg increments, from a starting baseline of 20mmHg to a final level of 30 mmHg.	Deep cervical flexor strengthening exercise group using a PBU, for 4 weeks, 3 times /week 3 set performed one set 10 times. Onetime for 10 seconds and rest for 5 sec.	Craniocervical flexion training with biofeedback unit's airbag placed suboccipital. Duration of CCFT exercise was 3 sets, 10 repetitions each set, 4 weeks, 4 days a week; 2 minutes rest among sets.	DCFE training with biofeedback pressure for4 weeks, 3 times per week,3 sets performed,1set 10 times, 1time for 10 seconds and rest for 5 sec.	Retraction neck with biofeedback pressure exercise for 6 weeks	
Control intervention	Upper cervical and upper thoracic segmental mobilization.	Group 2: exposed to Ultrasound for 10 min. and IFT for 10 min, 3 sessions per week for 4 weeks. Control group: given Electrotherapy Modalities (Ultrasound and infrared)	Stretching for 10 min and conventional deep neck flexor exercise (20–30 min, 10–16 repetitions × 1–4 sets)	McKenzie approach for 4 weeks for 3 times each week.	Stretching and strengthening exercises. Stretching exercises for sternocleidomastoid, upper trapezius, levator scapulae, suboccipitalis, andpectoralis muscles for 10 repetitions with 10 seconds hold. Strengthening exercises were given to deep cervical flexors, middle and lower trapezius,andserratus anterior for 10 repetitions with 10 seconds hold repetitions with 10 seconds hold.	Conventional isometrics training for 4 weeks	The isometric neck group will receive 2 sets of 12 retraction exercise once a day, 6 days every week for 6 weeks	
Outcomes	Decreasing pain and return CVA to normal measure	Reduce pain and enhance the endurance of muscle	Neck mobility and muscular endurance and CVA	Reduce disability and improving respiratory function	Return CVA to normal smaller CVA meaning present forward head	Decreasing Pain and disability and return the CVA to normal	Return forward head to normal	
Measures	CVA, NPRS,FVC, FEV1, and GRC	NDAP, VAS, the NDI, GH,BP, and VT were recorded for each group.	CVA,cervical ROM device, and PBU	NDI, FEV1,and FVC, and muscular endurance	CVA	VAS, NDI, and CVA	Metric base trisquare	
	DCFE = deep cervical flexor exercise PBU = pressure biofeedback unit VAS = visual analog scale	CCFT = craniocervical flexion test IFT = infrared treatment GRC = global rating of change CVA = craniocervical angle	FVA = forced vital capacity FEV1 = forced expiratory volume in 1second NPRS = numeric pain rating scale		ROM = range of motion NDAP = Neck Pain and Disability Scale PIF = pain		NDI = neck disability index GH = general health BP = bodily pain VT = vitality	

strengthening with conventional treatment vs conventional treatment [12], whereas other studies compared DCF training with PUB vs conventional isometric training [13].

Quality assessment of including studies

Item 1: Eligibility criteria were specified (not scored). Item 2: Subjects were randomly allocated. Item 3: Allocation was concealed. Item 4: The groups were similar at baseline regarding the most important prognostic indicators. Item 5: There was blinding of all subjects. Item 6: There was blinding of all therapists who administered the therapy. Item 7: There was blinding of all assessors who measured at least 1key outcome. Item 8: Measures of at least 1key outcome were obtained from >85% of the subjects initially allocated to groups. Item 9: Data for at least 1key outcome was analyzed by “intention to treat.” Item 10: The results of between-group statistical comparisons

were reported for at least 1key outcome. Item 11: The study provided both point measures and measures of variability for at least 1key outcome. 0=not satisfy the criteria; 1=satisfy the criteria.Level 1a of evidence (strong) was given if 2 or more “high” quality RCTs (PEDro≥6) demonstrated similar findings. Level 1b (moderate) was given when 1 RCT of “high” quality (PEDro≥6) existed, 2a (limited) was given when at least 1 “fair” quality RCT (PEDro=4–5) existed, and 2b (limited) was given when at least 1 “poor” quality RCT (PEDro b4) indicated exercise training to be effective [7].

Data synthesis

We calculated the standardized MDs with 95% CI and statistical heterogeneity in each study using chi-square test.

Outcome measures

CVA was measured in 3 studies [8, 10, 13], and pain intensity

Table 2. Summary of mean difference of studies

		Juchul Cho et al.,2018[8]	EunYoung Kim et al.,2015[11]	Bhuvan Deep Gupta et al., 2013[13]	Dong Yeon Kang,2015 after 4 weeks[10]			
Outcomes		CVA, Pain,FCV,FEV1	NDI,FVC,FEV1	CVA,VAS,NDI	CVA			
Means for control group	CVA	Pre= 48.8	NDI	Pre= 9.38	CVA	Pre= 41.00	CVA	Pre= 47.0
		Post= 52.5		Post= 3.7		Post= 41.05		
	Pain	Pre= 5.0	FVC	Pre= 2.13	Pain	Pre= 5.33		
		Post= 2.4		Post= 2.3		Post= 4.73		
FVC	Pre= 2.0	FEV1	Pre= 2.09	NDI	Pre= 16.93			
	Post= 2.5		Post= 2.3		Post= 16.33			
FEV1	Pre= 1.8							
	Post= 2.2							
Means for control group	CVA	Pre= 49.8	NDI	Pre= 8.08	CVA	Pre = 40.95	CVA	Pre= 48.9
		Post= 50.5		Post= 3.7		Post= 41.83		
	Pain	Pre = 4.4	FVC	Pre= 2.20	Pain	Pre= 5.27		
		Post= 3.2		Post= 2.25		Post= 3.80		
FVC	Pre= 2.1	FEV1	Pre= 2.18	NDI	Pre= 17.20			
	Post= 2.3		Post= 2.2		Post= 14.33			
FEV1	Pre = 2.0							
	Post =							
Means for control group	CVA	-3.7	NDI	5.68	CVA	0.05	CVA	-4.2
	Pain	2.6	FVC	-0.17	Pain	0.59		
	FVC	-0.5	FEV1	0.21	NDI	0.6		
	FEV1	-0.4						
	CVA	-0.7	NDI	4.38	CVA	0.88	CVA	-5.7
	Pain	1.2	FVC	-0.05	Pain	1.47		
	FVC	-0.2	FEV1	-0.02	NDI	2.87		
	FEV1							

Pre = pretreatment; Post = posttreatment
 CVA = cervicovertebral angle
 NDI = neck disability index

FVC = forced vital capacity
 FEV1 = forced expiratory volume in first second
 VAS = visual analog scale

Table 3. Quality assessment according to the Physiotherapy Evidence Database (PEDro)

Criteria	JuchulCho et al.,2018[8]	SaadAmmar and Shaik Husain, 2017[9]	Dong Yeon Kang,2015[10]	EunYoung Kim et al.,2015[11]	Nezamuddinet al.,2015[12]	BhuvanDeep Gupta et al.,2013[13]	VamsiGan-namane-ni,2005[14]
Eligibility criteria specified	Yes	Yes	No	Yes	Yes	Yes	yes
Randomly allocated to groups	Yes	no	Yes	Yes	Yes	Yes	yes
Concealed allocation	No	No	No	No	No	No	no
Similar prognosis at baseline	Yes	yes	Yes	Yes	Yes	Yes	Yes
Blinded participant	NO	NO	No	No	No	No	No
Blinded therapist	No	NO	No	No	No	No	No
Blind assessors	YES	NO	No	No	No	No	No
More than 85% follow-up for at least one key outcome	Yes	yes	No	Yes	Yes	yes	NO
Intention to treat analysis	No	NO	No	No	No	No	No
Between-group statistical variability for at least one key outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Point estimates of variability for at least one key outcome	Yes	Yes	Yes	Yes	Yes	yes	Yes
PEDro score	6	4	4	5	5	5	4

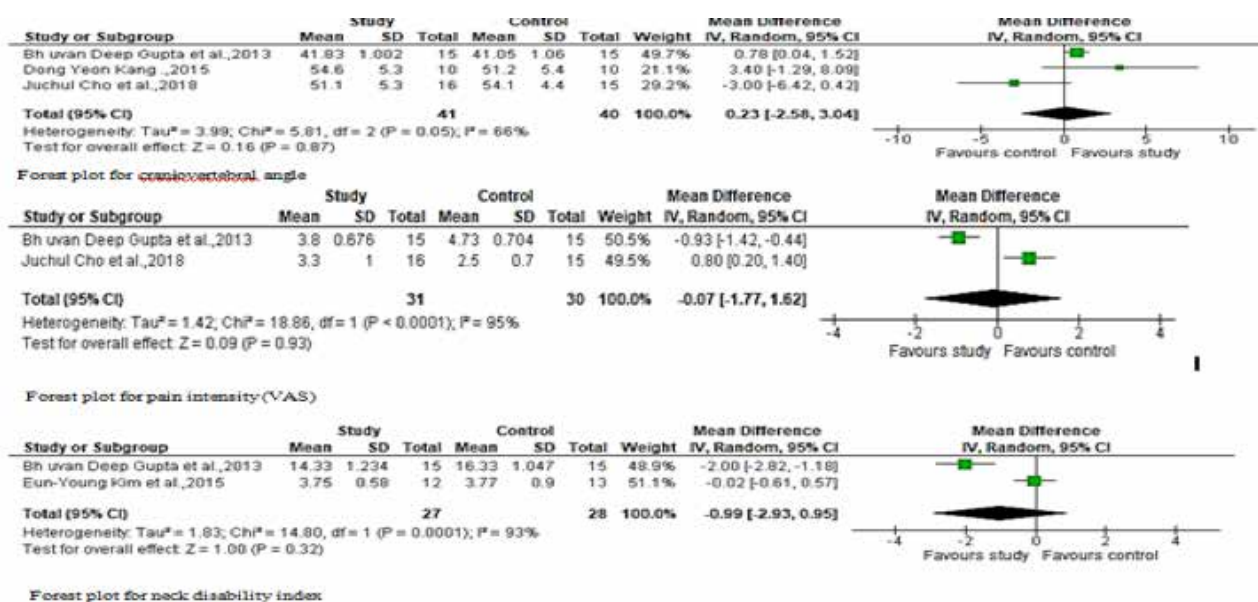


Figure 1. Forest plot for primary outcomes.

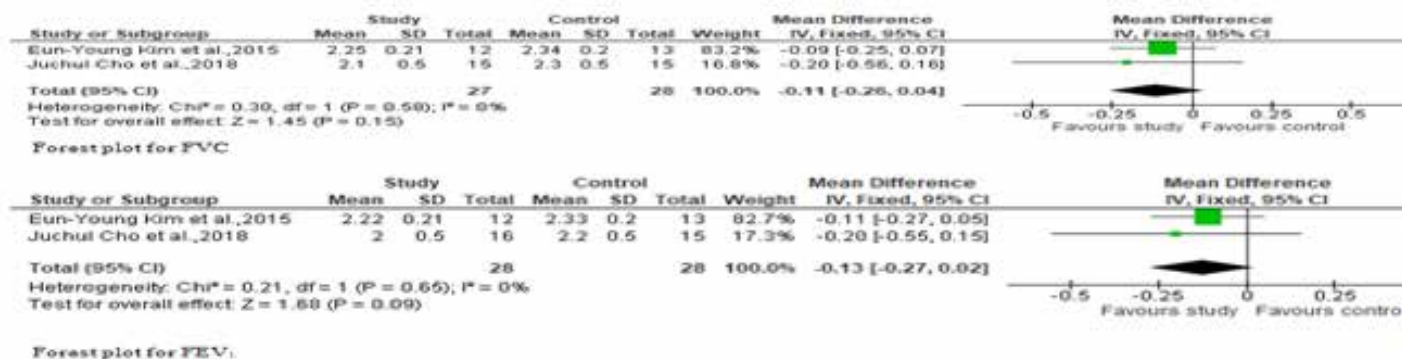


Figure 2. Forest plot for secondary outcomes.

measured by the visual analog scale was measured in 2 studies [8, 13]. Disability measured by neck disability index was assessed in 2 studies [11, 13], and forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were measured in 2 study [8, 11]; both variables were measured by spirometry.

CVA

According to the forest plot of CVA in Figure (1) the weight of study on CVA was higher in the study by Gupta et al. (2013), where in CI was small. Heterogeneity (I²) of >50% was present, which indicated more dissimilarity. A random model was used for analysis. The diamond touching the null effect line and a p-value of >0.05 indicate statistically insignificant difference among three.

Pain

According to forest plot of pain in Figure (1) the weight of studies was similar and CIs were small and more reliable; heterogeneity was very high at I²=95%. A random model was used for analysis. The diamond touching the null effect line and p>0.05 indicate an insignificant difference between both studies.

Disability (neck disability index)

According to the forest plot of disability in Figure (1), the

weight of the studies was similar to each other and CI was small. Heterogeneity was very high at I²=93%. The diamond shape was closest to the study group. The diamond touching the null effect line and p>0.05 indicate an insignificant difference between 2 studies.

FVC

According to the forest plot of FVC in Figure (2) the weight of studies according to the forest plot for FVC was higher in Eun Young Kim et al.'s study (2015) although the sample size in Junchul Cho et al.'s study was more than that of Eun Young Kim et al.'s study (2015), and the standard deviation in Kim's study was small. The heterogeneity was low at I²=0. A fixed model was used for analysis. The diamond touching the null effect line and p>0.05 indicates statistical insignificance.

Forced expiratory volume in 1 second

According to the forest plot of FEV1 in figure (2) the weight of studies according to the forest plot for FEV1 was higher in Eun Young Kim et al. (2015), although the sample size in Juchul Cho et al. (2018) was more than that of Kim's but the standard deviation in the study by Eun Young Kim et al. (2015) was small. The heterogeneity was low at I² = 0. A fixed model was used for analysis. The diamond that touches the null effect line and

P>0.05 indicate statistical insignificance.

Discussion

Summary of the evidence

After categorizing a moderate level of evidence and weak evidence from 7 trials, this systematic review suggested that DNF strengthening is beneficial in providing pain relief, improving CVA and respiratory function, and decreasing disability, but it is still insufficient because there are very few studies about DNF strengthening. Furthermore, in most studies, the sample size of the intervention group was too small to draw reliable conclusions.

Strengths and limitations

Up to now, there is no systematic review of randomized controlled trials about DNF on FHP. Other reviews that discussed the general strengthening of the spine and stretching did not mention DNF strengthening [1]. In addition, a systematic review and meta-analysis by Bolmgren et al. (2018) entitled "Effect of deep cervical training on impaired physiological functions associated with chronic neck pain" investigated the effects of DCF training on outcomes of cervical neuromuscular function, muscle size, kinematics, and kinetics as well as discussed neck pain without any mechanical changes.

All the trials in our systematic review failed to mention concealed allocation. All studies lacked blinding; only 1 trial stated about blinding of the assessor; and blinding of the patients was difficult in all studies. One study did not have the inclusion and exclusion criteria [10]. Retrieval of reviews was restricted to those of the English language only. Reviews published in other languages could not be completely searched.

Conclusion

This seems to be positive evidence for DNF strengthening in improving CVA and decreasing pain in FHP, although the effect size remained small. The level of evidence to support the effectiveness of DNF in patients with FHP in improving CVA and decreasing pain and disability is 1b (moderate). More studies with large sample size and with high quality are needed; only one study included in this review has high quality [8].

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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