Effectiveness of Therapeutic Exercise on Forward Head Posture: A Systematic Review and Meta-analysis

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Abstract

Objective: The purpose of this systematic review and meta-analysis was to summarize the results related to the effects of corrective exercises on postural variables in individuals with forward head posture (FHP).

Methods: A systematic review of the electronic literature through February 2017 was independently performed by 2 investigators. The electronic databases searched included PubMed, MEDLINE, Web of Science, ScienceDirect, Cochrane Central Register of Controlled Clinical Trials, Google Scholar, and Scopus. Methodological quality was evaluated using the Physiotherapy Evidence Database scale. Meta-analyses were carried out for craniovertebral angle (CVA), cranial angle (CA), and pain intensity.

Results: Seven randomized clinical trials comprising 627 participants met the study criteria. The between-groups pooled random odds ratios for CVA, CA, and pain were 6.7 (confidence interval [CI] = 2.53-17.9, $P = .0005$), 0.7 (CI = 0.43-1.2, $P = .2$), and 0.3 (95% CI = 0.13-0.42, $P < .001$), respectively. No publication bias was observed. Level 1a evidence (strong) indicates exercise training can effectively modify CVA, and level 1b evidence (moderate) indicates exercise may improve pain but not CA.

Conclusion: The findings suggest that therapeutic exercises may result in large changes in CVA and moderate improvement in neck pain in participants with FHP. The precise nature of the relationship between FHP and musculoskeletal pain, and improvements in both after therapeutic exercise, remains to be established. (J Manipulative Physiol Ther 2018;41:530-539)

Key Indexing Terms: *Posture; Head; Neck; Exercise; Review*

Introduction

Forward head posture (FHP) is a common postural variation in people of all ages, from childhood to old age.[1,2] Forward head posture is characterized by the head position in the sagittal plane being forward relative to the neck. Forward head posture is associated with hyperextension of the upper cervical spine (C1-C3) and flexion of the lower cervical spine (C4-C7). In some studies, FHP is characterized as pathologic when the craniovertebral angle (CVA) is ≥50°, even though such cutoffs lack rigorous validity.[3-5] Some research has shown that head and neck position are associated with other musculoskeletal disorders, such as neck pain,[6] headache,[7] and masticatory dysfunction.[8] Thus, it has been hypothesized that the treatment of FHP may be helpful in managing these disorders.

Corrective exercise is 1 of the interventional methods that had been suggested for treatment of FHP, including stretching, strengthening, and movement control exercises.[9-13] Moreover, there may be advantages in exercising adjacent body segments to the cervical spine, such as the thoracic spine, to enhance the effectiveness of exercise training on FHP.[14]

Several studies have shown that corrective exercise regimes can improve FHP and potentially related symptoms.[3-5,15-21] For example, exercise training protocols have resulted in improvement of CVA,[4,5,22,23] head tilt,[3] cranial or cervical

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range of motion,[22] neck disability,[22] and pain.[5,22] A systematic review with pooled meta-analysis would clarify the strength of the effect of such exercises on FHP. The purpose of this systematic review and meta-analysis was to summarize the results related to the effects of corrective exercises on postural variables in individuals with FHP.

Methods

Literature Search Strategy

To determine whether a systematic review on this topic had existed, the Cochrane Library and the Database of Abstracts of Reviews of Effectiveness were searched and none were found. An extensive review of the electronic literature was subsequently performed by 2 investigators (R.S. and P.S.). The electronic literature databases included PubMed, MEDLINE, Web of Science, ScienceDirect, Cochrane Central Register of Controlled Clinical Trials, Google Scholar, and Scopus. The keywords were originally selected from MeSH terms and then partially modified to try to ensure all eligible studies were found. These electronic databases were searched using combinations of the following keyword groups: (1) exercise, sport, movement therapy, exercise therapy, physical therapy, and corrective exercise; AND (2) FHP, forward head; AND (3) randomized study, randomized controlled trial, randomized clinical trial, randomized trial, randomized experiment. The "AND" operator was used between the 3 keyword groups, while the "OR" operator was used within each keyword group. The search period covered years from inception to February 2017. The reference lists contained in all eligible studies were checked to identify additional eligible studies.

Selection Criteria

Both reviewers (R.S. and P.S.) independently performed the searches, assessed inclusion criteria, and extracted data on trial design and outcomes, and disagreements were resolved by consensus. Potential publications were selected by screening titles and abstracts for clinical trials that used any kind of exercise intervention for FHP. All potentially eligible studies were retrieved, and the full-text articles were reviewed to determine whether they met the inclusion criteria. Only randomized controlled trials (RCTs) published in peer-reviewed journals were considered. Studies had to include a control group and at least 1 variable aimed at assessing head or neck alignment. Studies were not excluded based on the type of exercise protocol used or the type of measurement used to assess FHP. Studies had to be published in English. Studies were excluded if exercise was not performed or if it was performed in addition to other interventions, such as manipulation or medications, and the measured variables did not include head or neck alignment. Studies that had duplicated data were excluded, with only 1 of them selected for the review.

Data Extraction

Review authors (R.S. and S.S.) extracted study data on the following topics: first author name and date of publication, quality assessment of the study, participants' characteristics (eg, sample size, age, and sex), intervention type, frequency, duration, comparison group, outcome measures, and primary results (Table 1).

Quality Assessment and Level of Evidence

The quality assessment scores of eligible studies were obtained from the Physiotherapy Evidence Database (PEDro).[24] The PEDro[25] has a total score of 10 points, including internal validity evaluation criteria and statistical analyses presentation. The studies with scoring of 6 to 10 were considered methodologically "high," 4 to 5 were considered "fair," and ≤3 were considered "poor."[26] The level of evidence was determined according to Sackett et al.[27] 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 <4) indicated exercise training to be effective.[27]

Statistical Analysis

All relevant outcome data were extracted as provided in the studies. Results of comparable studies were combined using a random effect model of meta-analysis and a forest plot of the relative odds ratio (OR) with 95% confidence interval (CI). Considering the OR interpretation, based on the Cohen's rule of thumb, an effect size of 1.5 is considered to be small, 2.5 medium, and 4.30 large.[28] Heterogeneity between studies was assessed by the standard χ^2 test, which indicates only the presence of heterogeneity and the I^2 coefficient, which measures the percentage of total variation across studies due to true heterogeneity rather than chance.[29] I^2 ranges between 0% and 100%, with higher values indicating higher heterogeneity.[29] Publication bias was checked using both funnel plots and quantitative methods, including the rank correlation test, Egger's test of the intercept, and the trim and fill method.[30] A symmetrical inverted funnel plot, a nonsignificant negative rank correlation, a nonsignificant value of the Egger's regression test of the intercept, and an unchanged effect size using the trim and fill method were considered indicators that publication bias does not exist. Comprehensive Meta-Analysis version 3.0 (Biostat Inc, Englewood, New Jersey) was used for statistical analysis.

Results

Search Results

The search of selected databases provided a total of 3380 citations. Of these, 3333 articles were discarded after abstract review because they did not meet the inclusion criteria. The full text of the remaining 47 citations were examined in more detail, with 39 being excluded because they did not meet the inclusion criteria, leaving 8 studies. One study was also excluded[15] because it reported overlapping data with another paper included in this review.[3] Finally, a total of 7 clinical trials were therefore eligible (Fig 1).

Study Characteristics

The duration of the interventions ranged from 4 to 32 weeks, with 2 to 7 exercise sessions per week. A total of 3 studies had supervised sessions, 3 were nonsupervised, and 1 did not report on this. In total, the 7 clinical trials involved 627 participants, as shown in Table 1. The FHP parameters analyzed included CVA,[3-5,15-17,22,23] head tilt,[3,15-17] cranial range of motion,[22] anterior head translation,[31] head distance,[17] head sway,[16] shoulder-ear distance,[16] horizontal distance between the acromion and tragus,[17] and shoulder distance (horizontal distance from acromion to plumb line).[17] Three studies measured neck pain intensity.

Description of Selected Variables

Criteria to Define FHP. The criteria used to classify someone as having FHP differed between the eligible studies. Two studies presented no clear inclusion criteria to diagnose FHP[16,22]; 3 studies used a CVA angle of less than 50°[3-5]; 1 study used the position of the tragus being greater than 5 cm anterior to the posterior acromial angle;[17] finally, 1 study considered a thoracic kyphosis angle ≥42°, forward head angle ≥44°, and a simultaneously forward shoulder angle of ≥ 49°, as characteristic of FHP.[23]

Measurement of FHP. There was also considerable variation in the methods used to calculate FHP; 5 studies used photogrammetry;[3-5,17,23] 1 used electromagnetic sensors,[16] and 1 used X-ray assessment.[22] Cranial angle (CA) is a measure of upper cervical posture, typically obtained by calculating the angle between lines drawn from the canthus of the eye and the tragus of the ear and the horizontal line.[32] Cranial angle is also referred to as sagittal head tilt[3] and head angle[17] in the literature. An angle between lines drawn from the tragus to the C7 and the horizontal line is called CVA. The greater the CVA, the more the head is forward relative to the neck.[32] Craniovertebral angle is also referred to as cervical angle,[3] neck angle,[16,17] and forward head angle[23] in the literature (Fig 2).

Measurement of Pain. Pain intensity was measured in 3 studies using either the visual analogue scale[5,22] or Numerical Graphic Rating Scale.[16] There were no precise definitions of pain provided in these studies.

Exercise Protocols. The prescribed exercise protocols varied in the studies, including the following: FHP corrective exercise, including stretching and strengthening exercises of the spine and hamstrings[4,5]; a home exercise program, including 2 strengthening and 2 stretching exercises for the neck[17]; Pilates exercise, including stretching and strengthening exercises for the neck and upper back[22]; Rocabado 6 x 6 exercises for the neck and jaw[16]; strengthening and stretching in physical education class[3]; and local or comprehensive corrective exercise protocols, including general corrective stretching and strengthening exercises.[23]

Data Synthesis

Cranial Angle. Figure 3 shows the comparison of the OR of CA between individuals who attended a corrective exercise program and who did not across 3 studies.[3,15-17] The pooled random OR of CA between groups was 0.72 (CI = 0.43-1.2, z = -1.21, P = .2). This result suggests that, in total, there is no significant difference in CA between those persons who participated in an exercise program and those who did not.

In addition, a symmetrical inverted funnel plot, as shown in Figure 4; a nonsignificant negative rank correlation test (τ = -1.67, P = .11); an insignificant Egger's test of the intercept (intercept = 0.87, P = .3); and an unchanged effect size from the trim and fill method suggests no clear sign of publication bias. Furthermore, no evidence for heterogeneity was found (Q = 0.15, P = .9; I^2 = 0%).

These results indicate level 1b (moderate) evidence that exercise training is ineffective in reducing CA, based on 1 "high" quality RCT[3,15] and 1 "fair" quality RCT.[16]

Craniovertebral Angle. Figure 5 illustrates that persons who participated in an exercise program were significantly (z = 3.82, P = .0005) more likely to report increased CVA than those who did not across 7 studies. The pooled random OR of CVA between groups was 6.7 (2.53-17.9).

Regarding possible publication bias, a symmetrical inverted funnel plot, as shown in Figure 6, implies no clear sign of publication bias. In addition, using the trim and fill method, the effect size remained unchanged under both models (fixed and random). In addition, a nonsignificant negative rank correlation test (τ = 0.07, P = .8) and a nonsignificant Egger's regression test intercept (intercept = 1.05, P = .8) suggest no clear sign of publication bias.

A significant Q test (Q = 48.96, P = .0) indicated heterogeneity among the data, and the I^2 index (I^2 = 85%) quantified the high magnitude of the heterogeneity. With the exception of a single study,[16] most eligible RCTs found significant FHP differences between those allocated to the therapeutic exercise group and the control group. Thus, there is level 1a evidence (strong) based on 4[14,16,17,23] "high" quality RCTs that exercise training is effective in reducing CVA.

Table 1. *A Description of Eligible Studies*

	Subjects		Exercise Training Protocol					
Study	Sample Description	Sample Size (Men/Women) (Age ± SD)	Total Duration of Exercise (wks); Weekly Frequency (d); Supervision	Exercise Intervention Program	Control Intervention	Measured Variables in the Study	Main Outcomes	PEDro Scores
Diab 2012[15]	Seventy-six adolescent participants with scoliosis	E:38 (20/18) (13.2 ± 1.2) C:38 (21/17) (14.5 ± 1.3)	10; 3; NR	Stretching and strengthening exercises of the spine and hamstrings with FHP corrective exercise	Stretching and strengthening exercises of the spine and hamstrings without FHP corrective exercise	CVA	CVA was significantly improved in the group performing FHP corrective exercises	7/10
Diab and Moustafa 2011[16]	Ninety-six participants with unilateral lower cervical spondylotic radiculopathy and craniovertebral angle ≤50	E:48 (27/21) (46.3 ± 2.05) C:48 (23/25) (45.9 ± 2.1)	10; 4; No	Posture corrective exercise program in addition to ultrasound and infrared radiation	Ultrasound and infrared radiation	CVA VAS	CVA and pain were improved significantly in the intervention group	7/10
Harman, et al 2005[17]	Forty-one participants with FHP	E: 24 (10/14) (38.4 ± 11.3) C: 17 (5/12) (36.9 ± 9.5)	10; 4; No	Home exercise program including 2 strengthening and 2 stretching exercises	No exercise	CVA (neck angle) CA (head angle)	CVA, but not CA, was significantly different in the exercise group at post-test	4/10
Lee, et al, 2016[22]	Twenty-eight participants with FHP; sedentary, with pain in neck or shoulders	E: 14 (0/14) (29.2 ± 4.3) C:14 (0/14) (28.9 ± 5.0)	10; 3; Yes	Pilates based strengthening and stretching exercises	Typical strengthening and stretching exercises	CVA VAS	Both improved in pain but only the exercise group improved in FHP	4/10
Mulet, et al 2007[16]	Forty-two participants with myofascial pain of the masticatory muscles	E:20 (1/19) (25.1 ± 2.3) C:22 (1/21) (23.4 ± 2.1)	4; 7; No	Self-care + Rocabado's 6 X 6 exercises (general stretching, strengthening, and stability exercises)	Self-care including counseling, education, and encouragements to rest the masticatory muscles	Baseline+mean changes (Exp) CVA (neck angle) CA NGRS	CA and CVA did not improve in either groups but pain intensity was significantly improved	5/10
Ruivo, et al 2016[12]	Eighty-eight adolescent participants with FHP and protracted shoulder posture	E: 42 (16/26) (15.5 ± 1.0) C: 46 (15/31) (15.9 ± 1.1)	32; 2; Yes	Strengthening and stretching in addition to physical education class	Physical education class only	CA (sagittal head tilt) CVA (cervical angle)	CVA and CA were significantly improved in the group performing strengthening and stretching exercises	6/10
Seidi, et al 2014[23]	Sixty participants who had thoracic kyphosis ≥42°, FHP ≥44°, forward shoulder posture ≥44° and were aged 18-25 y	LCEP (20) + CCEP (20) + Control (20) Sum: (30/30) (20.84 ± 1.69)	12; 3; Yes	LCEP including exercises to stretch and strengthen the thoracic structures, CCEP including exercises to stretch and strengthen the thoracic, head and neck and shoulder structures	No exercise	CVA (FHA)	CVA was improved significantly in the LCEP and CCEP groups, but unchanged in the control group	5/10

C, control group; *CA*, cranial angle; *CCEP*, comprehensive corrective exercise program; *CVA*, craniovertebral angle; *E*, exercise group; *FHA*, forward head angle; *FHP*, forward head posture; *FSA*, forward shoulder
angle; *LCEP*, local corrective exercise program; *NGRS*, numerical graphic rating scale; *PEDro*, Physiotherapy Evidence Database; *NR*, not reported; *SD*, standard deviation; *VAS*, visual analogue scale.

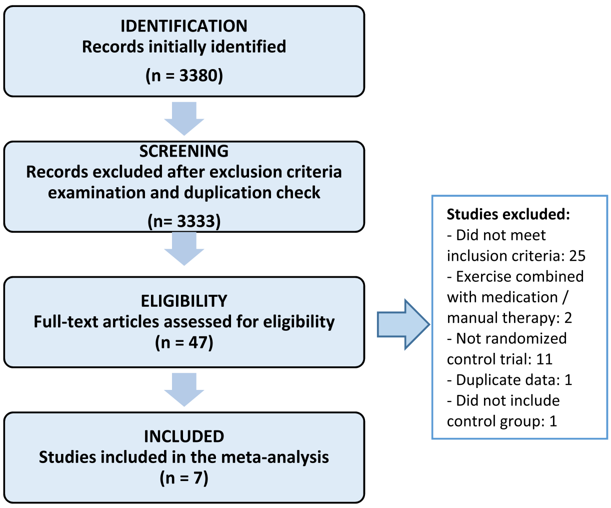


Fig 1. *Flow diagram for eligible studies.*

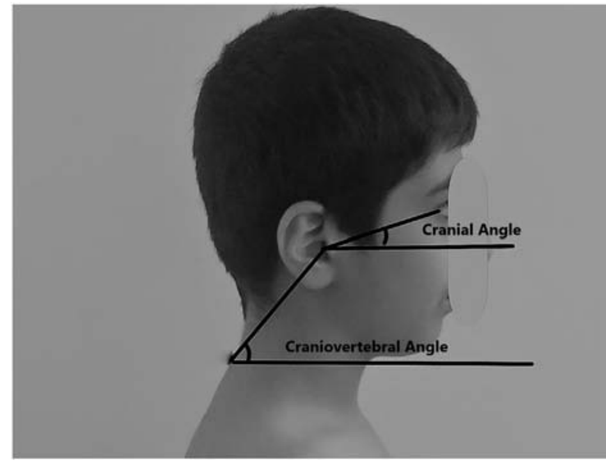


Fig 2. *Postural variables were analyzed in the study. Adapted with permission from Mulet M, et al 2007.*[16]

Pain

Figure 7 illustrates the OR of pain between individuals allocated to a corrective exercise program compared to those who were not, across 3 studies.[5,16,22] The pooled random OR (95% CI) of pain between groups was 0.23 (0.13-0.42, z = -4.8, *P* = .0005). People who participated in the exercise intervention were significantly less likely to report pain than those who were in the control group.

Regarding possible publication bias, a symmetrical inverted funnel plot, as shown in Figure 8, implies no clear sign of publication bias. In addition, the insignificant rank correlation test (τ = -1, *P* = .11) and Egger's test of the intercept (intercept = -5.6, *P* = .5), as well as unchanged effect size determined by the trim and fill method under both models of fixed and random effect models, suggest the absence of evidence for publication bias. There was evidence for significant heterogeneity (Q = 21.8, *P* = .0005; I^2 = 90%).

All 3 RCTs,[5,16,22] which examined neck pain intensity, showed a significant difference in pain between those who attended a therapeutic exercise program and those who did not. Therefore, there is level 1b (moderate) evidence, based on 1 "high" quality RCT[5,22] and 2 "fair" quality RCTs,[16,22] that exercise training is effective in reducing pain.

Discussion

To our knowledge, this is the first research aimed to review and analyze the studies in the field. The results of this review suggest there is strong evidence showing an improvement in FHP, as measured by CVA, in response to exercise training programs. However, CA did not change with exercise. While pain intensity was not the primary focus of this review, there was also moderate evidence that pain can be improved with exercise.

According to our results, very different exercise programs had an effect on FHP, but the effect of these exercises on pain was weaker. This may be due to the fact that pain has a multidimensional nature[33] and involves many factors in addition to posture. For example, it has been shown that neck pain is linked to psychosomatic stress symptoms,[34] anxiety,[35] and both physical and psychosocial exposure factors at work.[36] Therefore, it is reasonable that postural variables, such as FHP, might improve more easily than pain. The mean change in CVA was similar in those with or without neck pain (on average: 4.5° in those with neck or shoulder pain and 4.58° in pain-free participants), and it is not clear what degree of change in FHP would be clinically meaningful. No studies undertook a mediation analysis to establish whether it was changing FHP that caused the improvements in pain. The relative changes in CVA and CA suggest that CVA is more likely to be linked to changes in pain. However, it is also possible that exercise helps pain through another factor (eg, muscle strength, mood, or fear) and that this was how pain was relieved, rather than through changing FHP variables such as CVA. Further RCTs, which include mediation analysis of such a range of secondary measures, would add clarity to this situation.

Critical Appraisal of Methodological Quality

Some of the studies had small sample sizes, so the chance of type 2 errors may be increased. Moreover, dispersion measures (such as the standard error) may be

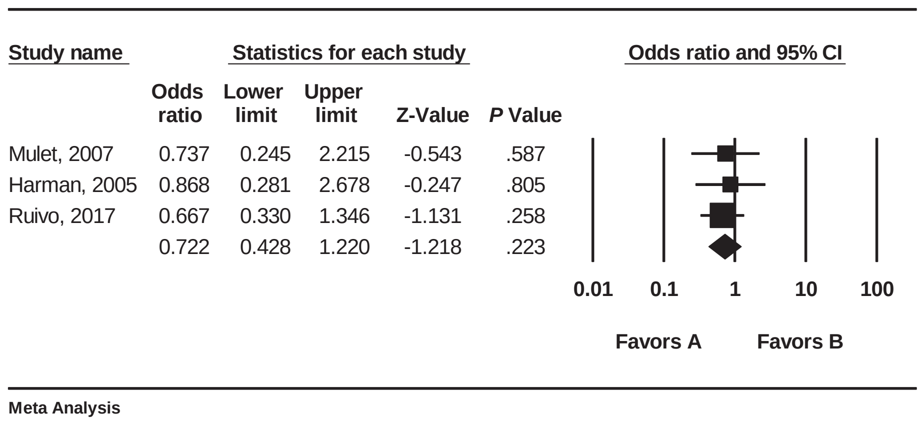


Fig 3. *Forest plot of the effect of exercise on cranial angle (favors A: exercise, favors B: control).* CI, *confidence interval.*

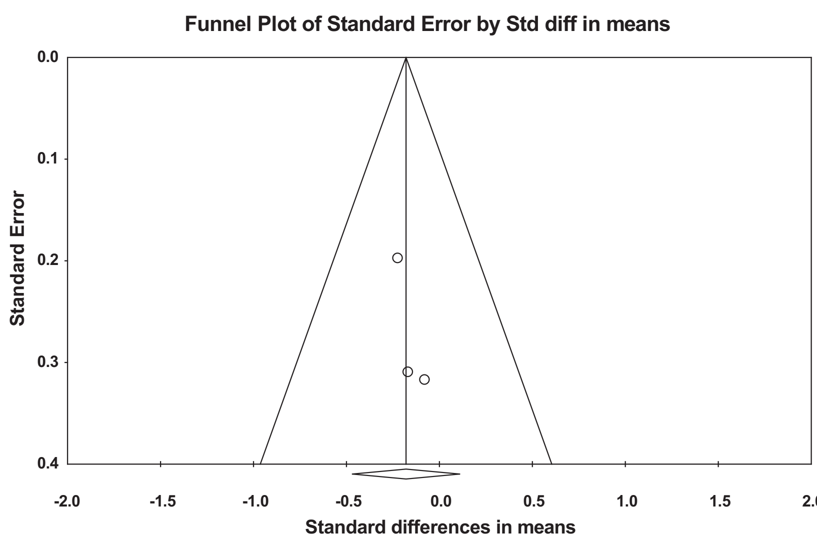


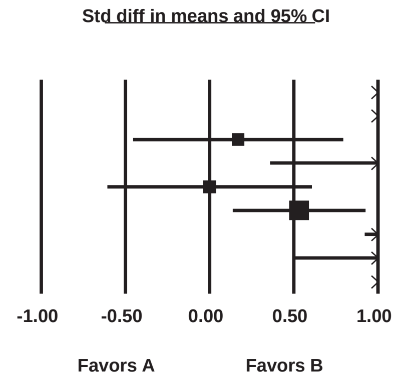
Fig 4. *Funnel plot of studies worked on cranial angle.*

increased with small sample size. Consequently, the risk of publication bias was assessed in the funnel plot analysis. In addition, the eligible studies varied among themselves in the variables that were measured, assessment tools and methods that were employed, the age of participants, exercise type, volume and intensity, supervision of the therapist or trainer, and study samples.

For the meta-analysis of CVA, high heterogeneity was seen. The high heterogeneity is possibly due to the different exercise types that were prescribed, different assessment methods that were used for CVA, or different exercise characteristics, which reduce the certainty of the results regarding CVA. The variety of therapeutic exercises were applied to a wide variety of participants, including participants from adolescents to adults; participants from different socioeconomic groups; and those who had neck pain, back pain, kyphosis, rounded shoulders, or scoliosis. None of the eligible studies excluded participants with high levels of fear avoidance scores that are likely to have poor outcomes.[37] Some studies did not blind the therapist, trainer, or participants.[4,5,17,23] Pain rating scales were self-recorded, though this is standard practice.

Only 3 studies had medium-term to long-term follow ups: 1 study with 16 weeks,[3] 1 with 3 months,[4] and another with 6 months.[5] In some studies, while the results showed statistically significant differences, the absolute changes were small, such that further studies, which determine minimal clinically important differences or minimally detectable changes for

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	*P* Value
	Statistics for each study						
Diab, 2011	1.809	0.242	0.059	1.334	2.284	7.466	0.000
Diab, 2012	1.949	0.279	0.078	1.403	2.495	6.995	0.000
Harman, 2005	0.169	0.318	0.101	-0.454	0.791	0.532	0.595
Lee, 2016	1.162	0.409	0.167	0.361	1.963	2.843	0.004
Mulet, 2007	0.000	0.309	0.095	-0.606	0.606	0.000	1.000
Ruivo, 2017	0.531	0.200	0.040	0.139	0.924	2.656	0.008
Seidi CCEP, 2014	1.639	0.365	0.134	0.923	2.356	4.485	0.000
Seidi LCEP, 2014	1.175	0.342	0.117	0.504	1.846	3.432	0.001
	1.029	0.101	0.010	0.830	1.228	10.151	0.000



Meta Analysis

Fig 5. *Forest plot of craniovertebral angle odds ratios between groups of study (favors A: exercise, favors B: control).* CI, *confidence interval;* std diff, *standard differences.*

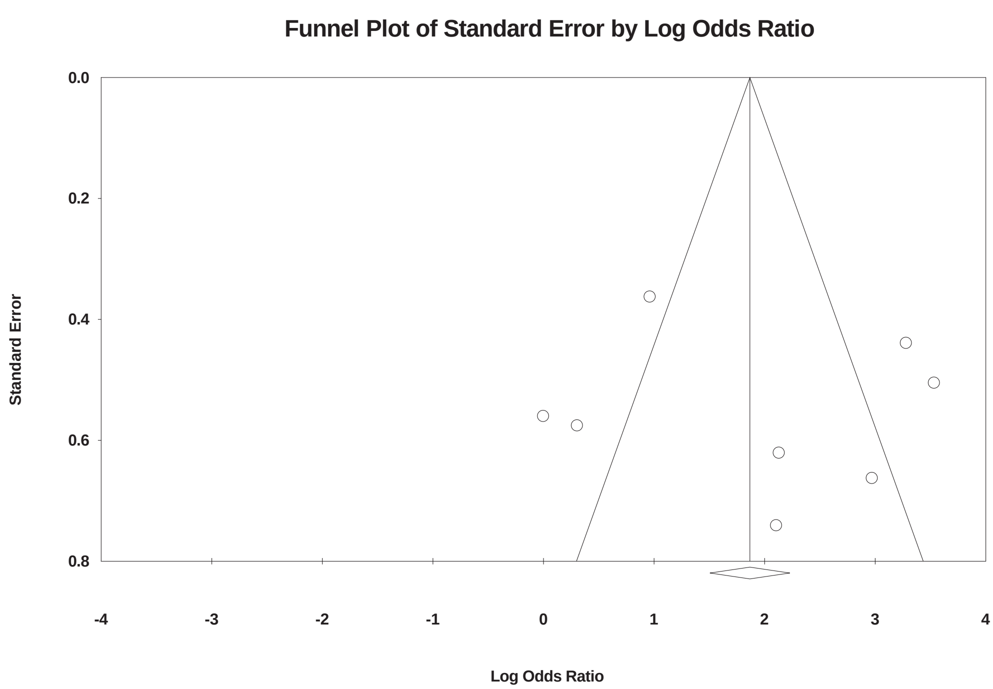


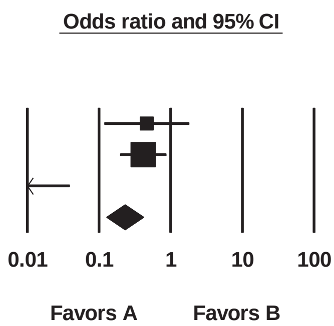
Fig 6. *Funnel plot of craniovertebral angle across the studies.*

therapeutic exercises, would be valuable. Most studies were A vs A and B study designs, which are weak.

Limitations

Two reviewers screened available full text independently for inclusion, and data extracting was checked independently to minimize bias through the review. We made no attempts to search in any language other than English. This review was not registered on a prospective register, such as PROSPERO, in advance. While we analyzed pain as an outcome, it was not the primary focus of the review, and pain was not used as a keyword, such that other studies on pain not included in this review could exist. While the level of evidence is strong, the high degree of heterogeneity

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	*P* Value
Lee, 2016	0.464	0.119	1.807	-1.107	.268
Diab, 2011	0.414	0.198	0.865	-2.346	.019
Mulet, 2007	0.009	0.002	0.039	-6.217	0.000
	0.230	0.127	0.417	-4.847	0.000



Meta Analysis

Fig 7. *Forest plot of pain odds ratios between groups of study (favors A: exercise, favors B: control).* CI, *confidence interval.*

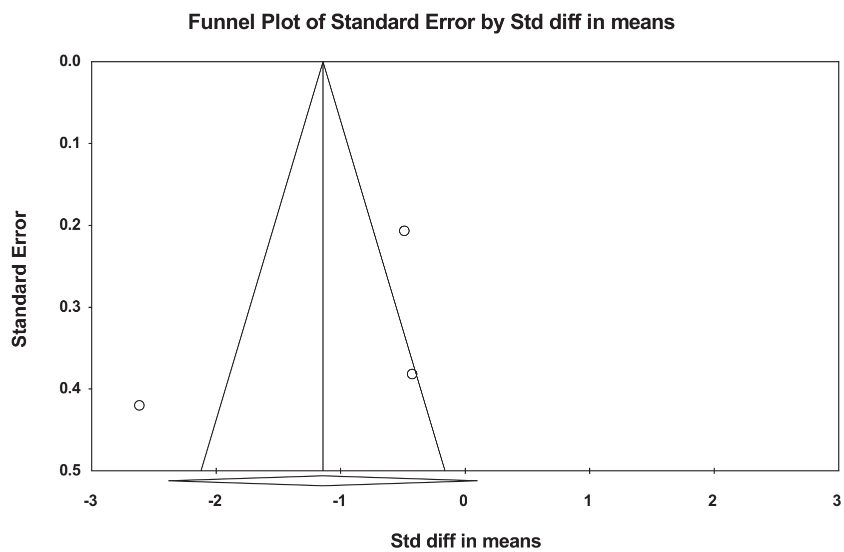


Fig 8. *Funnel plot of pain across the studies.*

highlights the need for caution in interpreting the results and generalizing the findings to all forms of exercise.

Conclusion

The results of this review provide level 1a evidence that prescribing therapeutic exercises may reduce CVA but level 1b evidence that prescribing therapeutic exercises cannot reduce CA. There is also level 1b evidence of a moderate improvement in neck pain when exercises are prescribed in participants with FHP. The degree of improvement in CVA and pain varied considerably between studies, suggesting some exercise programs may be more effective than others. There was considerable heterogeneity in the results, suggesting caution in extrapolating the findings to all participants with FHP and to all forms of exercise. The precise nature of the relationship between FHP and neck pain is not linear and requires further research.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): R.S., S.S., P.S., K.O.

Design (planned the methods to generate the results): R.S., S.S., P.S., K.O.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): R.S., K.O.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): R.S., S.S., P.S., K.O.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): R.S., S.S.

Literature search (performed the literature search): R.S., P.S.

Writing (responsible for writing a substantive part of the manuscript): R.S., S.S., K.O.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): K.O.

Practical Applications

- The results provide level 1a evidence that prescribing therapeutic exercises may reduce CVA.
- The effectiveness of exercise training on CA is questionable.
- There is 1b evidence of moderate neck pain improvement when exercises are prescribed in participants with FHP.
- These findings may help practitioners in the field to manage their clients.

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