Impact of physical exercise (strength and stretching) on repairing craniovertebral and reducing neck pain: A systematic review and meta-analysis

ABSTRACT

Background: The craniovertebral (CV) junction is crucial for head support, mobility, and protecting the upper spinal cord and vital nerve structures. Disorders in this area can cause severe symptoms such as neck pain, restricted movement, and neurological issues such as headaches and balance problems. Exercise and physical activity improves muscle strength, flexibility, joint stability, reducing pain, and enhancing joint function, while specifically for the CV junction, exercise can relieve muscle tension, boost blood flow, and improve posture, although the specific impact on CV junction health remains underexplored.

Methods: A comprehensive literature search was conducted using databases MEDLINE, Cochrane, Lilacs, and ScienceDirect, alongside manual searches through reference lists. The review focuses on exercise and CV junction issues and includes randomized controlled trials, cohort or case–control studies, and systematic reviews. Primary outcomes include pain levels, joint mobility, function, and quality of life.

Results: Results yield four meta-analyses with corrective exercise and conventional exercise in improving forward head posture risk difference 0.00 (−0.09, 0.09) 95% confidence interval (CI), between cervical and thoracic exercises odds ratio 1.04 (0.59, 1.84) 95% CI. Comparing exercise treatment and physiotherapy showed risk difference 0.11 (−0.10, 0.32) 95% CI and the comparative analysis between training and no treatment showed risk difference 0.09 (−0.01, 0.20) 95% CI.

Conclusion: Exercise-based rehabilitation programs tailored to patients with CV junction problems offer robust evidence, benefiting clinical management, and prevention efforts.

Keywords: Craniovertebral, forward head posture, neck pain, physical exercise

INTRODUCTION

The craniovertebral (CV) joint (CV junction) is a complex anatomical structure consisting of the skull bones and the first two bones in the spine, namely the atlas (C1) and the axis (C2).[1,2] The CV junction is crucial for head support, mobility, and the protection of the upper spinal cord and essential nerve structures, and disorders in this region, such as malformation, instability, or degeneration, can lead to severe symptoms including neck pain, restricted movement, and neurological issues such as headaches and balance disturbances.[3] Exercise and physical activity are known to have various health benefits, including joint and spine health. Exercise can improve muscle strength, flexibility, and joint stability, all of which contribute to reduced pain and improved joint function. Especially for the CV junction,

Access this article online	
Website: www.jcvjs.com	Quick Response Code
DOI: 10.4103/jcvjs.jcvjs_107_24	

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Submitted: 09-Jul-24 **Accepted:** 24-Jul-24
Published: 12-Sep-24

How to cite this article: Nazwar TA, Bal'afif F, Wardhana DW, Mustofa M. Impact of physical exercise (strength and stretching) on repairing craniovertebral and reducing neck pain: A systematic review and meta-analysis. J Craniovert Jun Spine 2024;15:266-79.

proper exercise can help reduce muscle tension around the neck and shoulders, increase blood flow, and improve body posture. A well-designed exercise program can also reduce the risk of injury and improve the quality of life for patients with CV junction problems.[4]

Research has shown that various types of exercise, such as strength training, stretching, and aerobics, have a positive effect on overall joint health.[5] However, the specific influence of exercise on the CV junction has not been studied in depth. Therefore, more research is needed to understand how certain types of exercise may affect the health and function of the CV joints. Such research may help in developing more effective rehabilitation programs for patients with CV junction problems. In a clinical context, it is important for health practitioners to know the types of exercise that are safe and beneficial for patients with CV junction disorders. A careful, individualized approach to exercise programs can optimize treatment outcomes and improve patient well-being. In addition, educating the wider community about the importance of exercise for joint health is essential to prevent and reduce CV junction disorders.

This study aims to evaluate the impact of exercise on CV joint (CV junction) health through systematic research and meta-analysis. It will assess how different types of exercise affect pain, mobility, and function of the CV joints to identify the most effective exercises for reducing symptoms and enhancing quality of life in patients with CV junction disorders. Despite potential benefits noted in previous research, inconsistencies and small sample sizes necessitate this study to provide robust conclusions and evidence-based recommendations for tailored rehabilitation programs, ultimately benefiting clinical management and prevention of CV junction problems.

METHODS

Literature search

The literature search process for this research will be carried out through several major medical databases such as Medline, Cochrane, Lilacs, and ScienceDirect. These databases were selected because they provide access to leading peer-reviewed journals in the field of health and medical sciences, covering a wide range of topics related to the effect of exercise on CV joint (CV junction) health. The use of several different databases is expected to ensure comprehensive coverage of the relevant literature and relevance of the findings to the research questions asked [Table 1]. In addition, a manual search will be carried out through the reference lists of relevant articles as well as a review of the abstracts and full text of the articles that have been found to ensure that no relevant studies have been missed. With this comprehensive search approach, it is hoped that this study can obtain a representative and diverse literature base for a more in-depth analysis of the influence of exercise on CV joint health.

The key outcome measures include pain reduction, improvements in joint mobility and function, and enhancements in quality of life and overall functional recovery. To achieve a comprehensive understanding, a literature search was conducted using the following MeSH terms:

("Craniovertebral Junction"[MeSH] OR "Craniovertebral Junction Abnormalities"[MeSH] OR "Craniovertebral Junction Diseases"[MeSH] OR "Atlanto-Axial Joint"[MeSH] OR "Basilar Invagination"[MeSH]) AND ("Exercise"[MeSH] OR "Exercise Therapy"[MeSH] OR "Physical Activity"[MeSH] OR "Rehabilitation"[MeSH] OR "Physical Therapy Modalities"[MeSH]) AND ("Treatment Outcome"[MeSH] OR "Pain Measurement"[MeSH] OR "Range of Motion, Articular"[MeSH] OR "Functional Recovery"[MeSH] OR "Quality of Life"[MeSH]).

Study selection

To ensure robustness, this systematic research and meta-analysis include randomized controlled trials (RCTs), cohort or case–control studies, observational studies, and relevant systematic reviews. Included interventions cover stabilization exercises, stretching, muscle strengthening, aerobic exercise, or combinations thereof, with outcomes including pain, joint mobility, function, quality of life, and other CV junction health parameters. The exclusions involve case reports, studies lacking controls, pediatric or animal populations, and interventions not primarily focused on exercise. Only peer-reviewed studies in English from the last 20 years are included. Selection involves comprehensive database searches, title/abstract screening, full-text review, data extraction, and quality assessment by two independent reviewers, resolving discrepancies through discussion or with a third reviewer. This approach aims to yield reliable conclusions on exercise effects on CV junction health.

Data extraction

Data extraction in this systematic review and meta-analysis will collect the key variables from selected studies, including demographic information (age, gender, and number of participants), clinical characteristics (specific CV junction disorders), and intervention details (type and duration of exercise). In addition, data on study design, allocation methods, and follow-up duration will be collected to assess methodological quality. The primary outcomes will focus on pain levels (using Visual Analog Scale [VAS] or numerical scales), joint mobility (measured by range of motion [ROM] tests), joint function (assessed with the Neck Disability Index [NDI]), and quality of life (measured with SF-36 or EQ-5D questionnaires). The changes in these parameters from baseline to the end of the intervention will be analyzed to determine the effectiveness of exercise on CV junction health. Validated assessment tools will be used, such as VAS and numerical scales for pain, goniometers for ROM, and NDI for joint function. Quality of life will be assessed using SF-36 or EQ-5D questionnaires. Risk of bias will be evaluated using tools such as the Cochrane Risk of Bias Tool for randomized studies from RevMan software (Cochrane Collaboration, London, W1G 0AN, United Kingdom). Two independent researchers will assess each study to ensure objectivity and consistency, resolving discrepancies through discussion or involving a third researcher if necessary. This approach aims to provide a comprehensive and reliable analysis of the effects of exercise on CV joint health.

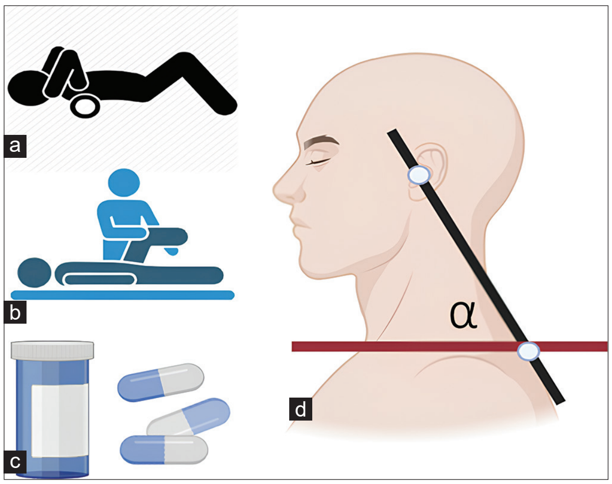

Figure 1: Illustration of efforts to rehabilitate choiches and craniovertebral angle (CVA) outcome (a) exercise intervention, (b) physiotheraphy intervention, (c) conservative intervention, (d) CVA assessment

Statistical analysis

The systematic review and meta-analysis will integrate the results from various studies to provide a precise effect estimate of exercise on CV joint (CV junction) health. The chosen effect model will depend on study homogeneity; a fixed-effect model for high homogeneity or a random-effects model for significant heterogeneity. Heterogeneity will be assessed using Cochran's Q and I^2 statistics, with high I^2 values indicating large heterogeneity. Sensitivity analysis will ensure the reliability of results by repeating analyses while removing one study at a time. Using RevMan software to analyzed listed studies.

RESULTS

Study flow

In conducting a systematic search on the effect of exercise on CV issues, a comprehensive review was undertaken across several databases. Initially, PubMed/NCBI yielded 63 articles, from which 20 relevant ones were identified after excluding RCTs. Similarly, ScienceDirect/Embase provided 206 articles, with 9 remaining after exclusion and sorting processes. Cochrane initially listed

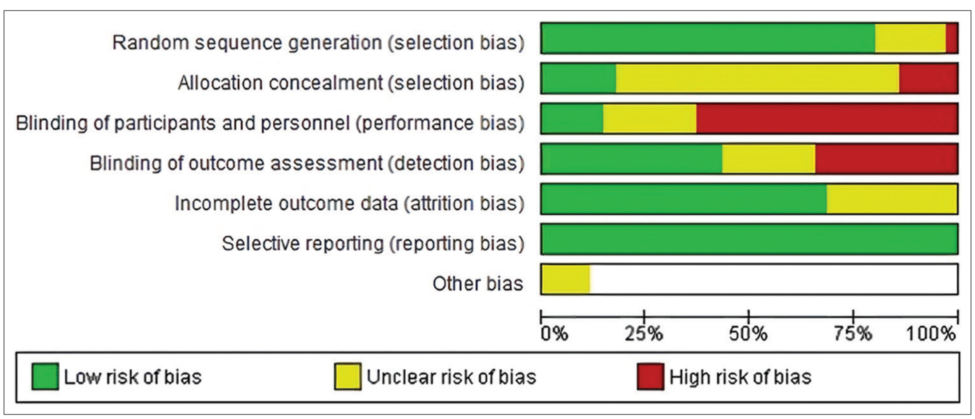

Figure 2: Risk of bias graph: Review authors' judgments about each risk of bias item presented as percentages across all included studies

Table 1: PICO framework and MeSH search terms on evaluate the effect of exercise on the health ofthe craniovertebral joint

Patient/problem (craniovertebral issues)	Intervention (exercise)	Comparison (optional)	Outcomes
"Craniovertebral Junction"	"Exercise"	"No Intervention"	"Treatment Outcome"
"Craniovertebral Junction Abnormalities"	"Exercise Therapy"	"Standard Care"	"Pain Measurement"
"Craniovertebral Junction Diseases"	"Physical Activity"	"Physical Therapy"	"Range of Motion, Articular"
"Atlanto-Axial Joint"	"Rehabilitation"	"Drug Therapy"	"Functional Recovery"
"Bacillary Invagination"	"Physical Therapy Modalities"		"Quality of Life"

PICO - Patient/problem Intervention Comparison outcome

Figure 3: Risk of bias summary: Review authors' judgments about each risk of bias item for each included study

161 trials, reduced to 139 after exclusion, while Lilacs yielded 2 articles, none meeting inclusion criteria postexclusion. In total, 48 studies were gathered and subsequently sorted, resulting in 43 unique articles after duplicates sourced from different databases were removed. These 43 articles were selected based on predefined inclusion criteria, and 35 studies marking the final set for detailed analysis and synthesis regarding the impact of exercise on CV health.

Overview of found studies and characteristics of study populations

Research on forward head posture (FHP) and related interventions has been conducted across diverse populations and training methods. The key studies include those by Abd El-Azeim *et al.*,[6] Alghadir and Iqbal,[7] Cho *et al*.,[8,9] Heydari *et al*.,[10] and Joshi and Poojary,[11] focusing on interventions such as scapular stabilization exercises (SSE), postural correction exercises (PCE), and deep cervical flexor (DCF) muscle exercises with biofeedback. For example, Abd El-Azeim *et al.*[6] targeted young adults (20–35 years) using SSE and PCE, while Alghadir and Iqbal[7] studied adults (25–40 years) using DCF exercises. Aneis *et al.*[12] used a multimodal approach including muscle energy techniques (METs) and ergonomic advice for patients with upper crossed syndrome. Elderly populations were studied by Astorga Verdugo *et al*.[13] and Jang *et al.*,[14] while adolescents with idiopathic scoliosis were studied by Diab [Figure 1].[15]

The findings consistently show that various exercises effectively reduce FHP and associated symptoms such as neck pain and disability. Abd El-Azeim *et al.*[6] found SSE more effective than PCE, and Malik[16] reported significant pain reduction with cervical isometric strengthening and stretching exercises. Overall, these interventions improve CV angles (CVA) and neck function, offering valuable insights for clinical practices aimed at treating FHP and neck pain across various age groups and conditions.

Researched sports interventions

The studies mentioned involved various types of interventions to improve FHP and its associated conditions. Abd El-Azeim *et al.*[6] uses SSE and postural correction exercises (PCE). Alghadir and Iqbal[7] focused on DCF muscle training using pressure biofeedback on pain and FHP. Aneis *et al*.[12] proposed a multimodal approach that includes MET, cervical and scapulothoracic stabilization exercises, and posture correction exercises with ergonomic suggestions. Cho *et al*.[8,9] compared the effects of upper thoracic and upper cervical spine mobilization with cervical flexor muscle training. Malik[16] investigated isometric cervical, rhomboid, and longus capitis strengthening exercises as well as stretching exercises for muscles such as the trapezius, scalene, sternocleidomastoid, and pectoralis major and minor. Various other studies, such as those conducted by Diab,[15] Joshi and Poojary,[11] and Suwaidi *et al*.,[17] also investigated different exercise approaches to address posture problems and neck stiffness.

Outcomes measured and main findings from analyzed studies

Studies have investigated the effects of physical therapy interventions and corrective exercises on FHP. Abd El-Azeim *et al.*[6] and Alghadir and Iqbal[7] reported significant increases in CVAs and muscle endurance after scapular stabilization and pressure biofeedback exercises. Aneis *et al*.[12] and Joshi and Poojary[11] found reductions in pain and functional disability with increased CVA in multimodal intervention groups. Astorga Verdugo *et al*.[13] and Heydari *et al*.[10] demonstrated that social exercise and selective corrective exercises improved CVA more effectively than conventional exercises. Cho *et al*.[8,9] showed upper thoracic and cervical spine mobilization provided better short-term outcomes in CVA and other functions.

Eftekhari *et al*.[18] and Sedaghat *et al.*[19] reported improvements in quality of life, thoracic posture, respiratory capacity, and CVA after corrective exercises. Hürer *et al*.[20] and Jang *et al*.[14] found significant postural and balance improvements in elderly women after Pilates and corrective thoracic exercises.

Kang *et al*.[21] and Kim *et al*.[22] showed enhanced CVA, respiratory capacity, and cervical spine ROM with combined interventions. Lee and Lee[23] and Sharma *et al.*[24] associated biofeedback and MET/myofascial release interventions with significant CVA and quality of life improvements. Vijayan *et al.*[25] and Suvarnnato *et al.*[26] demonstrated increased neck muscle strength and pain reduction with corrective posture exercises. Suwaidi *et al.*[17] and Titcomb *et al.*[27] found dynamic postural exercises and CEPs techniques effective in improving FHP in young adults. Finally, Yousef *et al.*[28] reported significant improvements in CVA and neck disability following corrective exercises. The tabulation of data from the listed studies can be found in Appendix 1 section of this document.

There is no strong evidence that corrective exercise is better or worse than conventional exercise in improving FHP, with both methods considered equally effective but with considerable uncertainty in the results [Figure 4]. The difference between cervical and thoracic exercises is not statistically significant [Figure 5], with thoracic exercises showing only a slight, nonsignificant advantage. Comparing exercise treatment and physiotherapy showed an 11% increase in improvement events in the treatment group, but this result is not statistically significant [Figure 6]. Similarly, the comparative analysis between training and no treatment showed a 9% improvement in the training group, but the result is not statistically significant [Figure 7]. More robust studies are needed to confirm these findings. Medical practitioners and physiotherapists should consider these uncertainties and individual patient conditions when making treatment recommendations. See Apendix 1.

DISCUSSION

Pain reduction

The results of this study are consistent with previous studies showing that physical exercise, especially neck stabilization exercises and stretching, is effective in reducing pain in patients with CV junction problems. The study showed significant reductions in the VAS and NDI after the intervention.[12,21] SSE and pressure biofeedback showed significant improvements in pain reduction.[6] The group that received upper spine mobilization and mobility exercises

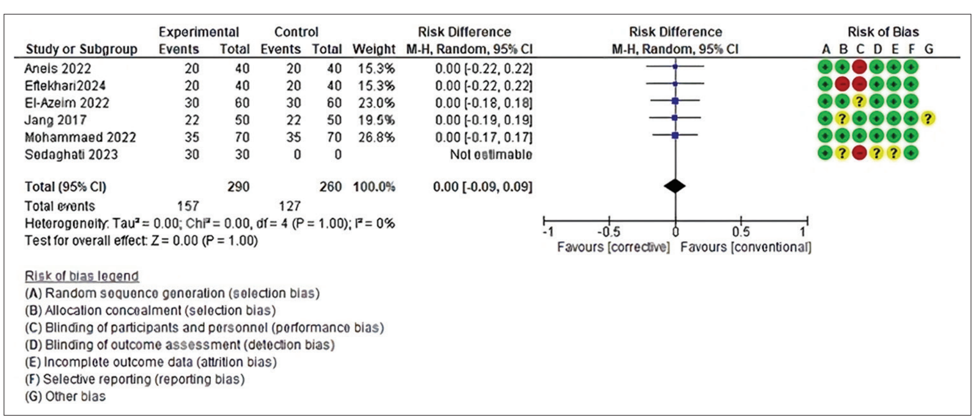

Figure 4: Corrective exercise versus conventional exercise. Image of forest plot on the effect of corrective exercise or conventional exercise. Mean differences and 95% confidence intervals (CIs) were plotted for each study. Pooled mean differences (diamond peaks) and 95% CIs (diamond widths) were calculated using a random effects model. A positive composite mean indicates conventional training. A negative mean difference indicates corrective exercise. Heterogeneity mean difference: τ^2 = 0.00; χ^2 = 0.00, df = 4 (P = 1.00); I^2 = 0%, test for overall effect: Z = 0.00 (P = 1.00). CI - Confidence interval

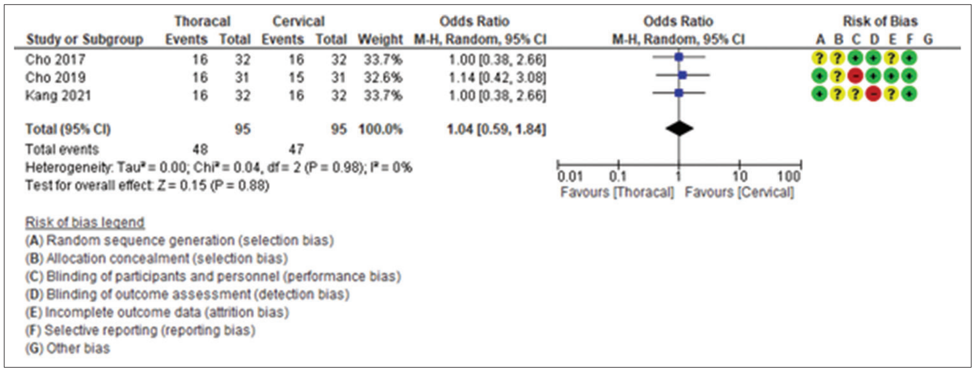

Figure 5: Thoracic versus cervical exercise. Image of forest plot on the effect of thoracic exercise or cervical exercise. Mean differences and 95% confidence intervals (CIs) were plotted for each study. Pooled mean differences (diamond peaks) and 95% CIs (diamond widths) were calculated using a random effects model. A positive composite mean indicates thoracic exercise. A negative mean difference indicates cervical training. Heterogeneity mean difference: $\tau^2 = 0.00$; $\chi^2 = 0.04$, df = 4 ($P = 0.98$); $I^2 = 0\%$, test for overall effect: $Z = 0.15$ ($P = 0.88$). CI - Confidence interval

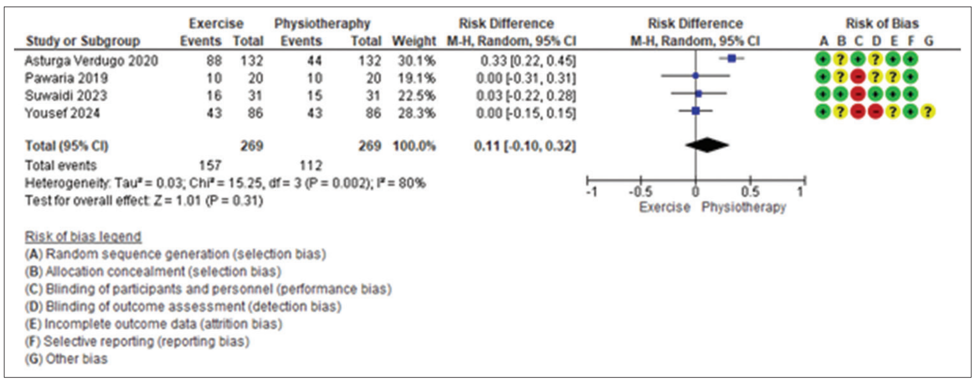

Figure 6: Exercise versus physiotherapy. Image of a forest plot on the influence of exercise or physiotherapy. Mean differences and 95% confidence intervals (CIs) were plotted for each study. Pooled mean differences (diamond peaks) and 95% CIs (diamond widths) were calculated using a random effects model. A positive composite mean indicates practice. A negative mean difference indicates physiotherapy. Heterogeneity mean difference: $\tau^2 = 0.03$; $\chi^2 = 15.25$, df = 3 ($P = 0.002$); $I^2 = 80\%$, test for overall effect: $Z = 1.01$ ($P = 0.31$). CI - Confidence interval

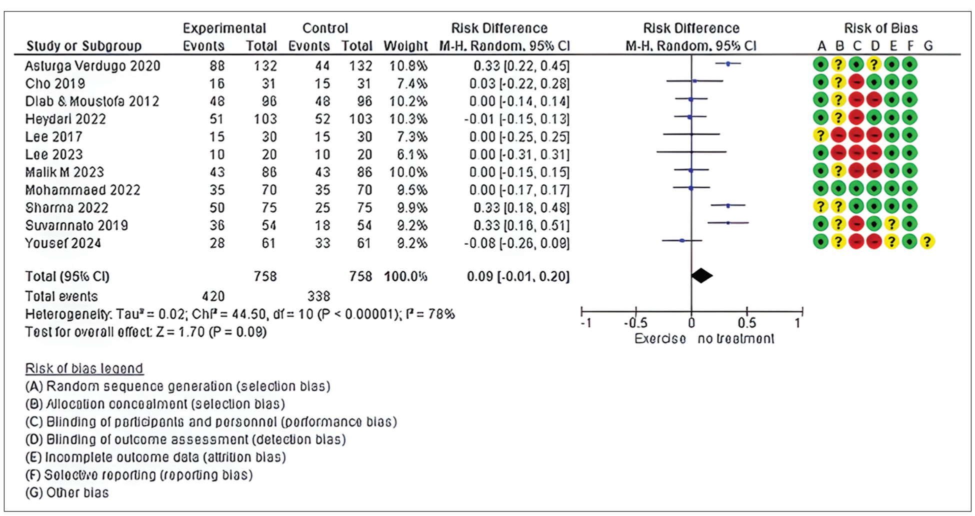

Figure 7: Exercise versus no treatment. Image of forest plot under the influence of training or no treatment. Mean differences and 95% confidence intervals (CIs) were plotted for each study. Pooled mean differences (diamond peaks) and 95% CIs (diamond widths) were calculated using a random effects model. A positive composite mean indicates practice. A negative mean difference indicates no treatment. Heterogeneity mean difference: $\tau^2 = 0.02$; $\chi^2 = 44.50$, df = 10 ($P = 0.00001$); $I^2 = 78\%$, test for overall effect: $Z = 1.70$ ($P = 0.09$). CI - Confidence interval

reported greater pain reduction compared with other interventions.[8] Another study showed that interventions with a combination of biofeedback and manual therapy were also effective in reducing neck pain.[23,29] These findings suggest that physical exercise can reduce muscle tension and increase blood flow, which contributes to pain reduction.

Increased mobility

Physical exercise was found to improve neck mobility and flexibility in patients with CV junction disorders. There was a significant improvement in CVA and cervical ROM (CROM) after intervention.[17,20,27,30] This supports existing evidence that exercises focused on increasing ROM and strengthening muscles can be helpful in reducing stiffness and improving joint function. Craniocervical flexor exercises combined with suboccipital releases show significant improvements in CROM.[16,26,31] Studies involving corrective exercises have also shown improvements in the neck muscle flexibility and strength.[10,14,15,18,19,27,32]

Improved joint function

Research shows that a proper exercise program can improve CV joint function, including increased stability and motor control. This is consistent with other evidence showing that physical exercise can strengthen the muscles around the neck and shoulders, thereby providing better support for the CV junction. SSE and upper spinal mobilization showed significant improvement in the CVA.[6,8,21] The combination of upper thoracic spine mobilization and mobility exercises showed better results in terms of CVA and cervical extension.[8,9] Study shows that corrective exercise can increase the peak-to-peak amplitude of dermatomal somatosensory-evoked potentials for C6 and C7 in cases of lower cervical spondylotic radiculopathy.[32]

Better quality of life

Patients who undergo exercise programs show improvements in their quality of life, which include decreased pain symptoms and increased ability to perform daily activities. The study showed significant improvements in quality of life, chest expansion, thoracic kyphosis angle, and CVA in the experimental group compared with the control group.[18] Corrective exercise and pressure biofeedback were associated with significant improvements in maximum inspiratory pressure, maximum expiratory pressure, forced vital capacity, CVA, FEV_1, VAS, and NDI.[21] Another study also showed that corrective exercise can improve well-being in elderly women with thoracic hyperkyphosis.[14] These findings suggest that physical and functional improvements through physical exercise can have a positive impact on patients' general well-being.

Consistency with clinical guidelines

The results of this study support clinical guidelines recommending exercise as part of conservative management for patients with CV joint disorders. Interventions such as SSE and upper spine mobilization are in accordance with clinical guidelines for the management of neck pain and FHP.[8] The combination of mobility and stabilization exercises applied in these studies supports clinical guideline recommendations that underscore the importance of physical exercise for healthy posture and joint functionality. Significant improvements in various clinical parameters (e.g. CVA, VAS, NDI, and FEV1) indicate that corrective exercise is effective and in accordance with clinical guidelines for the management of neck pain and dysfunction.

Various studies have explored the impact of physical exercise on repair of CV joints and reduction of neck pain. Häkkinen *et al.*[33] found that strength training and stretching, as well as stretching alone, were effective in reducing neck pain and disability. Salehi *et al.*[34] further supports the positive effects of exercise therapy, showing improvements in CVAs and head-and-neck ROM in individuals with FHP. Ylinen *et al.*[35] recommended a combination of strength training and stretching for effective rehabilitation in cases of chronic neck pain, while Louw *et al.*[36] emphasized the effectiveness of strengthening exercises in reducing neck pain and improving quality of life in office workers. These findings collectively suggest that strength training and stretching may contribute to CV joint repair and reduction of neck pain.

Clinical implications

Based on the research findings, rehabilitation programs for patients with CV junction problems should prioritize a physical exercise regimen focused on neck stabilization, stretching, and muscle strengthening. These exercises need to be customized to meet individual patient needs, ensuring they are maximally effective in addressing specific CV junction issues. Patient education plays a crucial role in emphasizing the importance of physical exercise for managing pain and enhancing joint function. This educational effort should encompass guidance on recommended exercise types, frequency, duration, and safe execution methods. To implement these programs successfully, collaboration among physicians, physiotherapists, and sports coaches is essential. This multidisciplinary approach ensures patients receive comprehensive and coordinated care, optimizing their rehabilitation outcomes and overall health management.

Research limitations

The meta-analysis identified significant variability in exercise interventions across studies, including differences in methods, duration, and intensity, which complicates direct comparisons and limits comprehensive conclusions. Publication bias is also a concern, as studies with positive outcomes may be more likely to be published, potentially skewing interpretations of exercise effectiveness [Figures 2 and 3].

In addition, the studies often involved small, homogenous populations, limiting the generalizability of findings to broader demographics. Methodological limitations, such as inadequate control groups and uncontrolled variables, further challenge the internal validity of results. Short follow-up durations in some studies may also obscure the long-term sustainability of observed benefits from exercise interventions on CV joint health.

CONCLUSION

This study underscores the efficacy of exercise interventions, particularly strength training and stretching, in significantly enhancing CV joint function and reducing associated pain symptoms. The combination of exercise with physiotherapy or medication demonstrates superior outcomes compared to exercise alone, highlighting the benefits of a multimodal approach. Despite variations in intervention methods, duration, and intensity across studies, the overall trend supports the positive impact of exercise training. However, limitations such as a homogeneous study population and potential publication bias temper the generalizability of findings. Clinically, integrating structured exercise programs tailored to individual patient needs can effectively manage CV joint issues, improving function, and quality of life.

Health-care providers are encouraged to incorporate strength training and stretching exercises as standard components of rehabilitation protocols for CV joint problems. Individualized exercise regimens should consider factors such as duration and intensity to optimize therapeutic benefits. Future research directions include investigating the underlying mechanisms of exercise benefits, conducting larger and more diverse studies to enhance applicability, and employing rigorous study designs with adequate controls and randomization to enhance validity. Long-term studies are warranted to assess sustained effects and determine optimal exercise program durations. Further exploration of combined approaches integrating exercise with other modalities such as physiotherapy and pharmacotherapy is also needed to refine clinical management strategies.

Financial support and sponsorship
Nil.

Conflict of Interest
There are no conflicts of interest.

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Appendix 1: Data tabulation of included studies

Author and year	Problem	Exercise method	*n*	Parameter	Outcomes
El-Azeim, 2022	FHP	SSE, posture correction exercises PCE three times a week for 10 weeks	60	CVA, pressure pain threshold, cervical flexor and extensor muscle endurance, NDI in Arabic, RMS of upper trapezius and sternocleidomastoid muscles at rest and activity	Showed a statistically significant difference between before and after treatment with a $P<0.05$, with better improvement in the group that received SSE
Al-Ghadir, 2021	FHP	Muscle training DCF uses pressure biofeedback on pain and FHP for 4 weeks	55	Pain and FHP were assessed using the NPRS and CVA using digital photography techniques	Mean improvements on both measures were more significant in the group that also received DCF muscle training using pressure biofeedback
Aneis, 2022	UCS	Multimodal approach, including MET, cervical and scapulothoracic stabilization exercises, and posture correction training with ergonomic advice for 4 weeks	40	Assessments were made of the CVA and SSA measured using photogrammetry, pain intensity measured using the VAS, and functional disability evaluated using the ANDI before and 4 weeks after the intervention	There was a significant decrease in VAS and ANDI and an increase in CVA after intervention in both groups ($P<0.001$). However, only the multimodal group showed significant changes in SSA ($P<0.0001$)
Asturga Verdugo, 2020	Social characteristics of the CVA in the elderly	4 months strength training protocol	132	CVA	The strength training protocol with social characteristics increased the CVA by an average of 14.6° and was 21% more effective than the group performing conventional strength training in increasing the CVA in the elderly
Cho, 2017	FHP	Combination of upper thoracic spine mobilization and mobility exercises for 4 and 6 weeks	32	CVA cervical range of motion, NPRS, tenderness threshold, NDI, and GRC	The combination of upper thoracic spine mobilization and mobility exercises showed better short-term results in terms of CVA (standing position), cervical extension, NPRS, NDI, and GRC compared with upper cervical spine mobilization and stabilization exercises in individuals with FHP
Cho, 2019	FHP	Mobilization of the upper cervical and upper thoracic spine compared with cervical flexor muscle training for 4–6 weeks	31	CVA, NPRS, respiratory function, and GRC	Combined upper cervical and upper thoracic spine mobilization demonstrated better overall short-term outcomes in terms of CVA, NPRS, respiratory function, and GRC compared with DCF muscle training in individuals with FHP
Malik M, 2023	Assessing the effectiveness of posture correction on blood pressure in individuals with FHP	Strengthening exercises (cervical isometrics, rhomboids, and longus capitis) and stretching exercises (trapezius, scalene, sternocleidomastoid, and pectoralis major and minor) with exercises performed 6 repetitions for each exercise, twice a week for 4 weeks	43	Blood pressure is measured using a sphygmomanometer. Measurements were taken at baseline and after 4 weeks of treatment	SBP and DBP were significantly reduced after 4 weeks
Diab, 2012	Evaluated the effectiveness of FHP correction on three-dimensional postural parameters and functional level in adolescent patients with idiopathic scoliosis	All patients received traditional treatment of stretching and strengthening exercises, while the study group also received a 3-month advanced head posture corrective exercise program	76	All posture parameters, including CVA, trunk inclination, lordosis, kyphosis, trunk imbalance, lateral deviation, pelvic torsion, and surface rotation	An advanced head posture corrective exercise program combined with conventional rehabilitation improves three-dimensional posture and functional status in adolescent patients with idiopathic scoliosis

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Author and year	Problem	Exercise method	*n*	Parameter	Outcomes
Diab and Moustofa, 2012	Pain and nerve root function in cases of cervical spondylotic radiculopathy	Posture corrective exercise program and a 6-month follow-up period	96	Dermatomal somatosensory peak-to-peak evoked potential amplitude, CVA and VAS	Correction of FHP using a posture corrective exercise program in addition to ultrasound and infrared radiation reduces pain and CVA, and increases the peak-to-peak amplitude of dermatomal somatosensory evoked potentials for C6 and C7 in a case of lower cervical spondylotic radiculopathy
Eftekhari, 2024	Thoracic spine hyperkyphosis in the elderly population	Rehabilitation-based breathing and corrective exercises with 6 weeks, with three sessions per week	40	QoL, disability, thoracic kyphosis angle, CVA, shoulder angle, cranial angle, and chest expansion	The experimental group, which performed corrective exercises, showed significant improvements in QoL, chest expansion, thoracic kyphosis angle, CVA, skull angle, and shoulder angle compared with the control group. However, there was no significant difference between the two groups in terms of physical abilities
Heydari, 2022	FHP	SCE on the CVA and SA in students with FHP. The selective corrective exercise program included strengthening and stretching exercises for 8 weeks	103	CVA and SA	There were significant differences between the experimental and control groups in terms of CVA and SA. After 8 weeks of selective corrective exercise, the MCID CVA and SA values were 1.40° and 1.34°, respectively
Hurer, 2021	Sagittal cervical disorientation	Clinical pilates: Pilates-based stabilization exercises performed in a clinic. Home Exercises: Conventional exercises done at home	46	Postural disorders: Postural disorders as measured by CVA, head tilt, and cervicothoracic angle. Strength and Endurance of DCF: The strength and endurance of the DCF muscles. CROM: The range of motion of the neck. Pain intensity: The intensity of the pain. Functional disability: Functional disability	Clinical pilates group: Demonstrated significant improvements in CVA, head tilt, cervicothoracic angle, and DCF muscle strength and endurance ($P<0.05$). No significant difference: There were no significant differences between the two groups in terms of right-left acromial distance, pain intensity, functional disability, and CROM parameters ($P>0.05$)
Jang 2017	Thoracic hyperkyphosis in elderly women	An 8-week thoracic corrective exercise program, consisting of specific exercises to improve breathing, thoracic mobility and stability, as well as awareness of thoracic alignment for 8 weeks, with a duration of 1 h per session, twice a week (16 sessions in total)	50	Includes the level of postural abnormalities (thoracic kyphosis angle, kyphosis index calculated in a relaxed state and best posture using flexicurve, kyphosis index ratio calculated in best/relaxed posture, CVA, and tragus-to-wall distance), balance (short physical performance battery and limit of stability), and well-being (Geriatric Depression Scale SF 36-item SF Health Survey)	A thoracic corrective exercise program shows significant improvements in spinal posture, balance, and well-being in elderly women with thoracic hyperkyphosis
Jeong 2022	Neck disease with hamstring stiffness	Comparison of the direct effects of static stretching and proprioceptive neuromuscular facilitation stretching on SLR, CVA, and CROM in neck pain patients with hamstring stiffness and one intervention session	64	Hamstring muscle flexibility and stiffness (measured by SLR test), CVA, and CROM	There were no between-group effects for any outcome variable; however, all outcome variables SLR, CVA, and CROM improved significantly in their respective groups after the one-session intervention
Jeong 2018	Neck pain and FHP	SMI and CCFE techniques are used to improve head posture and reduce neck pain with one intervention session	20	SLR, PA, CVA, and CROM test results	SLR, PA, CVA, and CROM test results improved significantly after both interventions
Jeong and Lee, 2024	FHP, arched shoulder posture, crossed upper syndrome	Telerehabilitation combining diaphragmatic breathing re-education and shoulder stabilization exercises with 4 weeks of intervention	40	Upper trapezius pain pressure threshold, CVA, arched shoulder posture, shoulder tilt degree, NDI, and closed kinetic chain upper limb stability test	After 4 weeks, both groups showed significant improvements in upper trapezius pressure pain threshold, CVA, curved shoulder posture, shoulder tilt degree, NDI, and closed kinetic chain upper extremity stability test

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Author and year	Problem	Exercise method	*n*	Parameter	Outcomes
Joshi *et al*., 2022	Neck pain, FHP, loss of function	MET with posture correction exercises versus control group with 3 weeks of intervention	48	Pain: Measured using the NPRS, Function: Measured using the NDI, CVA: Measured using the MB ruler	Group A (MET + posture correction exercises) showed: Significantly greater reduction in neck pain ($P<0.001$). Significantly greater reduction in NDI score ($P<0.001$). There was a significantly greater increase in the CVA ($P<0.025$). Group B (control) also showed within-group improvement, but less significant than Group A
Kang 2021	FHP	Scapular stabilization and thoracic extension exercises versus cervical stabilization exercises and stretching for 6 weeks	32	CVA, respiration (FEV_1, maximum inspiratory pressure, maximum expiratory pressure, forced vital capacity), pain VAS, NDI	The experimental group, which received scapular stabilization and thoracic extension exercises, showed significant improvements in maximum inspiratory pressure, maximum expiratory pressure, forced vital capacity, CVA, FEV_1, VAS, and NDI. The control group, which received cervical stabilization and stretching exercises, also showed significant improvements in CVA, FEV_1, VAS, and NDI
Kim, 2016	FHP	CCFE versus suboccipital release combined with CCFE	19	CVA: The angle between the head and the spine. Cervical flexion and extension range of motion. Activity of the sternocleidomastoid, anterior scalene, and splenius capitis muscles during CCFE	The CVA, cervical flexion range of motion, and cervical extension range of motion were significantly greater after suboccipital release combined with CCFE compared with CCFE alone. Sternocleidomastoid, anterior scalene, and splenius capitis muscle activity was significantly lower during suboccipital release combined with CCFE compared with CCFE alone, except during the first phase of CCFE
Lee and Lee, 2024	FHP and TTH	BF, MT, ST for 4 weeks	62	CVA, electroencephalography findings for attention, stress PPT, Headache during activities of daily living HDI, QoL assessment	BF interventions were associated with significant improvements in the following outcomes compared with MT and ST interventions
Lee, 2017	Can exercise change cervical angle and respiratory function in smartphone users	The exercise group did two types of exercise, while the control group maintained routine activities for 20 min	30	CVA, FVC, FEV_1, FEV_1/FVC ratio, peak expiratory flow, maximum inspiratory pressure, maximum expiratory pressure	Statistically significant differences in CVA, FVC, FEV_1, FEV_1/FVC ratio, peak expiratory flow, maximal inspiratory pressure, and maximal expiratory pressure between the exercise group and the control group ($P<0.05$)
Lee, 2019	On the distance between the lower crests, the CVA, and the rounded shoulder posture	Stable ground plank training group versus unstable ground plank training group for 4 weeks	30	Distance between lower crests, CVA, rounded shoulder posture	In the study, significant improvements were observed in head and spine angles as well as rounded shoulder posture in the unstable surface group after exercise, while no significant differences were found between the stable and unstable surface groups or the stable and unstable plank groups
Lee, 2023	Chronic neck pain	Combined extracorporeal shock wave therapy and sling exercises versus sling exercises alone with intervention 2×weekly for 4 weeks	20	NDI, Neck joint ROM, CVA, Neck alignment, posture control	Significant differences in the following results: NDI, CVA, Cobb angle, centaur data, ROM
Malik, 2023	Patients with mechanical neck pain	Suboccipital muscle inhibition technique versus CCFE for 6 months	28	NPRS, NDI, Goniometer (for CROM), CVA	Significant improvement in Group A and Group B in the following outcomes: NPRS, FHP, NDI, CROM

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Author and year	Problem	Exercise method	*n*	Parameter	Outcomes
Mohammad, 2022	In patients with FHP and cervical radiculopathy	BF FHP corrective exercise for 8 weeks versus no treatment for 8 weeks	70	Reaction time, central somatosensory conduction time, CVA, nerve conduction time at N13 and N20, referred arm pain, NDI	After 4 weeks, there were insignificant differences between the study and control groups in reaction time and central somatosensory conduction time. However, significant differences were observed in N13, N20, CVA, referred arm pain, and NDI scores. After 8 weeks, there were significant differences between the study and control groups in all outcome measures
Ozyurek, 2024	The relationship between hamstring flexibility and CROM, as well as DCF muscle endurance, in the context of the myofascial tensegrity network	Categorization of hamstring flexibility as "normal" or "limited" based on hip flexion angle using the PSLR test. Measurement of active CROM using the Clinometer smartphone app, including flexion, extension, and lateral flexion. Craniocervical flexion test performance to evaluate deep neck flexor muscle endurance, measured by performance index and highest stress score over 6 months	60	Hamstring flexibility (categorized as normal or limited), CROM (flexion, extension, lateral flexion), deep neck flexor muscle endurance (performance index, highest stress score)	No significant differences in cervical range of motion were observed between participants with normal hamstring flexibility and those with limited hamstring flexibility. Participants with limited hamstring flexibility demonstrated lower deep neck flexor muscle endurance scores (highest performance index and stress score) compared with participants with normal hamstring flexibility
Parks, 2021	Neck pain	The study group performed sling-based active thoracic exercises with cervical manual therapy for 50 min a day, twice a week for 4 weeks. The control group performed placebo exercises with cervical manual therapy in the same way as the study group. 50 min a day, 2 × a week for 4 weeks	27	Pain: Measured using pressure pain thresholds and NPRS scores. Function: Evaluated using CVA and NDI. QoL: Assessed using the SF-36 Questionnaire	After the treatment period, both the study group and the control group showed significant improvements in pain, function, and QoL. The patient's pressure pain threshold increased significantly in both groups. NPRS scores decreased significantly in both groups. The CVA increased significantly in both groups. Neck dysfunction decreased significantly in both groups. QoL improved significantly in both groups
Pawaria, 2019	FHP	Efficacy of cervical stabilization exercises on neck pain, neck deformity, CVA, and respiratory muscle strength over 6 weeks	20	NRPS, NDI, CVA, respiratory muscle strength (MIP and MEP)	The group receiving cervical stabilization exercises showed significant improvements in CVA and respiratory strength, with decreased NRPS and NDI scores, compared with the control group
Sedaghati, 2023	Improved respiratory function with COVID-19	Breathing exercises and corrective exercises in the cervical and thoracic spine for 2 weeks	30	Spirometry test, CVA, thoracic kyphosis test	Significant improvement in CVA, thoracic kyphosis, and respiratory capacity, including FEV_1, FEV_1/FVC, and SPO_2 in the group receiving corrective and breathing exercises compared with the control group
Sharma, 2022	FHP, causing shortening of the suboccipital muscles, increased lordosis, and neck pain	Compared the effects of MFR and MET with general neck exercises on CVA and headache in TTH patients, with a 2-week intervention	75	This study measured CVA and headache index as outcome measures	The results showed a significant improvement in the CVA and headache index in the MET and MFR groups compared with the control group. Both MET and MFR groups showed significant increases in CVAs compared with the control group
Suvarnato, 2019	Chronic mechanical neck pain	Effects of specific training for semispinalis (extensor) cervicitis and DCF (flexor) muscles, along with usual care, in individuals with chronic mechanical neck pain over 6 weeks	54	Thai version of the NDI, NPS, CVA, and neck muscle strength	The results showed that the extensor and flexor training groups showed significant improvements in neck disability, pain intensity, CVA, and neck muscle strength compared with the control group

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Author and year	Problem	Exercise method	*n*	Parameter	Outcomes
Suwaidi, 2023	FHP	Effects of CBP® intervention, including mirror image® exercises and DCTO, with a standard exercise-based FHP correction group (standard group) using commonly used stretching and strengthening exercises for the neck with 18 sessions during 6 weeks period	60	The primary outcome was CVA, with secondary outcomes including pain intensity, BBS, HRA, and CROM	The CBP group showed statistically significant improvements in CVA after 18 sessions, and at 3-month follow-up, the CBP group had statistically significant differences supporting all outcomes compared with the standard group
Titcomb, 2023	FHP	This study compared the effects of postural education and two CEP on the CVA in young adults with FHP. Intervention included self-myofascial release, stretching, and strengthening exercises for 4 weeks	72	The primary outcome was CVA, with secondary outcomes including pain intensity, BBS, HRA, and CROM	This study found that all three interventions were effective techniques for increasing FHP in young adults. CEP, especially SMRS and SMRSS, provides superior results compared with postural education alone
Vijayan, 2023	Pain and FHP	Interference therapy, Static neck exercises, Mulligan SNAGs for 2 weeks	20	Pain intensity NPRS, CROM (flexion, extension, right and left lateral rotation), CVA	In group analysis: Significant decrease in NPRS scores in both groups (Group A: $P=0.004$, Group B: $P=0.005$), Increase in CVA in both groups ($P=0.001$ for both), Increase in range of flexion, extension, and rotational movements cervix in both groups ($P<0.05$), Between group analysis: Significant difference in pre-post mean difference: NPRS score: Group A (3.30±0.67) versus Group B (4.60±0.96), CVA: Group A (0.46±0.24) versus Group B (5.62±1.21), cervical flexion: Group A (10±2.36) versus Group B (19±4.59), cervical extension: Group A (6.50±2.53) versus Group B (21±8.23), right lateral rotation: Group A (8±2.58) versus Group B (15±4.08), left lateral rotation: Group A (8.5±2.49) versus. Group B (16±4.24)
Yousef, 2024	FHP	PCWO versus DCF exercises for 6 weeks	61	CVA and NDI	In the PCWO group, there was a significant increase in the CVA ($P<0.0001$) and a significant decrease in the NDI score ($P<0.0001$). Similarly, in the DCF group, there was a significant increase in the CVA ($P<0.0001$) and a significant decrease in the NDI score ($P=0.0039$)

RMS - Root mean square; SSE - Scapular stabilization exercises; PCE - Postural correction exercises; NPRS - Numerical Pain Rating Scale; FHP - Forward head posture; UCS - Upper crossed syndrome; MET - Muscle energy techniques; CVA - Craniovertebral angle; SSA - Sagittal shoulder angle; VAS - Visual Analogue Scale; ANDI - Arabic version of the neck disability index; NPRS - Numerical Pain Rating Scale; NDI - Neck disability index; GRC - Global assessment of change; SBP - Systolic blood pressure; DBP - Diastolic blood pressure; SA - Shoulder angle; SCE - Selective corrective exercises; SF-36 - Short form 36; SLR - Straight leg raise; PA - Popliteal angle; SMI - Suboccipital muscle inhibition; CCFE - Cranio-cervical flexion exercise; FEV_1 - Forced expiratory volume in 1 s; TTH - Tension-type headaches; BF - Biofeedback; MT - Manual therapy; ST - Stretching; PPT - Pressure-pain threshold; HDI - Henry Ford headache disability inventory; QoL - Quality of life; FVC - Forced vital capacity; ROM - Range of motion; PSLR - Passive straight leg raise; SPO2 - Peripheral oxygen saturation; MFR - Myofascial release therapy; NPS - Numerical Pain Scale; CBP® - Chiropractic Biophysics®; DCTO - Denneroll™ cervical traction orthotic; BBS - Berg balance score; HRA - Head repositioning accuracy; CEP - Corrective exercise programs; SNAGs - Sustained natural apophyseal glides; PCWO - Posterior cervical weighing orthosis; CROM - Cervical range of motion; DCF - Deep cervical flexor; SMRSS - self-myofascial release + stretching + strengthening group; SMRS - self-myofascial release + stretching group; MCID - minimal clinically important diference; MIP - Maximum Inspiratory Pressure; MEP - Maximum Expiratory Pressure; MB - Mentum Basion (Mentum refers to the midpoint of the chin. Basion refers to a point on the occipital bone, where the base of the skull meets the cervical spine.)