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Craniovertebral Angle and Postural Control in Forward Head Posture: A Narrative Review

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Abstract

Background: Forward head posture (FHP) is a common postural disorder characterized by altered cervical alignment that may impair neuromuscular function and postural control. Craniovertebral angle (CVA) is widely used as an objective indicator to quantify FHP severity.

Objective: To analyze the relationship between CVA and postural control and to identify patterns and research gaps in the literature.

Methods: A narrative literature review was conducted using PubMed and ScienceDirect to identify studies published between 2015 and 2025. Eligible articles were original human studies involving individuals with FHP that reported CVA measurements and postural control outcomes. Included study designs comprised randomized controlled trials, cross-sectional studies, and case–control studies. Data were synthesized descriptively.

Results: Nine studies were included (five randomized controlled trials, two cross-sectional studies, and two case control studies), involving 26–160 participants. Individuals with FHP consistently demonstrated smaller CVA values (approximately 41°- 46°) compared with controls (approximately 53°-55°). Smaller CVA values were associated with increased postural sway, higher overall stability index, and greater cervical proprioceptive error. Intervention studies showed that improvements in cervical alignment were accompanied by increases in CVA and clinically meaningful improvements in balance, trunk control, and proprioception. In addition, one case-control EEG/EMG study reported increased corticomuscular coherence during challenging balance conditions, indicating compensatory neural strategies in individuals with FHP.

Conclusion: Reduced CVA is consistently associated with impaired postural control. Improving cervical alignment may enhance balance and neuromuscular function, supporting the relevance of CVA in postural assessment and rehabilitation

Keywords
Forward Head Posture; Craniovertebral Angle; Postural Control; Balance; Proprioception

Introduction

Forward head posture (FHP) is one of the most common postural deviations observed in young adults and individuals of productive age.[1,2] This postural alteration is characterized by anterior translation of the head relative to the trunk, resulting in changes in cervical alignment and increased mechanical loading on the cervical spine and surrounding musculoskeletal structures.[3] Prolonged exposure to this altered posture has been associated with neck pain, reduced functional capacity, and disturbances in neuromuscular function related to postural control and balance regulation.[4]

To objectively quantify the severity of forward head posture, the craniovertebral angle (CVA) is widely used as a standardized and reproducible parameter in both clinical and biomechanical research.[5,6] CVA is defined as the angle formed between a horizontal line passing through the spinous process of the seventh cervical vertebra and a line connecting this point to the tragus of the ear.[7] Smaller CVA values indicate a more pronounced forward head posture. Although a CVA threshold of <50° is commonly applied to classify FHP, other studies have proposed higher cut-off values, such as >53° or ≥55°, to define normal head posture.[8,9] These variations suggest that CVA classification may be influenced by methodological factors, including photographic protocols, landmark identification, population characteristics, and measurement tools, thereby requiring cautious interpretation when comparing results across studies.

The prevalence of forward head posture has increased in parallel with modern lifestyle changes, particularly prolonged use of digital devices, sustained static postures, and reduced physical activity levels.[1] Epidemiological studies have reported a wide range of FHP prevalence, from approximately 50–70% among university students and working-age adults to over 90% in populations with high exposure to electronic devices.[1,10] However, this variability is largely attributable to differences in operational definitions, CVA cut-off thresholds, and assessment methods rather than reflecting true epidemiological disparities.

Alterations in head and cervical alignment associated with forward head posture may also influence the systems responsible for maintaining postural stability.[11] Postural control is defined as the ability of the neuromuscular system to regulate body position and orientation relative to gravity during static and dynamic tasks.[12] This process relies on the integration of visual, vestibular, and proprioceptive inputs, which are centrally processed to generate coordinated motor responses.[13] Cervical proprioception plays a critical role in head orientation and spatial awareness; therefore, changes in cervical alignment may disrupt afferent input from cervical mechanoreceptors. In addition, anterior displacement of the head shifts the body's center of mass forward, potentially increasing the

demands placed on the postural control system, particularly under challenging balance conditions such as reduced visual input or unstable support surfaces.[11]

Several studies have examined the association between craniovertebral angle and postural control outcomes in both healthy individuals and clinical populations.[13] These studies generally report that smaller CVA values are associated with increased postural sway, reduced balance stability, and greater reliance on visual input to maintain equilibrium. Nevertheless, the strength and consistency of these associations vary considerably across studies, likely due to heterogeneity in study design, participant characteristics, CVA cut-off criteria, and postural control assessment instruments.

Despite the growing body of research in this area, no narrative synthesis has specifically focused on the relationship between craniovertebral angle and postural control using a structured analytical framework. Existing studies employ diverse balance assessment tools, including posturography systems, functional balance scales, and proprioceptive tests, and report heterogeneous outcome parameters such as overall stability index, weight distribution index, sway measures, and joint position error. This methodological heterogeneity limits direct comparison across studies and complicates interpretation of the CVA–postural control relationship.

Therefore, the aim of this narrative literature review is to synthesize and critically evaluate the available evidence on the relationship between craniovertebral angle and postural control in individuals with forward head posture. Specifically, this review seeks to determine whether reduced CVA values are consistently associated with impaired postural control and to explore how variations in CVA cut-off values and postural control measurement instruments may influence reported associations across studies. The findings of this review are expected to inform posture-based assessment and rehabilitation strategies in physiotherapy practice.

Method

This study was conducted as a narrative literature review aimed at synthesizing and critically evaluating existing evidence on the relationship between craniovertebral angle (CVA) and postural control in individuals with forward head posture (FHP). A narrative review design was deliberately selected to allow flexible integration of findings derived from heterogeneous study designs, participant characteristics, and outcome measures, which are not readily suited to formal systematic review or meta-analytic approaches. Consequently, this review did not adhere to PRISMA guidelines.

Relevant studies were identified through targeted electronic searches of PubMed and ScienceDirect, as these databases comprehensively index biomedical and rehabilitation research related to posture, balance, and neuromuscular control. Search terms were developed to reflect three core conceptual domains, namely forward head posture, craniovertebral angle, and postural control. Boolean operators were applied to enhance retrieval while maintaining relevance, and the following search strategy was used across both databases: “forward head posture” AND “craniovertebral angle” AND “postural control”. Only articles published in English between 2015 and 2025 were considered eligible for inclusion.

Studies were included if they were original human research involving participants with forward head posture or cervical postural alterations quantified using craniovertebral angle and if they assessed postural control, balance, postural stability, or related sensorimotor outcomes. Eligible study designs included randomized controlled trials, cross-sectional studies, and case–control studies. Studies were excluded if they were review articles, editorials, opinion papers, single case reports, or conference abstracts, if they did not report craniovertebral angle measurements or postural control-related outcomes, if they involved non-human subjects, if full-text articles were unavailable, or if forward head posture was not the primary focus of the research.

Study selection and data extraction were conducted by a single reviewer. Titles and abstracts were initially screened for relevance based on predefined eligibility criteria, followed by full-text evaluation when necessary. In cases of uncertainty regarding study eligibility or data interpretation, consultation with co-authors was undertaken to ensure consistency with the objectives of the review. Data were extracted using a structured framework capturing authorship and year of publication, study design, participant characteristics, craniovertebral angle measurement methods and cut-off values, postural control assessment instruments, and key outcomes related to balance, proprioception, and neuromuscular control.

Given the narrative nature of this review, extracted data were synthesized descriptively rather than quantitatively, and no meta-analysis was performed. To enhance clarity and coherence, findings were organized using a domain-based analytical framework according to the primary mechanisms of postural control assessed. These domains included mechanical balance and functional stability, proprioceptive and sensorimotor control, and neural control and central integration. Mechanical balance outcomes encompassed clinical balance scales and posturographic parameters, while proprioceptive outcomes included joint position error and cervical sensorimotor measures. Neural control outcomes were represented by neurophysiological indicators such as corticomuscular coherence and electroencephalographic activity during balance tasks. As this review did not involve direct data collection from human participants, no ethical approval was required.

Results

A total of nine studies met the inclusion criteria and were included in this narrative literature review, comprising five randomized controlled trials, two cross-sectional studies, and two case–control studies. The sample sizes of the included studies ranged from 26 to 160 participants and involved heterogeneous populations, including healthy young adults, older adults, individuals with chronic neck pain, patients with hyperkyphosis, and stroke patients presenting with forward head posture (FHP).

Across observational and case–control studies, individuals classified as having forward head posture consistently demonstrated smaller craniovertebral angle (CVA) values compared with control or non-FHP groups. Most studies defined FHP using a CVA threshold of <50°, while control participants typically exhibited CVA values above this threshold. Reported mean CVA values in FHP groups ranged from approximately 41° to 46°, whereas control groups demonstrated mean CVA values between approximately 53° and 55°. In one case–control study, participants with FHP exhibited a mean CVA of 45.3 ± 2.6°, compared with 54.8 ± 2.3° in individuals with normal head posture. Similar patterns were reported in populations with hyperkyphosis, where reduced CVA values were observed alongside altered spinal alignment.

Postural control outcomes were assessed using a wide range of clinical and instrumented measures, including the Berg Balance Scale, Timed Up and Go test, Overall Stability Index, Weight Distribution Index, postural sway parameters, and dynamic balance tests. Observational and case–control studies consistently reported poorer postural control performance in individuals with smaller CVA values, reflected by higher stability index values, increased postural sway, and altered weight distribution. Several

studies reported moderate to strong correlations between reduced CVA and impaired balance outcomes, although correlation coefficients varied depending on the assessment instruments and participant characteristics.
The characteristics of the included studies are summarized in Table 1.

Table 1. Summary of Included Studies Examining the Relationship Between Craniovertebral Angle and Postural Control

No	Study (Author, Year)	Design	Sample	Baseline CVA (Mean ± SD)	FHP Definition	Postural Control Outcomes	Measurement Tools	Main Results
1	Hyeon et al., 2025 [14]	RCT	26 stroke patients	45.12 ± 2.73° vs 46.44 ± 1.37°	Reduced CVA	Trunk control, balance, gait	K-PASS, BBS, TUG	CVA and balance improved in intervention group
2	Özalp et al., 2025 [15]	RCT	99 young adults	Not reported	Reduced CVA	Static & dynamic balance, proprioception	JPE, Stork Test, Y-Balance	Greater improvements with combined training
3	Salim et al., 2023 [2]	RCT	66 elderly	41.4 ± 2.6° vs 42.7 ± 3.2°	Reduced CVA	Balance, ROM, posture	BBS, CROM	Sustained improvements in CVA and balance
4	Moustafa et al., 2020 [16]	Cross-sectional	160 participants	<50° vs >50°	CVA <50°	Stability, sensorimotor control	Biodex OSI, SPNT	Reduced CVA associated with poorer balance
5	Miçoo et al., 2024 [17]	RCT	49 participants	46.02 ± 1.99°	Reduced CVA	Postural stability, proprioception	ProKin, JPE	Improved CVA and postural stability
6	Hosseinabadi et al., 2020 [18]	RCT	44 elderly	42.38 ± 2.09°	Reduced CVA	Balance, alignment	BBS, TUG	Balance and CVA improved
7	Moustafa et al., 2023 [19]	Case–control	160 neck pain patients	41 ± 5° vs 53 ± 4°	CVA reduction	Stability, autonomic control	Biodex OSI	Poorer balance with reduced CVA
8	Jang et al., 2025 [20]	Cross-sectional	54 healthy adults	50.57 ± 1.14°	Continuous CVA	Balance, proprioception	TETRAX, JPE	Higher CVA associated with better balance
9	Anwar et al., 2025 [21]	Case–control	64 participants	45.3 ± 2.6° vs 54.8 ± 2.3°	Reduced CVA	Neural control, balance	EEG, EMG, Biodex	Increased neural demand with reduced CVA

Abbreviations: CVA, craniovertebral angle; FHP, forward head posture; RCT, randomized controlled trial; BBS, Berg Balance Scale; TUG, Timed Up and Go; JPE, joint position error; OSI, overall stability index.

Table 1. Summary of Included Studies Examining the Relationship Between Craniovertebral Angle and Postural Control

In randomized controlled trials, baseline CVA values indicated the presence of forward head posture in all intervention groups. Following postural correction, cervical stabilization, scapulothoracic exercises, or orthotic interventions, treatment groups demonstrated increases in CVA accompanied by improvements in balance-related outcomes, including enhanced trunk control, improved dynamic balance, and reduced postural instability. Control groups generally showed smaller or less consistent changes in CVA and postural control parameters.

Proprioceptive and sensorimotor outcomes were reported in several studies using joint position error tests, cervical proprioception assessments, and spatial navigation measures. Individuals with smaller CVA values demonstrated greater proprioceptive error and altered sensorimotor responses compared with control participants. Intervention studies reported reductions in joint position error and improvements in proprioceptive accuracy following interventions that improved cervical alignment.

Neural control outcomes were examined in one case–control study using corticomuscular coherence and electroencephalographic analysis during balance tasks. Individuals with forward head posture demonstrated increased corticomuscular coherence and elevated neural activity during more challenging balance conditions, despite minimal differences in mechanical balance performance compared with controls. These findings indicate increased neural demand associated with reduced craniovertebral angle during postural control tasks.

Discussion

This narrative literature review demonstrates a consistent association between reduced craniovertebral angle (CVA) and impaired postural control in individuals with forward head posture (FHP). Across observational, case–control, and interventional studies, smaller CVA values were repeatedly associated with poorer balance performance, increased postural sway, and higher stability index values, indicating compromised postural control. These findings support biomechanical and neurophysiological theories suggesting that anterior head displacement alters cervical load distribution and disrupts sensorimotor integration necessary for maintaining postural stability.[17,22,23]

The observed relationship between reduced CVA and impaired balance can be explained by changes in cervical proprioceptive input and altered body alignment. Cervical mechanoreceptors play a critical role in head orientation and spatial awareness, and deviations in cervical posture may distort afferent feedback to central postural control centers.[1213] Studies included in this review reported greater joint position error and impaired sensorimotor control in individuals with smaller CVA values, particularly in populations with neurological conditions or chronic neck pain.[22,23] These findings suggest that forward head posture may negatively influence proprioceptive accuracy, thereby increasing reliance on other sensory systems to maintain balance.

In addition to proprioceptive alterations, forward head posture may affect postural control by shifting the body's center of mass anteriorly. This mechanical displacement increases the demands placed on the postural control system, especially during dynamic tasks or under challenging conditions such as reduced visual input or unstable support surfaces.[11] Studies using posturography systems consistently reported higher overall stability index values and increased postural sway in individuals with reduced CVA, reflecting diminished balance efficiency.[16,22,23]

Interventional studies included in this review further support the clinical relevance of the CVA–postural control relationship. Randomized controlled trials investigating corrective exercises, cervical stabilization, scapulothoracic training, and orthotic interventions demonstrated that improvements in cervical alignment were accompanied by increases in CVA and concurrent

improvements in balance performance and proprioceptive accuracy. [12,14,16] Although these findings do not establish causality, they suggest that postural correction may positively influence neuromuscular control mechanisms associated with balance.

Neural control mechanisms were explored in one case–control study using corticomuscular coherence and electroencephalographic analysis during balance tasks.[17] Individuals with forward head posture demonstrated increased neural activity and higher corticomuscular coherence during challenging balance conditions despite minimal differences in mechanical balance outcomes compared with controls. This finding suggests that individuals with reduced CVA may rely on compensatory neural strategies to maintain postural stability, potentially increasing cognitive and neural load during balance tasks. While these results provide novel insights into central adaptations associated with forward head posture, they should be interpreted cautiously due to the limited number of studies examining neural mechanisms.

Several methodological limitations across the included studies warrant consideration. First, there was substantial heterogeneity in craniovertebral angle measurement protocols, cut-off values used to define forward head posture, and postural control assessment tools. This variability limits direct comparison across studies and may contribute to inconsistencies in reported effect sizes. Second, many studies employed cross-sectional or case–control designs, which preclude causal inference. Third, formal risk-of-bias assessment was not conducted due to the narrative design of this review, further limiting the strength of conclusions regarding the magnitude of observed associations.

Despite these limitations, the findings of this review have important clinical implications. Measurement of craniovertebral angle is simple, non-invasive, and feasible in clinical settings, making it a valuable component of postural assessment in physiotherapy practice. However, CVA should not be used as a standalone indicator of postural dysfunction. Instead, it should be integrated with functional balance tests, proprioceptive assessments, and, when feasible, instrumented posturography to provide a comprehensive evaluation of postural control. Future research should prioritize standardized CVA measurement protocols, longitudinal study designs, and the development of a core outcome set for postural control to strengthen the evidence base and guide clinical decision-making.

Conclusion

This narrative literature review demonstrates a consistent association between reduced craniovertebral angle (CVA) and impaired postural control in individuals with forward head posture (FHP) across diverse populations and study designs. Individuals with FHP generally exhibit smaller CVA values, most commonly below 50°, which are associated with increased postural sway, higher overall stability index values, and reduced balance performance on both clinical and instrumented assessments. These findings indicate that alterations in cervical alignment are closely linked to deficits in mechanical balance and sensorimotor control.

Evidence from intervention studies further suggests that improvements in cervical alignment are accompanied by concurrent improvements in postural control and proprioceptive accuracy. Corrective exercise programs, cervical stabilization training, scapulothoracic interventions, and orthotic support were consistently associated with increases in CVA and enhanced balance-related outcomes. Although causal relationships cannot be established due to the predominance of non-longitudinal designs, the consistency of findings across randomized controlled trials supports the clinical relevance of addressing cervical posture in balance-oriented rehabilitation programs.

In addition to mechanical and proprioceptive mechanisms, limited evidence indicates that individuals with forward head posture may exhibit increased neural demand during balance tasks, reflected by elevated corticomuscular coherence and neural activity under challenging conditions. These findings suggest that postural misalignment may necessitate compensatory neural strategies to maintain stability, even when overt balance performance appears preserved.

Clinically, this review highlights the importance of incorporating CVA measurement as part of a comprehensive postural and balance assessment rather than relying on CVA as a standalone indicator. Future research should prioritize standardized CVA measurement protocols, longitudinal and interventional study designs, and the integration of mechanical, proprioceptive, and neural outcome measures to further clarify the mechanisms linking cervical posture and postural control.

Author Contribution

Anida Azkia Fitri: Conceptualization, methodology, data curation, formal analysis, writing—original draft.
Umi Budi Rahayu: Conceptualization, methodology, writing—review & editing, supervision.
Wahyuni: Writing—review & editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This study was a narrative literature review and did not involve human participants, animals, or identifiable personal data. Therefore, ethical approval was not required.

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