MSM

CLINICAL RESEARCH

e-ISSN 1643-3750
© Med Sci Monit, 2026; 32: e952950
DOI: 10.12659/MSM.952950

Received: 2026.01.26
Accepted: 2026.04.23
Available online: 2026.05.13
Published: 2026.XX.XX

Comparison of Radiographic Cervical Sagittal Alignment Parameters in Patients With Nonspecific Neck Pain, Degenerative Neck Pain, and Healthy Individuals

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Financial support: None declared
Conflict of interest: None declared

Background: Cervical spine imbalance can lead to neck pain and abnormal posture. However, the relationship between global cervical sagittal balance and different neck pain subtypes remains unclear. Therefore, this retrospective study aimed to compare radiographic cervical sagittal alignment parameters, including the sagittal vertical axis (SVA), spino–cranial angle (SCA), and intervertebral disc height, among 25 patients with nonspecific neck pain, 20 patients with degenerative neck pain, and 25 asymptomatic healthy controls.

Material/Methods: This retrospective observational study included 70 participants enrolled between January 2023 and January 2025, categorized into 3 groups: patients with nonspecific neck pain, patients with degenerative neck pain (structural pathology), and asymptomatic healthy controls. Using cervical radiographs, 3 cervical alignment parameters were evaluated: SVA, SCA, and disk height. Differences between groups were analyzed using one-way analysis of variance.

Results: SVA and SCA differed significantly between the nonspecific neck pain group and both the degenerative neck pain group ($P<0.05$) and healthy controls ($P<0.05$), whereas no significant differences were observed between the degenerative neck pain group and healthy controls. Intervertebral disc height did not differ significantly among the 3 groups ($P>0.05$).

Conclusions: Nonspecific neck pain is associated with changes in global cervical sagittal alignment, including greater anterior translation and altered lordosis. These patterns differ from those observed in patients with degenerative neck pain and asymptomatic controls, supporting the use of global rather than segmental alignment in clinical assessment.

Keywords: **Cervical Vertebrae • Neck Pain • Radiography • Spinal Curvatures**

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/952950

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Introduction

Neck pain is a common musculoskeletal disorder, with a lifetime prevalence reaching 66% [1]. The persistence of neck pain is partly attributed to modern lifestyle factors, including prolonged sitting and increased use of electronic devices [2]. Therefore, understanding these biomechanical and pathophysiological mechanisms is essential for developing effective treatment strategies.

Clinically, neck pain is classified as either nonspecific or degenerative based on structural pathology [3]: nonspecific neck pain lacks an identifiable structural cause, whereas degenerative neck pain involves identifiable structural abnormalities, such as disc herniation or spinal stenosis [4,5]. However, nonspecific neck pain remains poorly defined, complicating clinical decision-making and limiting targeted treatment. Currently, specific and nonspecific neck pain are differentiated based on clinical examination and reported symptoms. However, this approach is limited, as symptoms overlap between categories and lack of objective criteria [6]. Moreover, the inherent heterogeneity of nonspecific neck pain further complicates research and treatment decisions. Therefore, objective radiographic measures may improve the differentiation of pain subtypes and guide management.

Previous radiographic studies have demonstrated that neck pain occurs both in the presence and absence of identifiable radiological abnormalities [7]. However, most radiological evaluations have focused on disc spacing and cervical lordotic alignment, and comparative radiological analyses between specific and nonspecific subtypes remain limited [8,9]. Moreover, alterations in sagittal parameters can substantially modify the load distribution across vertebral segments, increase muscular and ligamentous stress, and compromise neural foraminal dimensions [10,11]. Normal cervical sagittal alignment is typically defined by a C2-C7 sagittal vertical axis (SVA) of less than 40 mm, a spino–cranial angle (SCA) of 75° to 85°, and a T1 slope less than 25°. Deviations from these normative ranges, including increased SVA, mismatch between T1 slope and cervical lordosis, and reduced SCA, are associated with sagittal imbalance. They can also contribute to altered biomechanical loading and the development of neck pain [12,13].

In a previous study, patients with nonspecific neck pain exhibited reduced T1 slope compared with healthy controls, with no change in global cervical lordosis, suggesting segmental rather than global alignment alterations [14]. Despite these reference values, the relationship between global cervical sagittal balance and different neck pain subtypes remains unclear. Moreover, no study has systematically compared SVA, SCA, and disc features within a single framework. Therefore, in the present study, we aimed to compare cervical sagittal alignment parameters among patients with nonspecific neck pain, degenerative neck pain, and asymptomatic controls. To this end, we evaluated radiographic measures, including SVA, SCA, and intervertebral disc height, to identify structural differences among the 3 groups.

Material and Methods

Ethics Statement

The study protocol was approved by the Institutional Review Board of Inje University (approval no. 2025-08-034). This retrospective study used radiographic and clinical data obtained from routine health screening. The requirement for additional informed consent was waived following institutional policy, as all participants had provided consent for the use of their medical data for research purposes. No additional procedures or radiation exposure were involved. To ensure participant confidentiality, all data were anonymized before analysis, and personal identifiers were removed. Access to the data was restricted to authorized study personnel. All methods used were in accordance with relevant institutional and national guidelines.

Study Design and Setting

This retrospective observational study utilized data obtained between January 2023 and January 2025 from the Department of Korean Medicine, Yeonsan Dang Dang Hospital, Busan, Republic of Korea.

Participants

This retrospective study included all eligible patients identified during the study period; therefore, a priori sample size calculation was not performed. A post hoc power analysis was conducted using G*Power software (version 3.1.6; Franz Faul, Kiel University, Kiel, Germany) for a one-way analysis of variance (ANOVA) with 3 groups: nonspecific neck pain, degenerative neck pain, and asymptomatic controls. Based on group differences in the primary alignment variables (SVA and SCA), the effect sizes corresponded to Cohen's f values of 0.39 to 0.42, with a power ranging from 0.95 to 0.97 at α=0.05. These findings indicate that the present sample size (n=70) was sufficient to detect meaningful intergroup differences.

A total of 70 participants were included in the analysis, including 25 patients with nonspecific neck pain, 20 patients with degenerative neck pain, and 25 asymptomatic healthy controls (**Figure 1**). Clinical diagnoses were performed by a licensed Korean Medicine Doctor (J.S.), one of the authors, with expertise in musculoskeletal disorders, using standardized criteria applied uniformly across all groups.

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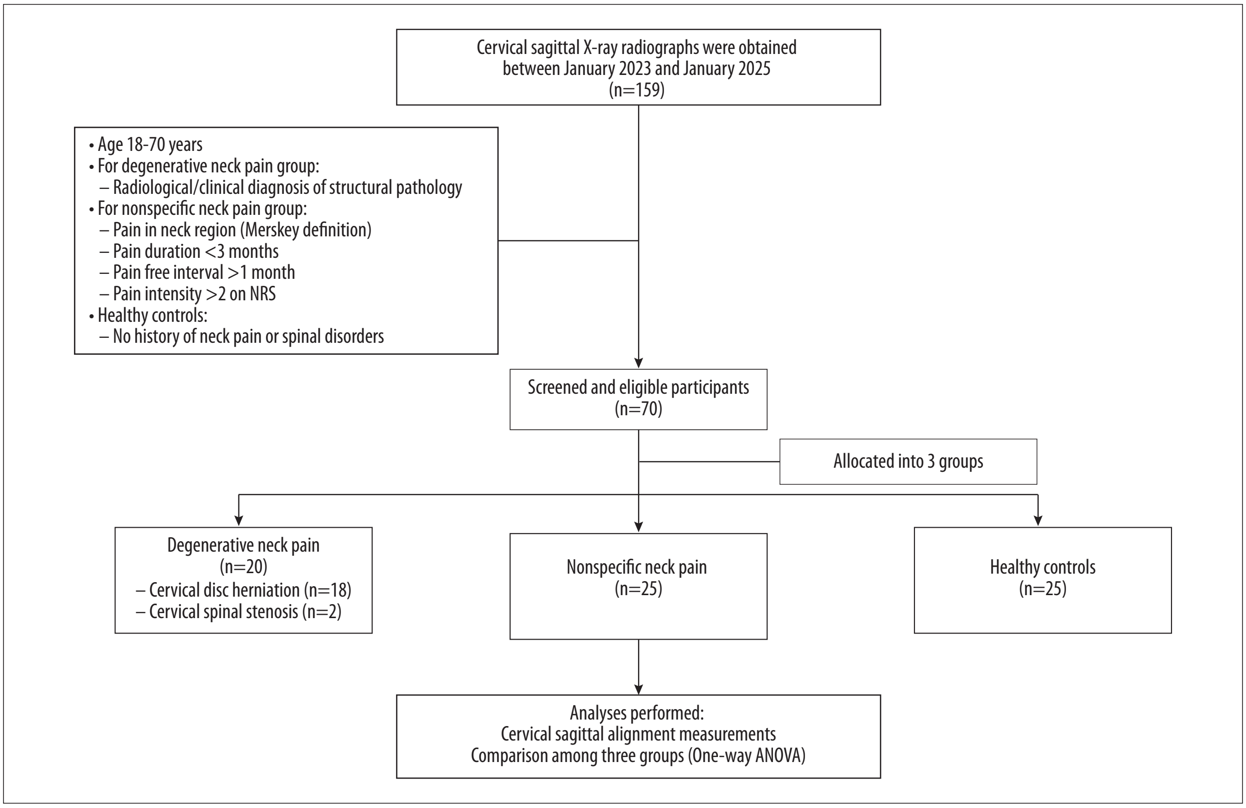

Figure 1. Flow chart depicting participant selection and allocation into the 3 study groups. A total of 70 participants were allocated into 3 groups: patients with nonspecific neck pain (n=25), degenerative neck pain (n=20), and asymptomatic healthy controls (n=25). NRS, Numerical rating scale; ANOVA, analysis of variance.

The inclusion criteria were as follows: (1) age between 18 and 70 years; (2) for the nonspecific neck pain group, (i) a primary concern of neck pain located at least partly within the anatomical region defined by Merskey, bounded superiorly by the superior nuchal line, inferiorly by an imaginary line through the tip of the first thoracic spinous process, and laterally by sagittal planes tangential to the lateral borders of the neck; (ii) pain duration of less than 3 months, with a pain-free interval of at least 1 month before the onset; (iii) pain intensity higher than 2 on a 10-point numerical rating scale; and (3) for the degenerative neck pain group, radiological or clinical diagnosis of structural pathology such as cervical disc herniation and stenosis.

Pathological causes of neck pain were systematically excluded in the nonspecific neck pain group through the following: (1) review of lateral cervical radiographs confirming the absence of structural abnormalities, such as disc space narrowing, osteophyte formation, and vertebral fracture; (2) clinical neurological examination excluding radiculopathy or myelopathy, including the absence of motor weakness, sensory deficits, or abnormal deep tendon reflexes; and (3) application of clinical and imaging criteria to exclude inflammatory, infectious, neoplastic, or traumatic causes of cervical pathology.

The degenerative neck pain group comprised patients with radiologically confirmed structural pathology, including cervical disc herniation, identified on magnetic resonance imaging (MRI) as a posterior disc protrusion or extrusion (n=18), and cervical spinal stenosis, confirmed by MRI or plain radiography and characterized by decreased spinal canal dimensions (n=2).

Participants in the healthy control group were asymptomatic and had no history of neck pain or spinal disorders; they were selected from among individuals who underwent routine health screening, including lateral cervical radiography, during the study period. Radiographic images were reviewed to confirm the absence of structural abnormalities in the cervical spine. The exclusion criteria were as follows: (1) history of cervical spine surgery or traumatic injury; (2) congenital or systemic musculoskeletal or neurological disorders (eg, rheumatoid arthritis, ankylosing spondylitis, and peripheral neuropathy); (3) presence of tumors, infections, or inflammatory disease affecting the cervical spine; (4) poor-quality radiographs preventing accurate measurement; and (5) refusal or inability to provide informed consent.

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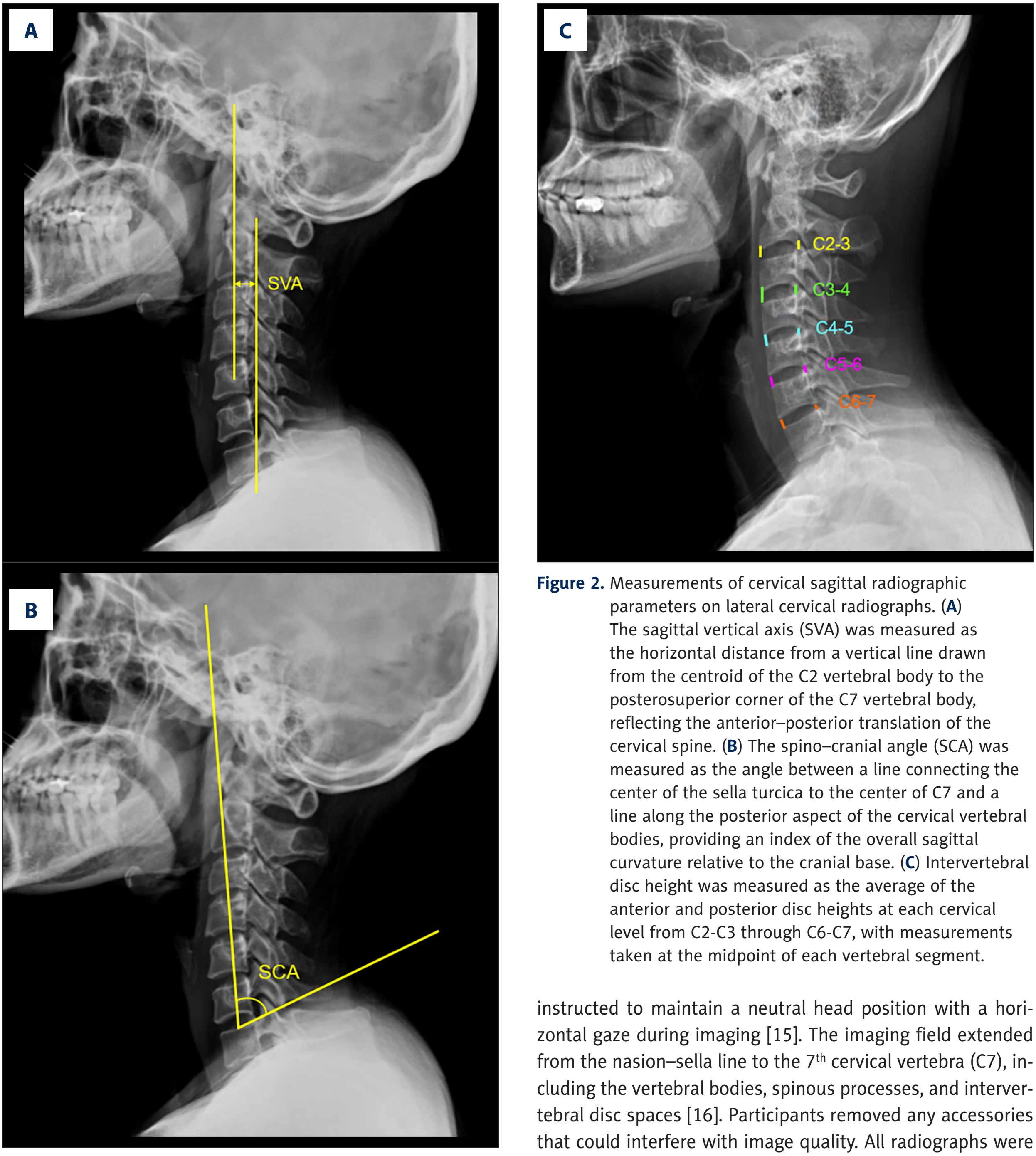

Figure 2. Measurements of cervical sagittal radiographic parameters on lateral cervical radiographs. (**A**) The sagittal vertical axis (SVA) was measured as the horizontal distance from a vertical line drawn from the centroid of the C2 vertebral body to the posterosuperior corner of the C7 vertebral body, reflecting the anterior–posterior translation of the cervical spine. (**B**) The spino–cranial angle (SCA) was measured as the angle between a line connecting the center of the sella turcica to the center of C7 and a line along the posterior aspect of the cervical vertebral bodies, providing an index of the overall sagittal curvature relative to the cranial base. (**C**) Intervertebral disc height was measured as the average of the anterior and posterior disc heights at each cervical level from C2-C3 through C6-C7, with measurements taken at the midpoint of each vertebral segment.

Radiographic Data Collection

Lateral cervical radiographs (SIG-40-525; Ecoray Inc., Seoul, Republic of Korea) were obtained for clinical purposes using a digital radiography system under standardized exposure conditions (70-80 kVp, 20-25 mAs, and a focus-to-film distance of approximately 180 cm). All images were captured with the participants standing, arms relaxed at their sides, and feet together to minimize postural variation. Participants were instructed to maintain a neutral head position with a horizontal gaze during imaging [15]. The imaging field extended from the nasion–sella line to the 7th cervical vertebra (C7), including the vertebral bodies, spinous processes, and intervertebral disc spaces [16]. Participants removed any accessories that could interfere with image quality. All radiographs were reviewed for adequate visualization of bony landmarks, and suboptimal images were repeated.

Radiographic Measurements

Cervical sagittal alignment was assessed using lateral cervical radiographs, focusing on 3 parameters: SVA, SCA, and intervertebral disc height. The SVA was measured as the horizontal distance between a vertical line from the centroid of C2 and the posterosuperior corner of C7, representing anterior–posterior

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Table 1. Demographic and clinical characteristics of the degenerative neck pain, nonspecific neck pain, and healthy control groups.

	Degenerative neck pain	Nonspecific neck pain	Control	*P* value
Number	20	25	25	–
Diagnosis				
Cervical disc herniation	18	–	–	–
Cervical spinal stenosis	2	–	–	–
Age (years)	44±14.19	41.84±18.25	44.44±21.33	0.870
Sex				
Female	13 (65%)	15 (60%)	14 (56%)	–
Male	7 (35%)	10 (40%)	11 (44%)	–
Height (cm)	168.5±8.2	170.2±7.9	169.8±8.0	0.650
Weight (kg)	70.4±12.5	72.1±11.8	71.3±12.1	0.720

Footnote: Data are presented as mean±standard deviation (SD) or number (%). * *P*<0.05 was considered statistically significant.

translation. The SCA was measured as the angle between a line connecting the center of the sella turcica to C7 and a line along the posterior border of the cervical vertebral bodies, reflecting global sagittal curvature relative to the cranial base [16-18]. The intervertebral disc height was calculated as the average of the anterior and posterior disc heights at each cervical level from C2-C3 through C6-C7, with measurements conducted at the midpoint of each vertebral segment [19].

Standardized anatomical landmarks were predefined before measurement to ensure consistency across all radiographs. All measurements were performed using a picture archiving and communication system (PACS; ViewRex 3.0, Techheim, Seoul, Korea) (**Figure 2**). Each parameter was measured 3 times by a blinded examiner with over 5 years of experience, and the mean values were used for analysis. Intraobserver reliability was excellent, with intraclass correlation coefficients ranging from 0.996 to 0.999 for SVA, 0.908 to 0.967 for SCA, and 0.981 to 0.995 for disc height.

Statistical Analysis

All analyses were performed using SPSS software (version 18.0; SPSS Inc., Chicago, IL, USA). Normality and homogeneity of variance were assessed using the Shapiro–Wilk and Levene's tests, respectively. Differences in cervical sagittal parameters (SVA, SCA, and intervertebral disc height) among the 3 groups were analyzed using one-way ANOVA. When significant, post hoc comparisons were performed using the Bonferroni correction. Continuous variables are presented as mean±standard deviation, and 95% confidence intervals (CIs) were calculated. A *P* value <0.05 was considered statistically significant.

Results

Participants Characteristics

Seventy participants were included in the analysis: 25 with nonspecific neck pain, 20 with degenerative neck pain, and 25 asymptomatic healthy controls. Mean age, height, and weight did not differ significantly among the 3 groups (*P*>0.05, **Table 1**). Female participants accounted for 65% (13), 60% (15), and 56% (14) of patients in the degenerative neck pain, nonspecific neck pain, and asymptomatic healthy control groups, respectively.

Cervical Sagittal Alignment

Cervical sagittal alignment significantly differed between the 3 groups in terms of both SVA and SCA (SVA: F=5.988, *P*=0.004; SCA: F=5.010, *P*=0.009; **Table 2**). Post hoc analysis with Bonferroni correction revealed that the nonspecific neck pain group exhibited a significantly higher C2-C7 SVA than both the degenerative neck pain (*P*=0.004) and healthy control (*P*<0.05) groups, indicating greater anterior translation of the cervical spine. Additionally, the SCA was significantly smaller in the degenerative neck pain group than in the nonspecific neck pain group (*P*=0.014), suggesting reduced overall cervical lordosis relative to the cranial base. The nonspecific neck pain group also demonstrated a significantly larger SCA than the healthy control group (*P*=0.041). In contrast, no statistically significant differences were observed between the degenerative neck pain and control groups for either parameter (**Figure 3**).

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Table 2. Comparison of cervical sagittal alignment parameters (sagittal vertical axis and spino–cranial angle) among the degenerative neck pain, nonspecific neck pain, and healthy control groups.

Variable	Between group		Mean difference	Standard error	*P* value	95% CI
C2-C7 SVA (mm)	DNP	NSNP	-7.45	2.41	0.008*	-13.24 to -1.66
		Control	-1.00	2.41	0.912	-6.78 to 4.80
	NSNP	DNP	7.45	2.41	0.008*	1.66 to 13.24
		Control	6.46	2.28	0.016*	1.00 to 11.92
	Control	DNP	1.00	2.41	0.912	-4.580 to 6.78
		NSNP	-6.46	2.28	0.016*	-11.92 to -1.00
SCA (°)	DNP	NSNP	-6.79	2.34	0.014*	-12.40 to -1.19
		Control	-1.33	2.34	0.84	-6.94 to 4.28
	NSNP	DNP	6.79	2.34	0.014*	1.19 to 12.40
		Control	5.46	2.20	0.041*	0.18 to 10.75
	Control	DNP	1.33	2.34	0.847	-4.28 to 6.94
		NSNP	-5.46	2.20	0.041*	-10.75 to -0.18

Footnote: Data are presented as mean±standard deviation (SD). SVA, sagittal vertical axis (mm); SCA, spino–cranial angle (degrees); DNP, degenerative neck pain; NSNP, nonspecific neck pain; CI, 95% confidence interval. * $P<0.05$ (Bonferroni post hoc correction).

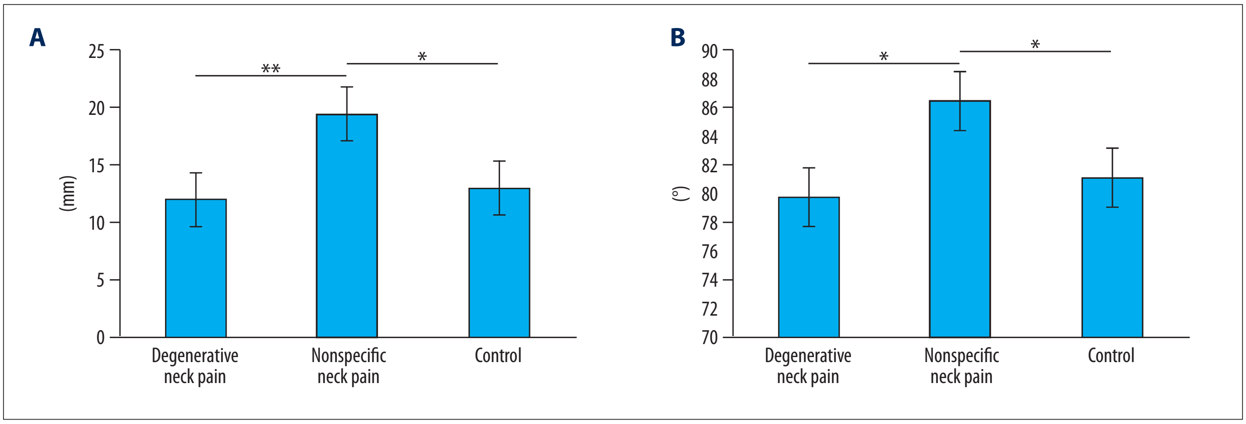

Figure 3. Comparison of cervical sagittal alignment parameters among the 3 groups. (**A**) sagittal vertical axis (SVA) and (**B**) spino–cranial angle (SCA) are presented for the nonspecific neck pain, degenerative neck pain, and healthy control groups. * $P<0.05$ (Bonferroni post hoc correction).

Intervertebral Disc Height

No significant differences in cervical intervertebral disc height were observed among the degenerative neck pain, nonspecific neck pain, and control groups ($P>0.05$, **Table 3**).

Discussion

The present study demonstrated that patients with nonspecific neck pain exhibited greater anterior cervical translation (SVA: 19.36±8.86 mm) and a higher spino–cranial angle (SCA: 86.70±7.87°) than those with degenerative neck pain and healthy controls. In contrast, intervertebral disc height did not differ among the groups. Our findings are consistent with those of Jouibari et al, who reported a reduction in T1 slope in patients with nonspecific neck pain compared with healthy controls but no significant differences in global cervical lordosis [14]. However, in contrast to the study by Jouibari et al, who focused on segmental parameters such as T1 slope and cervical lordosis, our study suggests that nonspecific neck pain is associated with alterations in global cervical sagittal alignment,

Table 3. Comparison of the sagittal vertical axis (SVA), spino–cranial angle (SCA), and intervertebral disc heights among the degenerative neck pain, nonspecific neck pain, and healthy control groups at cervical levels C2-C3 through C6-C7.

Variable	Degenerative neck pain	Nonspecific neck pain	Control	F	*P* value	η²
C2–C7 SVA (mm)	11.91±9.63	19.36±8.86	12.90±8.61	5.988	0.004*	0.15
SCA (°)	79.91±9.06	86.70±7.87	81.24±8.24	5.010	0.009*	0.13
Disc height (C2-C3) (mm)	4.42±0.93	4.09±0.97	3.93±0.80	1.659	0.198	0.05
Disc height (C3-C4) (mm)	4.22±0.83	4.51±1.03	4.12±0.97	1.089	0.343	0.03
Disc height (C4-C5) (mm)	4.42±1.11	4.23±1.04	4.13±0.86	0.461	0.633	0.01
Disc height (C5-C6) (mm)	4.54±1.25	4.25±0.82	4.11±0.90	1.030	0.362	0.03
Disc height (C6-C7) (mm)	4.57±1.23	4.62±1.09	4.01±1.14	2.132	0.127	0.06

Footnote: Data are presented as mean±standard deviation (SD). SVA, sagittal vertical axis; SCA, spino–cranial angle. * $P<0.05$ was considered statistically significant.

including increased SVA and SCA. These findings may reflect a biomechanical adaptation involving overall sagittal balance rather than isolated segmental compensation.

The present findings suggest that nonspecific neck pain is associated with a global alignment pattern. Specifically, the increased anterior translation observed in patients with nonspecific neck pain may distinguish this condition from other specific pathological conditions. Notably, this pattern suggests functional rather than structural alterations and different pathophysiological mechanisms underlying symptom development. This interpretation is supported by the preservation of disc height, indicating that symptoms can occur independently of degenerative changes. Notably, this conclusion aligns with previous studies demonstrating that pain intensity and disability are not necessarily correlated with disc height or degenerative grade [20,21].

In the present study, we observed no differences in disc height among the 3 groups. This contrasts with a previous study demonstrating an association between disc height loss and neck pain, with reduced disc height being associated with persistent symptoms [20], but it focused on specific pathological conditions rather than nonspecific neck pain conditions. Consistent with our findings, other studies have revealed relationships between disc height and pain intensity or functional disability, especially in nonspecific neck pain [21,22]. These findings collectively suggest that degenerative neck pain is associated with identifiable structural abnormalities, whereas nonspecific neck pain occurs without clear anatomical pathology [6,9].

Our findings support a distinction between the functional and structural etiologies of neck pain. Nonspecific neck pain appears to be related to postural dysfunction and neuromuscular imbalance rather than degenerative structural changes, which is consistent with previous evidence demonstrating that nonspecific neck pain is characterized by musculoskeletal dysfunction without clear structural correlates [23,24]. Moreover, the preservation of disc height across groups suggests that nonspecific neck pain results from altered biomechanical loading associated with postural adaptations rather than disc degeneration. Pain can arise from alternative mechanisms, including increased muscular demand, fascial restriction, altered proprioception, and cumulative loading of posterior cervical tissues [5]. Overall, these findings provide an alternative to traditional models linking neck pain to structural disc abnormalities. In nonspecific neck pain, the disc appears to retain structural integrity, whereas surrounding soft tissues may maladapt under sustained postural stress, which may explain why nonspecific neck pain responds to conservative interventions focused on postural correction and neuromuscular re-education [24,25]. Furthermore, the altered sagittal alignment observed in nonspecific neck pain results from compensatory mechanisms aimed at maintaining the visual field orientation and postural stability. Paradoxically, the sustained anterior head posture increases mechanical loading on posterior cervical structures, including extensor muscles, ligaments, and facet joints [26]. This altered loading pattern may contribute to muscular imbalance with superficial extensors and inhibition of deep flexors, reinforcing a postural dysfunction and pain [27,28].

The identification of SVA and SCA as radiological markers, combined with preserved disc height, may provide useful indicators for nonspecific neck pain. In particular, increased SVA and SCA with normal disc height may help distinguish functional from structural presentations. These objective measures may also support clinical assessment and inform rehabilitation strategies. Notably, the degenerative neck pain group demonstrated

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sagittal alignment comparable to that of the healthy controls despite the presence of structural pathology. However, this finding should be interpreted with caution, as the absence of global sagittal malalignment in this cohort does not diminish its relevance in other pathological conditions; instead, it suggests that global alignment was not the primary distinguishing factor in this group.

The contrasting findings between degenerative and nonspecific neck pain suggest differences in underlying pathophysiological patterns. Notably, patients with degenerative neck pain demonstrated normal sagittal alignment despite structural abnormalities, whereas those with nonspecific neck pain exhibited alignment changes without identifiable pathology. These divergent presentations underscore the clinical value of assessing global cervical sagittal alignment in nonspecific neck pain, particularly in the absence of a clear structural diagnosis. This distinction carries important therapeutic implications: degenerative neck pain may require targeted treatment of localized pathology (eg, decompression or anti-inflammatory approaches), whereas nonspecific neck pain benefits more from alignment-focused rehabilitation, including postural correction and neuromuscular re-education.

Limitations

This study has certain limitations. First, owing to its cross-sectional design, a causal inference cannot be established between sagittal alignment and neck pain. Therefore, longitudinal studies are required to establish temporal relationships. Second, as radiographic assessment was limited to a static standing posture, it may not reflect dynamic motion or functional loading conditions. Third, measurements were based on two-dimensional lateral images, which do not capture three-dimensional alignment or rotational components. Fourth, only SVA and SCA were used as global alignment parameters, and other factors, such as segmental alignment and neuromuscular function, were not assessed. Fifth, potential confounders, including body mass index, occupational posture, screen time, and daily postural habits, could not be controlled, owing to the retrospective design of the study; these factors may have influenced alignment and symptoms. Finally, the degenerative neck pain group was heterogeneous, with most patients presenting with disc herniation and only few with spinal stenosis, which limits subgroup analysis and generalizability. Future studies should incorporate longitudinal designs with dynamic and three-dimensional assessments while accounting for potential confounders.

Conclusions

The present study demonstrates distinct cervical sagittal alignment patterns in nonspecific neck pain compared to degenerative neck pain and healthy controls. Patients with nonspecific neck pain had increased anterior translation and altered global cervical lordosis, whereas intervertebral disc height did not differ among groups. These findings suggest that structural disc morphology is less relevant than global alignment patterns in nonspecific neck pain. Our results indicate that nonspecific neck pain is associated with global sagittal alignment changes rather than segmental abnormalities, demonstrating that clinical assessment and management strategies should focus on overall cervical alignment rather than isolated segmental features.

Acknowledgements

During the preparation of this manuscript, the authors used ChatGPT (OpenAI, San Francisco, CA, USA) solely for English language editing and grammatical refinement. The AI tool was not used to generate scientific content, including data, analyses, or interpretations. All AI-assisted text was carefully reviewed, edited, and validated by the authors, who take full responsibility for the accuracy, integrity, and originality of the final manuscript.

Departments and Institutions Where Work Was Done

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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