

Body mass index, craniovertebral angle, and pectoralis major and upper trapezius muscle length in young adults with neck pain: a cross-sectional observational study

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ABSTRACT

Background: Neck pain is a common musculoskeletal complaint in young adults, and postural change, muscle shortening and body composition are frequently implicated in its development. Whether body mass index (BMI), craniovertebral angle (CVA), pectoralis major (PM) length and upper trapezius (UT) length act together, rather than in isolation, to influence pain intensity in this age group has rarely been examined.

Objective: To determine the correlation of BMI, CVA, PM length and UT length with neck pain intensity in young adults.

Methods: In this cross-sectional observational study, 96 college students (70 men, 26 women; mean age 21.16 ± 1.81 years) with mild-to-moderate neck pain (Numeric Pain Rating Scale [NPRS] score 1–6) were recruited from colleges in Meerut, Uttar Pradesh, India. BMI was calculated from measured height and weight. CVA was assessed photogrammetrically using Kinovea software. PM and UT muscle lengths were measured bilaterally with a standard tape technique and averaged across sides. Because NPRS and BMI departed from a normal distribution on the Shapiro-Wilk test, Spearman's rank-order correlation was used throughout.

Results: PM length correlated negatively with NPRS ($\rho = -0.210$, $p = 0.040$). CVA ($\rho = -0.185$, $p = 0.071$) and UT length ($\rho = -0.195$, $p = 0.057$) showed negative trends that approached but did not reach significance. BMI was not directly associated with NPRS ($\rho = +0.151$, $p = 0.143$), but correlated significantly with CVA ($\rho = -0.483$, $p < 0.001$) and PM length ($\rho = +0.376$, $p < 0.001$).

Conclusion: Pectoralis major tightness was the only parameter independently and significantly associated with neck pain intensity in this sample. CVA and upper trapezius length showed clinically relevant marginal trends, and BMI appears to influence neck pain indirectly, through posture and muscle length, rather than as a direct predictor. A multimodal physiotherapy approach that prioritises pectoralis major stretching alongside postural correction may benefit young adults with neck pain.

Keywords: neck pain; craniovertebral angle; body mass index; pectoralis major; upper trapezius; forward head posture; Numeric Pain Rating Scale.

INTRODUCTION

Neck pain is among the most common musculoskeletal complaints worldwide and, after low back pain, the second most frequent spinal disorder in children and adolescents.¹ A 2024 analysis based on the Global Burden of Disease Study 2021 estimated that roughly 203 million people across 204 countries and territories had neck pain in 2020 an increase of more than three-quarters since 1990 although the age-standardised prevalence rate itself changed only marginally over that period.¹ Sex differences are well described: women tend to have smaller cervical musculature and comparatively less structural stability, which is thought to contribute to ligament laxity and joint instability, and women report neck pain more often than men, most commonly between 18 and 29 years and again between 40 and 49 years.^{2,3} Clinically, neck pain presents as tension, fatigue or discomfort in the neck that can radiate to the shoulder, arm and head.³ Postural change is one of the more consistent findings associated with neck

pain. Protracted shoulders and forward head posture occur more often in symptomatic than in asymptomatic individuals,⁴ and are thought to arise from altered length–tension relationships in the muscles linking the scapula, cervical spine and chest wall, which increase compressive and shear loading on the neck.^{4,5} People with neck pain also show altered activation and pain sensitivity in the axioscapular muscles compared with healthy controls.⁶

The craniovertebral angle (CVA) is the angle between a horizontal line through C7 and a line joining C7 to the tragus of the ear – a widely used photogrammetric proxy for forward head posture, with a smaller angle indicating a more forward-carried head.⁷ Because sedentary behaviour, prolonged screen use and reduced physical activity have become increasingly common among young adults, the postural changes associated with them, and the neck pain that follows, appear to be emerging earlier in life. Body composition may compound these postural changes. BMI is a crude measure of adiposity, but a higher BMI has been linked to uneven load distribution across the joints and to gradual shifts in posture and muscle coordination over time.⁸ Separately, shortening of the pectoralis major (PM) and upper trapezius (UT) muscles is a recognised feature of upper-body postural dysfunction: a tight pectoralis major draws the shoulders forward, and altered trapezius length affects cervical and scapular alignment, both of which can drive mechanical neck pain.⁹

Despite this evidence, BMI, CVA, PM length and UT length have rarely been studied together, in the same cohort, in relation to neck pain intensity; most work has treated them as separate lines of inquiry rather than as an interacting set of postural and anthropometric factors. Clarifying how these variables relate to one another, and to pain, could sharpen early identification of young adults at risk of postural neck disorders and help target physiotherapy more precisely. This study examined the correlation of BMI, CVA, PM length and UT length with neck pain intensity in college-going young adults.

MATERIALS AND METHODS

Study design and setting

This cross-sectional observational study was conducted among college students from local colleges and universities in Meerut, Uttar Pradesh, India, during the 2025–2026 academic year. An observational, single-time-point design was used because the aim was to describe associations between variables at one point in time rather than to test an intervention.

Participants

Participants were college students aged 18–25 years, recruited by simple random sampling. Based on standard sample-size guidance for correlation studies ($\alpha = 0.05$, power = 80%, expected $r = 0.25$), a minimum of approximately 100 participants was estimated; 96 met eligibility criteria and completed the study.

Inclusion criteria were: age 18–25 years; either sex; mild-to-moderate neck discomfort (NPRS score 1–6, excluding 0 and scores above 6); and willingness and ability to give written informed consent. Participants were excluded if they had a history of cervical spine fracture, trauma or surgery; a diagnosed neurological disorder affecting the cervical spine (e.g., radiculopathy, myelopathy); a congenital spinal deformity such as scoliosis or Klippel-Feil syndrome; an upper-limb or cervical injury within the preceding three months; a recent respiratory infection or acute systemic illness; or were unable or unwilling to provide consent.

Outcome measures

Body mass index was calculated as weight (kg) divided by height squared (m^2), using a digital weighing scale and a wall-mounted stadiometer. Participants were classified as underweight ($<18.5 \text{ kg}/m^2$), normal weight (18.5–24.9), overweight (25.0–29.9) or obese (≥ 30.0) according to World Health Organization cut-offs.

The craniovertebral angle was measured photogrammetrically using Kinovea, a freely available and validated motion-analysis software. A lateral photograph was taken of each participant in relaxed standing, at a standardised camera distance and orientation, and the angle was calculated between the horizontal plane and a line joining the C7 spinous process and the tragus of the ear; a smaller angle indicates greater forward head posture.

Pectoralis major length was assessed with the participant supine, as the distance from the olecranon process to the examination table with the shoulder in 90° abduction and the elbow extended. Upper trapezius length was assessed with the participant seated, as the distance from the mastoid process to the acromioclavicular joint with the head in neutral. Both measurements were taken bilaterally with a standard tape measure, repeated three times per side; the mean of the three readings was taken for each side, and the mean of the two sides was used in the analysis.

Neck pain intensity was rated on the 11-point Numeric Pain Rating Scale (0 = no pain, 10 = worst imaginable pain); only participants scoring 1–6 were eligible for inclusion.

Procedure

After written informed consent, each participant underwent, in sequence: registration and demographic data collection; NPRS rating; height and weight measurement; a standing lateral photograph for CVA; supine bilateral PM length measurement; and seated bilateral UT length measurement. All measurements were taken by the same trained assessor to limit inter-rater variability. The study was conducted in accordance with the Declaration of Helsinki; ethical clearance was obtained before data collection began, and data were collected and stored anonymously, with no personally identifying information included in the analysis or reporting.

Statistical analysis

Data were entered in Microsoft Excel Version 2021 and analysed using the same. Descriptive statistics i.e. mean, standard deviation, minimum, maximum and median were computed for all continuous variables. Normality of distribution was assessed with the Shapiro-Wilk test; because NPRS and BMI departed from a normal distribution, Spearman's rank-order correlation was used for all correlation analyses, with the threshold for significance set at $p < 0.05$ (two-tailed). Ninety-five percent confidence intervals for the correlation coefficients were estimated by bootstrapping with 1000 resamples.

RESULTS

Ninety-six participants completed the study (70 men [72.9%], 26 women [27.1%]; mean age 21.16 ± 1.81 years, range 18-25). Most participants (60, 62.5%) had a normal BMI; 20 (20.8%) were overweight, 9 (9.4%) underweight and 7 (7.3%) obese (Table 1).

Table 1 Demographic and anthropometric profile of participants (N = 96)

Characteristic	Value
Total participants	96
Men	70 (72.9%)
Women	26 (27.1%)
Age, years (mean $\pm$ SD, range)	21.16 ± 1.81 (18–25)
Normal weight (18.5–24.9 kg/m ²)	60 (62.5%)
Overweight (25.0–29.9 kg/m ²)	20 (20.8%)
Underweight (<18.5 kg/m ²)	9 (9.4%)
Obese (≥ 30.0 kg/m ²)	7 (7.3%)

Mean NPRS score was 2.95 ± 1.51 (median 3), with most participants scoring in the mild range (NPRS 1–3: 63 participants, 65.7%) and fewer in the moderate range (NPRS 4–6: 33 participants, 34.3%). Mean BMI was 23.40 ± 4.10 kg/m² (range 16.51–39.08), mean CVA was $45.82 \pm 7.30^\circ$ (range 30.20–67.20°), mean UT length was 21.86 ± 1.88 cm, and mean PM length was 5.38 ± 0.85 cm (Table 2).

Table 2 Descriptive statistics of study variables (N = 96)

Variable	Mean	SD	Minimum	Maximum	Median
Age (years)	21.16	1.81	18	25	21
NPRS score	2.95	1.51	1	6	3
BMI (kg/m ²)	23.40	4.10	16.51	39.08	22.62
CVA (degrees)	45.82	7.30	30.20	67.20	46.70
UT length, mean (cm)	21.86	1.88	17.10	26.35	21.88
PM length, mean (cm)	5.38	0.85	3.25	8.00	5.25

NPRS and BMI departed from a normal distribution on the Shapiro-Wilk test, whereas CVA, UT length and PM length did not (Table 3), confirming Spearman's correlation as the appropriate method for all subsequent analyses.

Table 3 Shapiro-Wilk normality test results

Variable	W statistic	p value	Distribution
NPRS	0.908	< 0.001	Non-normal
BMI (kg/m ²)	0.931	< 0.001	Non-normal
CVA (degrees)	0.989	0.612	Normal ($p > 0.05$)
UT length, mean (cm)	0.990	0.699	Normal ($p > 0.05$)
PM length, mean (cm)	0.978	0.098	Normal ($p > 0.05$)

PM length showed a statistically significant negative correlation with NPRS ($\rho = -0.210$, $p = 0.040$): participants with a shorter, tighter pectoralis major reported more neck pain. CVA ($\rho = -0.185$, $p = 0.071$) and UT length ($\rho = -0.195$, $p = 0.057$) showed negative correlations with NPRS that approached, but did not reach, conventional significance. BMI was not significantly correlated with NPRS ($\rho = +0.151$, $p = 0.143$) (Table 4).

Table 4 Spearman correlation of BMI, CVA, UT length and PM length with neck pain intensity (NPRS)

Variable	Spearman ρ	p value	95% CI (low, high)
BMI (kg/m ²)	+0.151	0.143	-0.054, +0.349
CVA (degrees)	-0.185	0.071	-0.383, +0.023
UT length, mean (cm)	-0.195	0.057	-0.389, +0.012
PM length, mean (cm)	-0.210*	0.040	-0.401, -0.011

* $p < 0.05$.

The inter-correlation matrix (Table 5) showed that BMI was significantly associated with CVA ($\rho = -0.483$, $p < 0.001$) and with PM length ($\rho = +0.376$, $p < 0.001$), and that CVA and UT length were also significantly associated ($\rho = +0.223$, $p < 0.05$). No other inter-variable correlation reached significance.

Table 5 Inter-correlation matrix of all study variables

Variable	NPRS	BMI	CVA	UT mean	PM mean
NPRS	1.000	+0.151	-0.185	-0.195	-0.210*
BMI	+0.151	1.000	-0.483**	-0.168	+0.376**
CVA	-0.185	-0.483**	1.000	+0.223*	-0.041
UT mean	-0.195	-0.168	+0.223*	1.000	+0.148
PM mean	-0.210*	+0.376**	-0.041	+0.148	1.000

* $p < 0.05$; ** $p < 0.01$. UT = upper trapezius; PM = pectoralis major.

DISCUSSION

This cross-sectional study examined how BMI, CVA, PM length and UT length relate to neck pain intensity in 96 young adults, and found that pectoralis major length was the only one of the four variables independently and significantly associated with pain.

The negative correlation between PM length and NPRS ($\rho = -0.210$, $p = 0.040$) indicates that participants with tighter pectoralis major muscles reported more pain. A shortened pectoralis major rolls the shoulders forward and encourages compensatory cervical extension, increasing load on the posterior cervical structures a mechanism widely implicated in mechanical neck pain and consistent with the broader literature on upper-crossed postural dysfunction, in which tightness of the pectoralis major and minor combines with weakness of the deep neck flexors and lower trapezius to produce forward head posture and cervical strain.^{9,22} This finding supports pectoralis major stretching as a targeted intervention for young adults with neck pain, rather than treatment directed at the cervical spine in isolation.

CVA showed a negative trend with NPRS that did not reach significance ($\rho = -0.185$, $p = 0.071$). This is broadly consistent with earlier work linking a reduced CVA greater forward head posture to neck pain and disability,^{12,13,19} although several of those studies were conducted in older or office-working samples, in which postural loading accumulates over a working day; the younger, more physically active sample studied here, together with the single-time-point design, may partly explain the weaker association observed. Even so, the direction and near-significance of the trend support continued clinical attention to postural correction such as chin-tuck exercises and deep cervical flexor training as part of neck pain management in this age group.

UT length also showed a marginal negative correlation with NPRS ($\rho = -0.195$, $p = 0.057$). A shortened or hypertonic upper trapezius contributes to cervical tension and altered scapular movement, both of which can heighten pain, and the upper trapezius has previously been identified as one of the muscles most consistently affected by forward head posture.¹⁰ Although the correlation observed here did not reach statistical significance, the finding is biologically plausible and, together with the CVA trend, points toward a shared postural mechanism connecting head position and cervical muscle length to pain.

BMI was not directly associated with neck pain intensity ($\rho = +0.151$, $p = 0.143$), which at first appears to sit at odds with reports of BMI as a risk factor for musculoskeletal and neck pain.^{8,17} The inter-correlations observed here, however, point to an indirect pathway: BMI was strongly associated with CVA ($\rho = -0.483$, $p < 0.001$) and

with PM length ($p = +0.376$, $p < 0.001$), consistent with photogrammetric evidence that a higher body mass shifts the gravitational line anteriorly and produces a compensatory forward head posture.¹¹ The relatively young, largely normal-weight sample studied here (62.5% normal weight; mean BMI 23.40 kg/m²) may partly explain why a direct BMI–pain association did not emerge; such an association might be more apparent in a sample with a greater proportion of overweight or obese participants.

The inter-correlation between CVA and UT length ($p = +0.223$, $p < 0.05$) is also notable: better cervical alignment was associated with greater upper trapezius length, consistent with the known biomechanical link between head position and cervical musculature, and reinforces evaluating these variables together rather than in isolation.¹⁰ This is broadly consistent with photogrammetric work in younger populations reporting an association between reduced postural angles and self-reported neck and shoulder pain.²³

Together, these findings suggest a network of postural and muscular factors around neck pain in young adults rather than a single dominant cause. From a physiotherapy standpoint, pectoralis major stretching appears to warrant priority given its significant association with pain, while postural correction targeting CVA and upper trapezius length remain reasonable adjuncts despite falling short of significance. Because BMI appears to act on neck pain indirectly, weight management may be a useful preventive measure alongside, rather than instead of, direct musculoskeletal treatment.

Limitations

This study has several limitations. Its cross-sectional design cannot establish causality or the temporal sequence between the variables measured. Data were collected at a single site among college students, which may limit generalisability to other populations and settings. BMI does not distinguish fat mass from lean mass, limiting what it can indicate about body composition specifically. Tape-based measurement of PM and UT length is likely to involve greater measurement variability than three-dimensional motion analysis. The sample skewed male (72.9%), which may limit generalisability to women, who tend to report more neck pain. Finally, potential confounders such as sleep quality, smartphone use and psychological stress were not measured and may have influenced the associations observed.

CONCLUSION

In this sample of 96 young adults with mild-to-moderate neck pain, pectoralis major length was the only variable independently and significantly associated with pain intensity, while craniovertebral angle and upper trapezius length showed marginal trends in the same direction. BMI was not directly associated with neck pain but was significantly linked to both craniovertebral angle and pectoralis major length, suggesting that it contributes to neck pain indirectly, through posture and muscle length, rather than as a standalone risk factor. These findings support a multimodal physiotherapy approach for neck pain in young adults one that prioritises pectoralis major stretching and includes postural correction and upper trapezius lengthening and point to BMI management as a plausible, if indirect, preventive strategy. Larger, longitudinal and multivariate studies are needed to confirm these relationships and clarify their direction.

Declarations

Ethics approval and consent to participate: The study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from Institutional Ethics Committee prior to data collection. Written informed consent was obtained from all participants.

Availability of data and materials: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare no competing interests.

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