

Impact of Screen Time and Cervical Biomechanics on Neck Disability Index among Healthcare Students: A Cross-Sectional Study with Biomechanical Validation

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Abstract:

➤ Background:

Nowadays, smartphones and digital screens have become a regular part of study life for nursing, physiotherapy, and allied health students. Reading PDF notes and watching lectures on mobile phones for long hours often makes students bend their necks forward without noticing it. Although this problem is commonly called text neck syndrome, it is still unclear whether neck disability comes mainly from total daily screen hours or from the actual physical load placed on the neck due to faulty sitting postures.

➤ Objectives:

This study aimed to find the prevalence of self-reported neck disability among healthcare students in Kuppam, measure their daily screen time from smartphone tracking logs, calculate their physical neck tension in natural study postures, and find a safe diagnostic cut-off value for cervical spine loading.

➤ Materials and Methods:

A descriptive cross-sectional study with biomechanical validation was conducted among 428 undergraduate students from nursing, physiotherapy, and allied health science colleges in Kuppam, Chittoor District, Andhra Pradesh, selected by convenient sampling. Data were collected using four tools: a socio-demographic and anthropometric sheet, the 10-item Neck Disability Index (NDI) questionnaire, 7-day average daily screen time recorded directly from Android Digital Wellbeing or iOS Screen Time settings, and physical neck ergonomics measurements. Active neck flexion angle (θ) was measured with a calibrated smartphone inclinometer, lever arm length (L) was measured from the C7 spinous process to the head center of gravity, and cervical tension (T) was calculated using the formula $T = W_{\text{head}} \times L \times \sin(\theta)$, taking head weight as 8 percent of body weight. Data were analyzed in SPSS Version 23 using Spearman's rank correlation, Kruskal-Wallis H test, Chi-Square test, Fisher's Exact test, and Receiver Operating Characteristic (ROC) curve analysis.

➤ Results:

Most participants were female (91.6 percent) and studying B.Sc. Nursing (64.5 percent). The average daily screen time was 391.08 ± 72.07 minutes (around 6.5 hours per day; median 387.36 minutes). Overall, 60.3 percent (258 out of 428 students) had some degree of neck disability on the NDI scale: 18.2 percent had mild disability, 16.6 percent had moderate disability, 20.3 percent had severe disability, and 5.1 percent had complete disability. Spearman's correlation showed a statistically significant positive correlation between calculated cervical tension and NDI score ($r = 0.136$, $p = 0.005$), whereas daily screen time alone had no significant correlation with NDI score ($r = -0.026$, $p = 0.596$). Neck disability

differed significantly across study postures (Kruskal-Wallis $\chi^2 = 79.424$, $p < 0.001$); students sitting cross-legged on the floor had the highest rate of severe disability (52.6 percent), while those changing postures frequently had the highest comfort (81.8 percent no disability). Course of study ($p < 0.001$), academic year ($p = 0.008$), and residential background ($p < 0.001$) were significantly associated with NDI severity, and gender was associated with cervical tension level ($p = 0.017$). ROC curve analysis confirmed that the cervical tension formula significantly separated symptomatic from asymptomatic students (AUC = 0.580, $p = 0.006$), giving an optimal cut-off value of 0.24 kg·m (sensitivity 42.8 percent, specificity 70.6 percent).

➤ Conclusion:

More than three-fifths of healthcare students suffer from functional neck disability, mainly due to poor sitting posture—especially sitting on the floor—rather than total screen hours alone. Keeping cervical tension below 0.24 kg·m through proper desk and chair support, eye-level mobile stands, and regular posture breaks is essential to protect the spine health of future healthcare workers.

Keywords: Text Neck Syndrome; Neck Disability Index (NDI); Screen Time; Cervical Tension; Study Posture; Healthcare Students; Dorothea Orem Self-Care Deficit Theory.

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I. INTRODUCTION

Over the last fifteen years, mobile phones and digital screens have completely changed how college students read, communicate, and prepare for exams. In India, low-cost mobile data and affordable smartphones have made digital learning an everyday habit for young adults [1, 2]. After the COVID-19 pandemic, most medical, nursing, and allied health colleges shifted their study materials to PDF textbooks, recorded video lectures, online tests, and WhatsApp study groups [3, 4]. While these digital tools make learning convenient, they also keep students sitting in one place for long hours with their heads bent downward toward a small screen [4, 5].

The human cervical spine is made up of seven small vertebrae (C1 to C7), intervertebral discs, and supporting muscles and ligaments that carry the weight of the head [1]. In a normal upright position, the ears stay in line with the shoulders and the natural inward curve of the neck (cervical lordosis) balances the head with very little muscular effort. In this neutral posture, an adult head weighs around 4.5 to 5.5 kg (10 to 12 pounds) [1]. However, when a student bends the neck forward to look at a phone kept on the lap, bed, or floor, the center of gravity of the head shifts forward away from the spine. As shown in the surgical biomechanics model by Hansraj [1], the effective weight pulling on the cervical spine rises sharply as the neck flexion angle increases: at 15 degrees of forward tilt the load becomes about 12.2 kg (27 pounds), at 30 degrees it reaches 18.1 kg (40 pounds), at 45 degrees it rises to 22.2 kg (49 pounds), and at 60 degrees the neck has to bear nearly 27.2 kg (60 pounds) of force [1].

When this forward head posture—commonly called "Text Neck Syndrome"—is held for hours, the muscles at the back of the neck and upper shoulder, such as the upper trapezius, splenius capitis, and levator scapulae, have to stay tightened continuously to stop the head from dropping

forward [1, 6, 7]. At the same time, the deep cervical flexor muscles become weak and tired. Over time, this constant muscle tension reduces local blood supply, builds up lactic acid, and causes aching neck pain, stiffness, frequent headaches, and early wear and tear of the cervical discs [8, 9, 10]. To measure how much this neck pain disturbs daily life, Vernon and Mior developed the Neck Disability Index (NDI), a 10-item clinical scale covering pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation [2, 11].

Healthcare students—especially those in nursing, physiotherapy, and allied health sciences—face a double physical load on their necks [3, 4, 12]. On the academic side, they spend 6 to 7 hours daily reading heavy subjects, writing care plans, and preparing assignments on mobile phones. On the clinical side, they spend long hours standing in hospital wards, intensive care units, and operation theatres, where they have to bend forward over patient beds to insert intravenous cannulas, dress wounds, check vital signs, and write patient charts [3, 12]. In addition, many students living in rural or semi-urban hostels do not have proper study tables or chairs and end up studying cross-legged on the floor or lying on beds [4, 5].

➤ Need for the Study and Theoretical Framework

Although several Indian and international studies have reported that 45 to 70 percent of medical and nursing students suffer from neck pain [3, 4, 5, 6], most earlier surveys relied only on self-reported screen time estimates and pain questionnaires. Self-reported screen hours are often inaccurate, and questionnaires alone do not measure the actual mechanical torque acting on the student's neck during study hours. There is very limited Indian data combining objective smartphone screen tracking logs (such as Android Digital Wellbeing and iOS Screen Time) with direct physical measurement of neck flexion angle, lever arm length, and calculated cervical tension.

To connect these physical measurements with nursing care, the present study was guided by Dorothea Orem's Self-Care Deficit Nursing Theory (1971) [13]. In this model, 'Self-Care Agency' represents the student's awareness, posture habits, and lifestyle choices. 'Therapeutic Self-Care Demand' represents the physical strain placed on the neck by daily screen use, study posture, neck flexion angle, and lever arm distance. When the physical neck tension crosses what the neck muscles can safely support, a 'Self-Care Deficit' develops, which shows up clinically as functional disability on the Neck Disability Index (NDI). Finding an exact biomechanical cut-off value for cervical tension allows nursing educators and college administrators to set up a 'Supportive-Educative Nursing System'—teaching students safe reading postures and improving hostel study furniture before permanent spinal problems set in.

➤ Objectives of the Study

- To determine the prevalence of self-reported musculoskeletal neck symptoms and functional disability among healthcare students in Kuppam using the Neck Disability Index (NDI).
- To measure the average daily screen time of healthcare students using objective smartphone tracking logs.
- To assess the neck ergonomics of healthcare students, including typical study posture, neck flexion angle, lever arm length, and calculated cervical tension.
- To evaluate the relationship of screen time and cervical biomechanics with Neck Disability Index scores and determine a diagnostic cut-off threshold for cervical tension using Receiver Operating Characteristic (ROC) curve analysis.

II. MATERIALS AND METHODS

➤ Study Design, Setting, and Population

A quantitative approach with a descriptive cross-sectional study design and biomechanical validation was carried out across professional healthcare colleges on the PES campus in Kuppam, Chittoor District, Andhra Pradesh, India. The participating institutions included the PES College of Nursing, PES College of Physiotherapy, and PES College of Allied Health Sciences (AHS). The target population comprised undergraduate students enrolled across the first, second, third, fourth, and fifth year (internship) batches of these courses.

➤ Sample Size Estimation and Sampling Technique

The minimum sample size was calculated using Cochran's single-proportion formula, $n = Z^2 \times P(1 - P) / d^2$, taking an expected neck pain prevalence (P) of 54 percent (0.54) from a previous study on nursing students by Mahmoud et al. [3], at a 95 percent confidence level ($Z = 1.96$) and 5 percent margin of error ($d = 0.05$). This gave a base sample size of 382 students. After adding a 10 percent adjustment for possible incomplete entries ($n_{adj} = 382 / (1 - 0.10) = 425$), the minimum required sample was 425. Using a non-probability convenient sampling technique, a final total of 428 eligible undergraduate healthcare students were enrolled and completed all assessments.

➤ Inclusion and Exclusion Criteria

Undergraduate students from Nursing, Physiotherapy, and Allied Health Sciences (1st year to internship) who owned a personal smartphone with built-in screen tracking (Digital Wellbeing on Android or Screen Time on iOS) and gave written informed consent were included in the study. Students with a known history of cervical spine fracture, congenital spinal deformity, or previous neck surgery, as well as those with acute accidental neck injury during the week of data collection, were excluded.

➤ Data Collection Tools and Biomechanical Measurement Protocol

Data were gathered using a structured four-part instrument validated by faculty experts from Community Medicine, Medical-Surgical Nursing, and Community Health Nursing:

- Section A — Socio-Demographic and Anthropometric Profile: Collected baseline details including age, gender, course of study, academic year, residential locality (urban, rural, or semi-urban town), father's and mother's occupation, type of mobile phone, daily mobile internet data pack, home Wi-Fi availability, and regular weekly exercise habit. Height (cm) and weight (kg) were measured using a calibrated stadiometer and digital weighing scale to compute Body Mass Index (BMI). Participants also reported their most common study posture: Desk and Chair, Bed (lying or reclining), Floor (sitting cross-legged), Couch, or Variable (changing positions often).
- Section B — Neck Disability Index (NDI): Functional limitation due to neck pain was assessed using the standardized 10-item Neck Disability Index developed by Vernon and Mior [2]. It covers 10 daily activities: Pain Intensity, Personal Care, Lifting, Reading, Headaches, Concentration, Work, Driving, Sleeping, and Recreation. Each item is scored from 0 (no pain or limitation) to 5 (worst pain or complete inability), giving a total score out of 50 (converted to 0–100 percent). Standard cut-offs were used: 0–4 points (0–8 percent) = No Disability; 5–14 points (10–28 percent) = Mild Disability; 15–24 points (30–48 percent) = Moderate Disability; 25–34 points (50–64 percent) = Severe Disability; and 35–50 points (70–100 percent) = Complete Disability [2]. The NDI has high internal consistency (Cronbach's $\alpha > 0.70$) in student populations [2, 11].
- Section C — Objective Screen Time Assessment: Instead of asking students to guess their phone usage, the investigators checked each student's built-in smartphone dashboard (Digital Wellbeing on Android phones or Screen Time on iPhones) and recorded the exact daily usage over the past 7 days to compute the average daily screen time in minutes.
- Section D — Neck Ergonomics and Biomechanical Tension Calculation: Each student was asked to sit in their usual study posture while holding their phone naturally. Three physical values were recorded: (1) Neck Flexion Angle (θ , in degrees), measured by placing a calibrated smartphone digital inclinometer along the cervical spine; (2) Lever Arm Length (L, in cm and converted to meters), measured with a flexible measuring

tape as the horizontal distance from the prominent spinous process of the seventh cervical vertebra (C7) to the center of gravity of the head; and (3) Estimated Head Weight (W_{head} , in kg), calculated as 8 percent of the student's measured body weight ($0.08 \times \text{body weight}$). Physical cervical tension (T , in kilogram-meters, kg·m) was then calculated using the trigonometric torque equation:

- Biomechanical Cervical Tension Formula: $T = W_{\text{head}} \times L \times \sin(\theta)$, where T is Cervical Tension in kilogram-meters (kg·m), W_{head} is estimated head weight ($0.08 \times \text{total body weight in kg}$), L is horizontal lever arm distance from the C7 spinous process to the head center of gravity (in meters), and θ is the active neck flexion angle (in degrees).

➤ Ethical Considerations and Data Collection Procedure

Formal ethical approval was obtained from the Institutional Human Ethics Committee of PES Institute of Medical Sciences and Research (PESIMSR), Kuppam (Proposal No.: PESIMSR/HEC/198-25; Certificate No.: PESIMSR/HEC/C-198/2025, dated 30/12/2025). Administrative permissions were taken from the Principals of the Nursing, Physiotherapy, and Allied Health Sciences colleges. After explaining the procedure in simple language during free lecture hours, written informed consent was obtained from all 428 participants. Each assessment took about 15 minutes per student, and all records were kept strictly confidential.

➤ Statistical Analysis

Data were coded in Microsoft Excel and analyzed using IBM SPSS Statistics Version 23.0. Descriptive statistics (frequency, percentage, mean, standard deviation, median, and interquartile range [IQR]) were used to summarize demographic and clinical variables. The Shapiro-Wilk test showed that continuous variables departed significantly from a normal distribution ($p < 0.05$). Therefore, non-parametric tests were applied: Spearman's rank correlation coefficient (r) was used to test correlations between screen time, cervical tension, and NDI scores; the Kruskal-Wallis H test was used to compare NDI distributions across study postures; and Pearson's Chi-Square test (or Fisher's Exact test when expected cell counts

were < 5) was used for categorical associations. Receiver Operating Characteristic (ROC) curve analysis and Youden's Index ($J = \text{Sensitivity} + \text{Specificity} - 1$) [14] were used to validate the cervical tension formula and find the best diagnostic cut-off value. A p -value < 0.05 was taken as statistically significant.

III. RESULTS

➤ Socio-Demographic, Digital Access, and Anthropometric Profile

Out of the 428 undergraduate healthcare students evaluated, 236 (55.10 percent) were aged 20 years or below and 192 (44.90 percent) were above 20 years. Female students made up 91.60 percent ($n = 392$) of the sample, while male students accounted for 8.40 percent ($n = 36$), which reflects the usual gender enrollment in Indian nursing and allied health colleges. Course-wise, nearly two-thirds were from B.Sc. Nursing (64.50 percent, $n = 276$), followed by Allied Health Sciences (22.20 percent, $n = 95$) and Physiotherapy (13.30 percent, $n = 57$). First-year students formed the largest batch (36.70 percent), followed by third-year (24.30 percent), fourth-year (18.50 percent), second-year (15.20 percent), and fifth-year/internship students (5.40 percent). Nearly half of the students came from semi-urban towns (46.50 percent), 31.30 percent from rural villages, and 22.20 percent from urban cities.

Regarding family occupation, fathers were mostly self-employed or in business (35.00 percent), farmers or agricultural workers (34.60 percent), or salaried employees (29.70 percent), while most mothers were homemakers (72.20 percent). Almost all students (94.60 percent, $n = 405$) used a smartphone as their main mobile device. Two-thirds (66.80 percent) used a 1.5 GB daily mobile data pack, and 88.60 percent ($n = 379$) did not have Wi-Fi at their residence or hostel, meaning they relied heavily on mobile phone screens rather than desktop computers for internet study. On BMI assessment, 60.70 percent had a healthy weight, 26.90 percent were underweight, 10.50 percent were overweight, and 1.90 percent had obesity. Notably, 81.80 percent ($n = 350$) of the students did not do any regular weekly physical exercise (Table 1).

Table 1 Frequency and Percentage Distribution of Socio-Demographic and Anthropometric Profile of Healthcare Students (N = 428)

Socio-Demographic / Anthropometric Variable	Frequency (n)	Percentage (%)
Age Category		
≤ 20 Years	236	55.10%
> 20 Years	192	44.90%
Gender		
Male	36	8.40%
Female	392	91.60%
Healthcare Course		
Nursing	276	64.50%
Physiotherapy	57	13.30%
Allied Health Sciences (AHS)	95	22.20%
Academic Year		
1st Year	157	36.70%
2nd Year	65	15.20%
3rd Year	104	24.30%

Socio-Demographic / Anthropometric Variable	Frequency (n)	Percentage (%)
4th Year	79	18.50%
5th Year or Internship	23	5.40%
Residential Background		
Urban (City)	95	22.20%
Rural (Village)	134	31.30%
Semi-urban (Town)	199	46.50%
Father's Occupation		
Salaried Employee (Govt / Private)	127	29.70%
Self-employed / Business	150	35.00%
Farmer / Agricultural Worker	148	34.60%
Retired / Unemployed	3	0.70%
Mother's Occupation		
Homemaker	309	72.20%
Salaried Employee (Govt / Private)	47	11.00%
Self-employed / Business	34	7.90%
Farmer / Agricultural Worker	34	7.90%
Retired / Unemployed	4	0.90%
Primary Mobile Device		
Smartphone	405	94.60%
Feature Phone	9	2.10%
Both	14	3.30%
Daily Internet Data Package		
1 GB or Less	34	7.90%
1.5 GB	286	66.80%
2 GB	78	18.20%
More than 2 GB	30	7.00%
Residential Wi-Fi Access		
Yes	49	11.40%
No	379	88.60%
Body Mass Index (BMI) Classification		
Underweight	115	26.90%
Healthy Weight	260	60.70%
Overweight	45	10.50%
Obesity	8	1.90%
Regular Physical Activity		
No	350	81.80%
Yes	78	18.20%

- Note: Data are presented as frequency (n) and percentage (%) of the total sample (N = 428).

➤ **Daily Screen Time Exposure and Typical Study Postures**

Objective smartphone screen logs from the preceding 7 days showed a high level of daily screen exposure across the student cohort. The mean daily screen time was 391.08 ± 72.07 minutes (approximately 6.5 hours per day), and the median daily screen time was 387.36 minutes (around 6.45

hours), with an interquartile range (IQR) of 346.07 to 437.39 minutes. Regarding typical study posture, 308 students (72.00 percent) reported using a Desk and Chair setup. However, the remaining 28.00 percent studied in non-neutral positions: 57 students (13.30 percent) routinely sat cross-legged on the Floor, 46 (10.70 percent) studied while lying or reclining on a Bed, 11 (2.60 percent) used a Variable posture by changing positions frequently, and 6 (1.40 percent) sat or reclined on a Couch (Table 2).

Table 2 Descriptive Analysis of Objective Average Daily Screen Time and Typical Study Postures Among Healthcare Students (N = 428)

Behavioral Variable	Statistical Metric / Posture Category	Value / Frequency (n)	Percentage (%) / Spread
Objective Average Daily Screen Time (minutes/day)			
Parametric Summary	Mean $\pm$ SD	391.08 ± 72.07 min	Clustered (~6.52 hrs/day)
Non-Parametric Summary	Median (IQR)	387.36 min	IQR: 346.07 – 437.39 min

Typical Study Posture (N = 428)			
A) Desk & Chair	Standard Seated	308	72.00%
B) Bed (Lying / Reclining)	Recumbent / Semi-Fowler	46	10.70%
C) Floor (Cross-legged)	Unsupported Floor Sitting	57	13.30%
D) Couch (Reclining / Sitting)	Soft Upholstered Seating	6	1.40%
E) Variable (Changes Frequently)	Dynamic Posture Shifting	11	2.60%

- *Note: Screen time was recorded directly from built-in smartphone utilities (Android Digital Wellbeing / iOS Screen Time). SD = Standard Deviation; IQR = Interquartile Range.*

➤ **Prevalence of Functional Neck Disability and Cervical Tension Levels**

Evaluation of the Neck Disability Index (NDI) scores revealed a high prevalence of functional neck disability among the healthcare trainees. While 170 students (39.70 percent) had No Disability (0–8 percent score), a clear

majority of 258 students (60.30 percent) experienced measurable functional neck disability. Specifically, 78 students (18.20 percent) had Mild Disability, 71 (16.60 percent) had Moderate Disability, 87 (20.30 percent) suffered from Severe Disability, and 22 (5.10 percent) fell into the Complete Disability category. On biomechanical calculation of cervical tension ($T = W_{\text{head}} \times L \times \sin(\theta)$), 415 students (97.00 percent) fell within the Mild Tension category, while 13 students (3.00 percent) had higher mechanical loads classified as Moderate Tension (Table 3).

Table 3 Frequency and Percentage Distribution of Neck Disability Index (NDI) Categories and Calculated Cervical Tension Categories (N = 428)

Clinical / Biomechanical Parameter	Severity Category	Frequency (n)	Percentage (%)
Level of Functional Disability (Neck Disability Index, NDI)			
No Disability (0–4 points)	0–8% Disability	170	39.70%
Mild Disability (5–14 points)	10–28% Disability	78	18.20%
Moderate Disability (15–24 points)	30–48% Disability	71	16.60%
Severe Disability (25–34 points)	50–64% Disability	87	20.30%
Complete Disability (35–50 points)	70–100% Disability	22	5.10%
Total Symptomatic Neck Disability (Mild to Complete)	≥ 10% Disability	258	60.30%
Calculated Cervical Tension Category ($T = W_{\text{head}} \times L \times \sin(\theta)$)			
Mild Cervical Tension	Low-to-Baseline Torque	415	97.00%
Moderate Cervical Tension	Elevated Torque Load	13	3.00%

- *Note: Overall prevalence of functional neck disability (NDI score ≥ 5 points) was 60.30% (n = 258).*

➤ **Correlation Between Screen Time, Cervical Tension, and Neck Disability Scores**

Spearman's rank correlation (r) was used to test whether neck disability was driven more by daily screen duration or by physical neck tension (Table 4). There was a statistically highly significant positive correlation between calculated cervical tension (kg·m) and total NDI disability

score ($r = 0.136$, $p = 0.005$). This confirms that as the mechanical torque on the neck rises due to forward head bending and lever arm distance, the student's functional neck disability increases significantly. In contrast, average daily screen time showed no significant correlation with NDI disability score ($r = -0.026$, $p = 0.596$) and no significant correlation with cervical tension ($r = -0.044$, $p = 0.367$). In simple terms, how a student holds their neck while studying matters much more for neck injury than the total number of minutes spent on the phone.

Table 4 Spearman's Rank Correlation (r) Between Average Daily Screen Time, Calculated Cervical Tension (kg·m), and Total Neck Disability Index Scores (N = 428)

Variable	Statistical Metric	Average Daily Screen Time (min)	Disability Score (NDI)	Cervical Tension (kg·m)
Average Daily Screen Time (min)	Spearman's rho (r)	1.000	-0.026	-0.044
	Sig. (2-tailed) p-value	—	0.596 (NS)	0.367 (NS)
Disability Score (NDI)	Spearman's rho (r)	-0.026	1.000	0.136**
	Sig. (2-tailed) p-value	0.596 (NS)	—	0.005**
Cervical Tension (kg·m)	Spearman's rho (r)	-0.044	0.136**	1.000
	Sig. (2-tailed) p-value	0.367 (NS)	0.005**	—

- *Note: **Correlation is statistically highly significant at the $p < 0.01$ level (2-tailed). NS = Not Significant.*

➤ *Comparison of Neck Disability Across Typical Study Postures*

Comparison of NDI disability distributions across the five typical study postures using the Kruskal-Wallis H test showed a highly significant difference ($\chi^2 = 79.424$, $p < 0.001$; Table 5). Students who habitually studied sitting cross-legged on the Floor ($n = 57$) had the worst neck disability: more than half of them (52.60 percent, $n = 30$) suffered from Severe Disability and another 7.00 percent ($n = 4$) had Complete Disability, while only 28.10 percent were pain-free. When sitting on the floor without a desk, students usually place their phone or book on their lap or on the

ground, which forces the neck into a sharp downward bend for hours.

Among the 308 students using a Desk and Chair, 35.70 percent had No Disability, 20.50 percent had Mild Disability, 20.80 percent had Moderate Disability, 17.50 percent had Severe Disability, and 5.50 percent had Complete Disability. On the other hand, students who used Variable postures by changing their sitting position often ($n = 11$) had the highest comfort rate, with 81.80 percent reporting No Disability and 0.00 percent reporting moderate, severe, or complete disability. Similarly, 67.40 percent of students who studied on a Bed ($n = 46$) had No Disability, likely because pillows or mattress support reduced the gravitational pull on the neck muscles.

Table 5 Comparison of Neck Disability Index (NDI) Severity Categories Across Typical Study Postures (N = 428)

Typical Study Posture	No Disability n (%)	Mild Disability n (%)	Moderate Disability n (%)	Severe Disability n (%)	Complete Disability n (%)	Total Cohort N (%)
A) Desk & Chair	110 (35.70%)	63 (20.50%)	64 (20.80%)	54 (17.50%)	17 (5.50%)	308 (100.0%)
B) Bed (Lying/Reclining)	31 (67.40%)	9 (19.60%)	3 (6.50%)	3 (6.50%)	0 (0.00%)	46 (100.0%)
C) Floor (Cross- legged)	16 (28.10%)	3 (5.30%)	4 (7.00%)	30 (52.60%)*	4 (7.00%)	57 (100.0%)
D) Couch	4 (66.70%)	1 (16.70%)	0 (0.00%)	0 (0.00%)	1 (16.70%)	6 (100.0%)
E) Variable	9 (81.80%)	2 (18.20%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	11 (100.0%)
Total Sample	170 (39.70%)	78 (18.20%)	71 (16.60%)	87 (20.30%)	22 (5.10%)	428 (100.0%)

- *Note: Kruskal-Wallis H test across study posture categories: $\chi^2 = 79.424$, $p < 0.001$ * (Statistically highly significant).*

➤ *Association of Demographic Variables with Cervical Tension and Neck Disability*

Table 6 presents the association between demographic variables and calculated cervical tension categories. Gender showed a statistically significant association with cervical

tension ($\chi^2 = 8.700$, Fisher's Exact $p = 0.017$), where 11.10 percent of male students fell into the Moderate Tension group compared to only 2.30 percent of female students. This is mainly because male students generally have higher body weight and longer neck lever arms, which increases calculated torque in the formula $T = W_{\text{head}} \times L \times \sin(\theta)$. Healthcare course ($p = 0.350$), academic year ($p = 0.851$), and residential background ($p = 0.240$) showed no significant association with cervical tension categories.

Table 6 Association of Categorical Demographic Variables with Calculated Cervical Tension Classifications (N = 428)

Demographic Variable	Category	Mild Tension n (%)	Moderate Tension n (%)	Chi-Square (χ^2)	p-value
Gender	A) Male ($n = 36$)	32 (88.9%)	4 (11.1%)	8.700	0.017* (Fisher's Exact)
	B) Female ($n = 392$)	383 (97.7%)	9 (2.3%)		
Healthcare Course	A) Nursing ($n = 276$)	270 (97.8%)	6 (2.2%)	2.101	0.350 (NS)
	B) Physiotherapy ($n = 57$)	54 (94.7%)	3 (5.3%)		
	C) Allied Health (AHS) ($n = 95$)	91 (95.8%)	4 (4.2%)		
Academic Year	A) 1st Year ($n = 157$)	152 (96.8%)	5 (3.2%)	1.358	0.851 (NS)
	B) 2nd Year ($n = 65$)	62 (95.4%)	3 (4.6%)		
	C) 3rd Year ($n = 104$)	101 (97.1%)	3 (2.9%)		
	D) 4th Year ($n = 79$)	77 (97.5%)	2 (2.5%)		
	E) 5th Year / Intern ($n = 23$)	23 (100.0%)	0 (0.0%)		
Residential Background	A) Urban (City) ($n = 95$)	93 (97.9%)	2 (2.1%)	2.857	0.240 (NS)
	B) Rural (Village) ($n = 134$)	132 (98.5%)	2 (1.5%)		
	C) Semi-urban (Town) ($n = 199$)	190 (95.5%)	9 (4.5%)		

- *Note: *Statistically significant at $p < 0.05$. NS = Not Significant.*

When demographic variables were tested against functional Neck Disability Index (NDI) classifications (Table 7), three variables showed statistically significant associations: Healthcare Course ($\chi^2 = 27.096$, $p < 0.001$), Academic Year ($\chi^2 = 32.657$, $p = 0.008$), and Residential Background ($\chi^2 = 149.136$, $p < 0.001$), whereas Gender was not statistically significant ($p = 0.066$). Nursing students had the highest burden of neck disability (only 32.60 percent had No Disability, while 23.20 percent had Severe Disability

and 5.80 percent had Complete Disability), whereas Physiotherapy students had the highest proportion of pain-free necks (63.20 percent No Disability). Across academic batches, disability increased with seniority: 5th-year interns had the highest rate of Severe Disability (34.80 percent), while 1st-year students had the highest rate of No Disability (48.40 percent). By residence, students from semi-urban towns showed a much higher rate of Severe Disability (37.70 percent) and Moderate Disability (27.60 percent) compared to urban (63.20 percent No Disability) and rural students (58.20 percent No Disability).

Table 7 Association of Categorical Demographic Variables with Neck Disability Index (NDI) Classifications (N = 428)

Demographic Variable & Category	No Disab. n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Complete n (%)	χ^2 (p-value)
Gender						8.795 (p = 0.066 NS)
A) Male (n = 36)	21 (58.3%)	7 (19.4%)	1 (2.8%)	5 (13.9%)	2 (5.6%)	—
B) Female (n = 392)	149 (38.0%)	71 (18.1%)	70 (17.9%)	82 (20.9%)	20 (5.1%)	—
Healthcare Course						27.096 (p < 0.001*)
A) Nursing (n = 276)	90 (32.6%)	52 (18.8%)	54 (19.6%)	64 (23.2%)*	16 (5.8%)	Significant
B) Physiotherapy (n = 57)	36 (63.2%)	10 (17.5%)	3 (5.3%)	4 (7.0%)	4 (7.0%)	
C) Allied Health (AHS) (n = 95)	44 (46.3%)	16 (16.8%)	14 (14.7%)	19 (20.0%)	2 (2.1%)	
Academic Year						32.657 (p = 0.008*)
A) 1st Year (n = 157)	76 (48.4%)	24 (15.3%)	20 (12.7%)	25 (15.9%)	12 (7.6%)	Significant
B) 2nd Year (n = 65)	24 (36.9%)	17 (26.2%)	10 (15.4%)	13 (20.0%)	1 (1.5%)	
C) 3rd Year (n = 104)	44 (42.3%)	19 (18.3%)	17 (16.3%)	23 (22.1%)	1 (1.0%)	
D) 4th Year (n = 79)	21 (26.6%)	12 (15.2%)	21 (26.6%)	18 (22.8%)	7 (8.9%)	
E) 5th Year / Intern (n = 23)	5 (21.7%)	6 (26.1%)	3 (13.0%)	8 (34.8%)*	1 (4.3%)	
Residential Background						149.136 (p < 0.001*)
A) Urban (City) (n = 95)	60 (63.2%)	25 (26.3%)	8 (8.4%)	1 (1.1%)	1 (1.1%)	Significant
B) Rural (Village) (n = 134)	78 (58.2%)	25 (18.7%)	8 (6.0%)	11 (8.2%)	12 (9.0%)	
C) Semi-urban (Town) (n = 199)	32 (16.1%)	28 (14.1%)	55 (27.6%)	75 (37.7%)*	9 (4.5%)	

- *Note: *Statistically significant at $p < 0.05$; $p < 0.001$ is highly significant. NS = Not Significant.*

➤ Biomechanical Validation and Diagnostic Threshold Determination (ROC Curve Analysis)

To check whether the mathematical formula for cervical tension ($T = W_{\text{head}} \times L \times \sin(\theta)$) can reliably separate students with clinically significant neck disability from those without, a Receiver Operating Characteristic (ROC) curve analysis was performed (Table 8). The ROC analysis gave an Area Under the Curve (AUC) of 0.580 (95

percent Confidence Interval: 0.525 to 0.635), which was statistically significant ($p = 0.006$). Using Youden's Index ($J = \text{Sensitivity} + \text{Specificity} - 1$) [14], the best diagnostic cut-off value for cervical spine tension was found to be exactly 0.240 kg·m (Youden's $J = 0.134$). At this 0.24 kg·m threshold, the formula gives a sensitivity of 42.8 percent (0.428) and a high protective specificity of 70.6 percent (0.706). This 70.6 percent specificity means that students who keep their posture-related neck tension below 0.24 kg·m have a strong likelihood of staying free from significant neck disability.

Table 8 Biomechanical Validation and Diagnostic Threshold Determination via Receiver Operating Characteristic (ROC) Curve Analysis (N = 428)

Test Cut-off Value (kg·m)	Sensitivity (True Positive Rate)	1 – Specificity (False Positive Rate)	Specificity (True Negative Rate)	Youden's Index ($J = \text{Sens} + \text{Spec} - 1$)
0.125 kg·m	0.994 (99.4%)	1.000	0.000 (0.0%)	0.004
0.163 kg·m	0.933 (93.3%)	0.919	0.081 (8.1%)	0.014
0.201 kg·m	0.694 (69.4%)	0.617	0.383 (38.3%)	0.077
0.240 kg·m (Optimal Cut-off)*	0.428 (42.8%)	0.294	0.706 (70.6%)*	0.134* (Maximum J)
0.288 kg·m	0.217 (21.7%)	0.113	0.887 (88.7%)	0.104

0.335 kg·m	0.033 (3.3%)	0.028	0.972 (97.2%)	0.005
0.453 kg·m	0.000 (0.0%)	0.004	0.996 (99.6%)	-0.004

- *Note: ROC Model Summary: Area Under the Curve (AUC) = 0.580, $p = 0.006^{**}$ (95% CI: 0.525 – 0.635). *Optimal diagnostic threshold identified via Youden's Index at 0.240 kg·m.*

IV. DISCUSSION

➤ Daily Screen Time and Prevalence of Neck Disability

The present study evaluated 428 undergraduate healthcare students in Kuppam and found an objective mean daily screen time of 391.08 ± 72.07 minutes (about 6.5 hours per day), with 60.30 percent of the students suffering from mild-to-complete neck disability on the Neck Disability Index (NDI). These findings match closely with recent Indian and international studies on health science trainees. In a 2026 study among 303 medical students in Chennai, Tamil Nadu, Benilsha et al. [4] reported a 56.4 percent prevalence of text neck syndrome and noted that poor ergonomic awareness was significantly linked to neck pain ($p = 0.0068$). Similarly, Kamaraj et al. [6] found that 46.9 percent of medical students in Puducherry had text neck symptoms, with 55.6 percent reporting mild-to-moderate disability on the NDI scale. In Sangli, Maharashtra, Vasantha et al. [5] recently reported neck disability in 68.0 percent of college students on the NDI (53.0 percent mild and 15.0 percent moderate disability). Outside India, Mahmoud et al. [3] documented a 54.0 percent prevalence of neck pain among Saudi nursing students, Salameh et al. [7] reported text neck symptoms in 73.6 percent of Jordanian medical students, and Rafiyan et al. [8] found a 65.4 percent prevalence of neck disability on the NDI among Iranian medical students.

➤ Cervical Tension vs. Screen Duration: Why Study Posture Matters More

One of the most important findings of our study is that total daily screen time did not show a statistically significant linear correlation with NDI disability scores ($r = -0.026$, $p = 0.596$), whereas calculated physical cervical tension showed a highly significant positive correlation with NDI scores ($r = 0.136$, $p = 0.005$). At first glance, people often assume that more hours on the phone automatically cause more neck pain. However, as Table 2 shows, almost all students in our sample used their phones for around 6 to 7 hours daily (IQR 346.07 to 437.39 minutes) because 88.60 percent lacked residential Wi-Fi and depended on smartphones for both classes and entertainment. When screen duration is uniformly high across almost everyone, what separates a pain-free student from a disabled student is how they hold their head and neck while looking at the screen.

This mechanical explanation is strongly supported by Hansraj's cervical spine load model [1], which showed that bending the neck forward from 0 degrees to 60 degrees multiplies the gravitational pull on the cervical spine nearly five times (from 5 kg to 27.2 kg). In agreement with our results, Kim and Kim [12] and Salama et al. [10] demonstrated that a smaller craniovertebral angle (greater forward head posture) correlates directly with higher NDI disability scores. Similarly, Barczyk-Pawelec and Sipko

[13] and John et al. [9] observed that holding mobile devices below eye level without arm support places continuous isometric load on the posterior neck extensor muscles, leading to muscle ischemia, trigger points, and functional reading and concentration difficulties.

➤ High-Risk Study Postures and Demographic Factors

Our comparison of study postures (Table 5) clearly showed that sitting cross-legged on the floor was the most harmful habit ($p < 0.001$), with 52.60 percent of floor-studying students suffering from severe neck disability. In many Indian hostels and semi-urban homes, students sit on the floor with notebooks or mobile phones placed on the ground or in their lap. Without a table to raise the screen, the student has to flex the neck to 50–70 degrees for hours at a stretch. In contrast, students who changed their posture frequently (Variable group) had the highest rate of No Disability (81.80 percent), showing that regular movement gives tired neck muscles time to recover.

Among demographic factors (Table 7), nursing students had significantly higher neck disability (23.20 percent severe disability) than physiotherapy students (63.20 percent no disability; $p < 0.001$). Physiotherapy students learn spinal biomechanics, posture correction, and neck stretching exercises early in their syllabus, which helps them protect their own necks, whereas nursing students spend long clinical hours bending over hospital beds for patient care [3, 10]. Senior 5th-year interns also had the highest severe disability rate (34.80 percent; $p = 0.008$), showing the cumulative effect of four to five years of academic study plus full-time hospital internship duties. Furthermore, 81.80 percent of our students did not do regular physical exercise, which leaves the neck and upper back muscles weak and easily fatigued [7, 10].

➤ Diagnostic Cut-off Threshold, Orem's Self-Care Deficit Model, and Nursing Implications

Using ROC curve analysis and Youden's Index [14], our study validated a practical diagnostic threshold of 0.24 kg·m for calculated cervical tension ($AUC = 0.580$, $p = 0.006$), with a specificity of 70.6 percent. Viewed through Dorothea Orem's Self-Care Deficit Theory, 0.24 kg·m marks the boundary where the physical demand on the cervical spine exceeds the student's natural muscle endurance, creating a functional self-care deficit. Community health nurses, nursing faculty, and college management can apply these findings in four practical ways: (1) In Nursing Practice, school and college health nurses can use a simple smartphone inclinometer and measuring tape during annual student check-ups to screen students whose neck load exceeds 0.24 kg·m; (2) In Nursing Education, ergonomic training, chin-tuck exercises, and scapular retraction drills [10] should be taught in first-year foundation courses; (3) In Nursing Administration, hostel wardens and college management should provide proper study desks, chairs, and affordable mobile reading stands so students do not have to study sitting on the floor; and (4) In Nursing Research, future studies can test how much posture-training workshops reduce NDI scores over an academic year.

V. LIMITATIONS AND RECOMMENDATIONS

This study has a few limitations. First, because it used a cross-sectional design at a single time point, it shows statistical association rather than long-term cause and effect. Second, the sample was drawn from colleges in a single town (Kuppam), and 97.00 percent of students fell within the mild tension bracket, which kept the overall ROC AUC modest (0.580). Third, factors such as exam mental stress, clinical duty hours, and sleep quality were not separately controlled. Future multi-center longitudinal studies across different states, comparing medical, nursing, and engineering students, and testing simple ergonomic interventions such as angled book/phone stands and scheduled 20-20-20 posture breaks are strongly recommended.

VI. CONCLUSION

This study shows that 60.30 percent of undergraduate healthcare students in Kuppam suffer from measurable neck disability on the Neck Disability Index, with 20.30 percent experiencing severe disability. Objective smartphone logs and biomechanical testing proved that functional neck disability is driven by posture-induced cervical tension ($r = 0.136$, $p = 0.005$) and high-risk study positions—especially sitting cross-legged on the floor ($p < 0.001$)—rather than total daily screen hours alone ($p = 0.596$). Keeping cervical spine tension below the validated diagnostic cut-off of 0.24 kg·m through proper desk seating, raising mobile screens closer to eye level, taking frequent posture breaks, and practicing regular neck strengthening exercises can effectively prevent text neck disability among future healthcare professionals.

➤ Ethical Approval and Declarations

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