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ASSOCIATION BETWEEN SMARTPHONE USAGE AND NECK PROPRIOCEPTION AMONG UNIVERSITY STUDENTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background and aims: The excessive use of smartphones could cause forward head posture and affect proprioception; however, the relationship between smartphone addiction and proprioception in the neck region is unknown. This study aimed to assess the association between smartphone addiction and the cervical proprioception of university students.

Methods: A total of 271 students were recruited via convenience sampling and completed a demographic data sheet and Smartphone Addiction Scale-Short Version. Participants were divided into addicted and non-addicted groups based on the sex-specific cut-off scores. The cervical range of motion and joint position error (JPE) were measured using the CROM Device and JPE method.

Results: 271 students (177 female, 65.3%) were recruited, of whom 109 (40.2%) were smartphone-addicted. Because of the Mann-Whitney U test was used to compare the JPE of addicted and non-addicted groups as the data followed non-normal distribution. The analysis revealed that the extent of the JPE of flexion (3.00° vs 2.66°, p = 0.021), extension (3.66° vs 3.00°, p = 0.001), right rotation (3.33° vs 3.00°, p = 0.021), and left rotation (3.33° vs 2.66°, p = 0.025) in the addicted group was greater than that of the non-addicted group. The mean differences of the JPE were between 0.55° and 0.88°, with the largest difference being detected in extension (4.17 ± 2.42° vs 3.29 ± 1.91°).

Interpretation: Smartphone addiction was associated with increase in cervical JPE in all the movement directions. Because of the cross-sectional design, causality cannot be inferred, and the clinical relevance of these small differences needs to be confirmed in longitudinal studies.

KEYWORDS

Cross-sectional studies, neck proprioception, smartphone addiction

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INTRODUCTION

Smartphone ownership has increased dramatically over the last decade, and excessive use among adolescents and young adults is a growing public health concern[1]. India holds the second position in terms of the number of mobile phone users after China, and it grows at a faster pace than in China[2]. Usage of smartphones amongst young adults has become increasingly prevalent, with a published study from Saudi Arabia reported smartphone addiction in 64% (n = 160) of 250 participants[3]. A 2022 research study of medical students from 7 Asian countries (mainly India and Malaysia, but also China, Saudi Arabia, Turkey, Nepal and Iran) concluded that 2181 of the 5497 participants met the criteria for smartphone addiction, with a pooled prevalence of 41.93%[4].

Recent studies show there is an increase in smartphone addiction among college-going students in India. A recent study reported that an alarming 45.8% of the participants were found to be prone to smartphone addiction[5]. Another study conducted among Indian medical students reported that the prevalence of smartphone addiction was reported to be 46.15% in males and 33.33% in females[6]. Among university students, those classified as smartphone addicts reported a higher incidence of musculoskeletal problems and greater upper extremity disability compared to non-addicted individuals[7]. Neck pain was the most commonly reported discomfort associated with smartphone addiction, affecting around 60.8% of individuals, followed by pain in the lower back at 46.8% and in the shoulders at about 40%[8]. Smartphone addiction significantly affects neck flexor muscle endurance and increases pain intensity in both males and females[9]. A positive moderate correlation between smartphone addiction and neck disability has been found using the Neck Disability Index (NDI) scale[10]. Proprioception refers to the body's ability to sense movement and position, encompassing both joint position awareness and the perception of motion[11].

Cervical proprioception plays a vital role in motor learning, motor control, and the maintenance of balance and posture. Any structural or functional changes in the deep or superficial cervical muscles can affect sensory input and consequently alter proprioceptive function[12]. The suboccipital muscles contain a dense concentration of proprioceptive receptors, suggesting their crucial role in maintaining precise proprioceptive function[13]. In subjects with chronic pain, studies show there is impairment of cervical joint position sense (proprioception)[14]. Incorrect alignment of the head and cervical joints in individuals with forward head posture impairs cervical proprioceptive function[13].

Several studies have investigated the impact of the excessive use of smartphones on an individual's health, resulting in poor posture, neck pain, and musculoskeletal disorders. In this regard, previous studies have demonstrated that musculoskeletal impairments can affect proprioceptive abilities. However, the specific relationship between smartphone overuse and cervical proprioception has been explored only to a limited extent.

Neck dysfunction in chronic non-specific neck pain is not limited to pain but also presents with reduced neck muscle strength and endurance, restricted range of motion, and an imbalance between the activation of deep and superficial neck muscles proved to be associated with the chronicity of pain[15]. Exercise that targets neck movement and motor control is one of the main conservative treatment for this condition[15]. In young adults, a recent cross-sectional study of medical students reported that those with smartphone addiction had a significantly smaller craniovertebral angle (greater forward head posture) and lower trunk muscle endurance than non-addicted students, whereas neck flexor and extensor endurance did not differ significantly[16]. The present study aims to fill this gap by investigating the association between smartphone usage and neck proprioception among university students.

MATERIALS AND METHODS

This is an observational cross-sectional study, reported in accordance with the STROBE statement for cross-sectional studies *(Fig. 1)*. The study was conducted among university students at a single institution and conducted over eight months, starting in October 2025 and finishing in May 2026.

It was registered with the Clinical Trials Registry-India (CTRI), a WHO ICTRP primary registry, under CTRI/2025/09/094855 in September 2025, prior to the initiation of recruitment in October 2025. This study was approved by the Institutional Ethics Committee (ref. no.: CSP/25/JUL/164/328).

The participants were recruited using a convenience sampling method, among the students of the study institution who were aged between 18 and 24 years and used mobile phones. The data collection procedure was

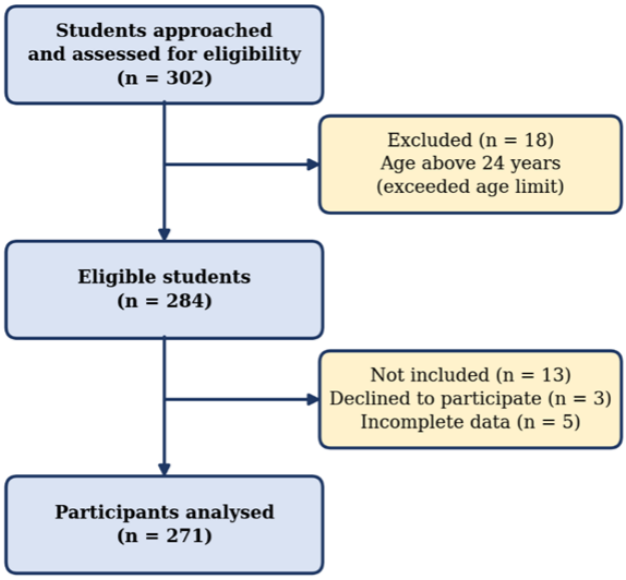

Figure 1. *STROBE flow diagram of participant recruitment and analysis.*

carried out by the investigators approaching students to participate in the study after explaining its nature. The exclusion criteria included a history of neck injury or chronic neck pain, vestibular disorders, diagnosed cervical pathology (cervical spondylosis), previous cervical surgery, neurological or neuromuscular disorder affecting neck function, or chronic uncontrolled medical conditions.

The participants gave their written informed consent to participate. Of the 302 students approached, 13 declined to participate, and 18 were excluded based on the exclusion criteria. Thus, a total of 271 participants were recruited for the study.

The sample size was calculated using G POWER (version 3.1.9.7). Using $\alpha = 0.05$ and power $(1-\beta) = 0.95$, the calculated sample size needed for the study is 271. The primary outcome, smartphone addiction in students, was assessed by the standardized smartphone addiction scale (short version) using a Google Form. The secondary outcome, neck proprioception in students, was assessed by the joint position error method using a CROM device.

The demographic data we obtained include name, age, gender, height, and weight. Lifestyle habits and neck pain were assessed, including pain during or after physical activity, neck stiffness or tightness, and any pre-existing cervical pathologies like cervical spondylosis, history of neck injury, and neck surgery. Data about smartphone usage were obtained, including the purpose of smartphone usage, hours of smartphone usage per day, and duration of smartphone usage.

Smartphone addiction among participants was assessed using the smartphone addiction scale–short version (SAS-SV). Participants were divided into two groups: smartphone-addicted and smartphone non addicted. Both groups were assessed for neck proprioception using the cervical range of motion (CROM) device using the joint position error (JPE) method. SAS-SV consists of 10 questions answered on a 6-point Likert scale that ranges from 1 (strongly disagree) to 6 (strongly agree). The SAS-SV cut-off score of ≥31 was used for males, while ≥33 for females was used to determine smartphone addiction. Based on the SAS-SV cut-off scores, subjects were divided into two categories: A) those who are smartphone addicted and B) those who are not addicted.

Both groups were assessed for neck proprioception using the CROM device in flexion, extension, left and right rotation. Proprioception was measured using the JPE method. CROM device is a head-mounted instrument used to measure the cervical range of motion in the sagittal, horizontal, and frontal planes.

The participants were comfortably made to sit in a chair and wear the CROM device with consent. Participants actively performed neck movements (cervical flexion, extension, right rotation, left rotation) with eyes open. The normal cervical ROM is measured, and 50 percent of the ROM is selected as the target position angle to be repositioned by the participants. The participant is asked to close their eyes; the examiner passively positions the neck in the targeted angle (50 percent of the measured angle). The participant is asked to stay for 5 seconds and memorize the position. The examiner guides the participant to bring back the head to the beginning position (neutral). Then, the participant is asked to move their head to the previously memorized target head position. After the participant positions their head, the reposition angle is noted. The target position angle and reposition angle are compared in degrees to find the level of error in repositioning of the head. The procedure is done for 3 times to find the mean of the joint position error. This procedure is repeated in cervical flexion, cervical extension, cervical right and left rotation.

Statistical analysis

Data were analyzed using IBM SPSS Statistics software. Descriptive statistics were used to describe the data. Specifically, the mean ± standard deviation (SD) was reported for the continuous variables and frequencies and percentages for categorical variables. Shapiro-Wilk test was conducted to assess the normality of the distribution of all cervical JPE variables. The results of the test revealed that none of the variables followed a normal distribution pattern. Therefore, the non-parametric test was used for the comparison of JPE in the addicted and non-addicted groups. Specifically, the Mann-Whitney U test was conducted to compare the distribution of JPE in flexion, extension, right rotation, and left rotation between the addicted and non-addicted groups. Group differences are also described as mean differences with 95% confidence intervals (independent-samples t-test, descriptive only). A p value of less than 0.05 was considered statistically significant for all the statistical tests conducted.

RESULTS

A total of 271 university students participated in this study *(Fig. 1)*. Of these, 177 (65.3%) were female, and 94 (34.7%) were male. According to the gender-specific SAS-SV cut-off scores, 109 participants (40.2%) were classified as smartphone addicted and 162 (59.8%) as non-addicted *(Table 1)*. The Shapiro-Wilk test showed that JPE values were not normally distributed in either group for any of the four movements (all $p < 0.001$); therefore, the Mann-Whitney U test was used to compare the groups *(Table 2)*.

In smartphone-addicted students, the mean JPE was 3.31 ± 1.91° for flexion, 4.17 ± 2.42° for extension, 3.80 ± 1.91° for right rotation, and 3.69 ± 2.15° for left rotation. The largest JPE was obtained in extension. In non-addicted students, the mean JPE was lower for all movements: flexion 2.71 ± 1.63°, extension 3.29 ± 1.91°, right rotation 3.25 ± 1.78° and left rotation 3.12 ± 1.52°; the highest value was also recorded for extension. JPE was significantly higher in the addicted group in flexion ($U = 7305.0$, $p = 0.021$), extension ($U = 6754.5$, $p = 0.001$), right rotation ($U = 7376.5$, $p = 0.021$), and left rotation ($U = 7415.5$, $p =$

Demographic variables	Male (n = 94)	Female (n = 177)
Age in years (mean ± SD)	20.6 ± 1.7	20.3 ± 1.5
Height in cm (mean ± SD)	172.76 ± 19.12	158.83 ± 13.48
Weight in kg (mean ± SD)	75.30 ± 15.46	58.88 ± 10.82
SAS-SV in points (mean ± SD)	29.79 ± 9.57	29.00 ± 8.82
Neck pain during or after physical activity Yes, n (%) No, n (%) Maybe, n (%)	 13 (13.8%) 56 (59.6%) 25 (26.6%)	 35 (19.8%) 93 (52.5%) 49 (27.7%)
Neck stiffness or tightness Yes, n (%) No, n (%) Maybe, n (%)	 28 (29.8%) 52 (55.3%) 14 (14.9%)	 50 (28.2%) 84 (47.5%) 43 (24.3%)
Smartphone usage per day in hours 1-2 hours, n (%) 2-4 hours, n (%) 4-6 hours, n (%) More than 6 hours, n (%)	 37 (39.4%) 32 (34.0%) 16 (17.0%) 9 (9.6%)	 74 (41.8%) 66 (37.3%) 25 (14.1%) 12 (6.8%)
Purpose of smartphone usage Gaming, n (%) Studying, n (%) Watching videos (movies, YouTube), n (%) Social media, n (%)	 51 (54.3%) 62 (66.0%) 73 (77.7%) 70 (74.5%)	 43 (24.3%) 122 (68.9%) 130 (73.4%) 129 (72.9%)

Table 1. *Demographic data male and female participants.*

Movement	Addicted, mean ± SD	Non-addicted, mean ± SD	Addicted median (IQR)	Non-addicted median (IQR)	Mean diff. (95% CI)	U	p
Flexion	3.31 ± 1.91	2.71 ± 1.63	3.00 (2.00–4.33)	2.66 (1.33–4.00)	0.59 (0.16–1.02)	7305.0	0.021
Extension	4.17 ± 2.42	3.29 ± 1.91	3.66 (2.66–5.33)	3.00 (2.00–4.33)	0.88 (0.36–1.40)	6754.5	0.001
Right rotation	3.80 ± 1.91	3.25 ± 1.78	3.33 (2.66–5.00)	3.00 (1.66–4.33)	0.55 (0.11–1.00)	7376.5	0.021
Left rotation	3.69 ± 2.15	3.12 ± 1.52	3.33 (2.33–4.66)	2.66 (2.00–4.00)	0.57 (0.13–1.01)	7415.5	0.025

Table 2. *Comparison of cervical joint position error (°) between smartphone-addicted and non-addicted students.*
Abbreviations: SD, standard deviation; IQR, interquartile range; CI, confidence interval.

0.025). The mean between-group differences were small, ranging from 0.55° (right rotation) to 0.88° (extension) *(Table 2)*. The lower JPE in non-addicted students indicates slightly better cervical joint position sense than in smartphone-addicted students.

DISCUSSION

This study aimed to explore the relationship between smartphone addiction and cervical proprioception among university students. The assessment of cervical proprioception was conducted using JPE through the CROM instrument, while smartphone addiction was tested through the SAS-SV. Students who had smartphone addiction were found to have an increased cervical joint position error, indicating a poorer neck position sense; however, the differences were small. The results showed that smartphone addiction was associated with increased JPE values in all planes of motion, most prominently in extension. As smartphone use was measured by questionnaire and both exposure and outcome were measured at the same time, these findings suggest a link and do not establish that smartphone use leads to a reduction in joint position sense.

The present study found that increased smartphone addiction was associated with poorer cervical proprioception among university students. The findings are consistent with the study by Pashine et al.[12], which reported that prolonged smartphone use negatively affects cervical proprioception and cervical movement control. Similarly, Goo et al.[13] demonstrated that forward head

posture is associated with impaired cervical proprioceptive accuracy, supporting the notion that altered cervical alignment can affect sensorimotor function.

Sustained forward head posture is thought to overload the deep neck flexors and suboccipital muscles, producing fatigue and altered sensory input from the muscle spindles and joint receptors. This disruption of cervical sensorimotor function may impair head awareness and increase joint position error. The work by Peng et al.[17] focused on cervical proprioceptive impairment in neck pain, and the work by Norasteh et al.[18] focused on exercise therapy for proprioception in forward head posture. Neither of these reviewed the potential of smartphone exposure nor the extension-specific deficits. This increased error with extension should be regarded as a hypothesis and not as an established mechanism.

The higher JPE in the addicted group despite being young and healthy otherwise indicates that cervical position sense might differ between high smartphone users. However, the mean differences (0.55°–0.88°) were small; their clinical relevance remains unclear, and the observational, cross-sectional design does not allow discernment between these differences preceding, following, or being unrelated to neck symptoms. On the basis of this study, JPE cannot be recommended as a diagnostic procedure or a biomarker of early smartphone-related injury; longitudinal studies are needed. The CROM measuring device employed in the present research is a reliable and convenient clinical instrument[19].

Our findings are consistent with recent work in young adults without a history of neck or back pain, in which smartphone addiction was associated with a smaller craniovertebral angle and lower trunk endurance[16]; the current study adds a sensorimotor outcome, joint position error, to this. Diminished neck muscle endurance, restricted motion and altered deep–superficial muscle activation are well-established features of neck pain[15], and altered posture or muscle fatigue could conceivably impact on position sense. However, we did not measure posture or muscle endurance; thus, we are unable to determine whether these factors explain our findings.

The present study is characterized by various methodological advantages that increase its validity and importance. Firstly, a relatively large sample of 271 participants allowed obtaining adequate statistical power for the detection of significant differences in the cervical joint position error between groups in various planes. Secondly, smartphone addiction was identified with the use of the internationally validated SAS-SV test, which had gender-specific cutoff scores (≥31 for males, ≥33 for females)[20]. Thirdly, cervical proprioception was evaluated with the help of the CROM device, a well-established and reliable technique, using the three-trial average[19]. Furthermore, all data were collected in one institutional location, where the age group ranged from 18 to 24 years, which resulted in a relatively homogeneous sample in terms of academic burden and lifestyle peculiar to the university students. Finally, the normality of the data was formally tested with the Shapiro-Wilk test and an appropriate non-parametric test (Mann-Whitney U) was used for the group comparisons.

Although there are some positives associated with this topic, there are still many limits to be recognized. Participants were recruited by convenience sampling at a single institution, which may introduce selection bias, and 65.3% of the sample were female. The group comparisons were unadjusted for potential confounders such as age, sex, neck posture or neck pain, and the observed differences were small. Posture (e.g., craniovertebral angle) and neck muscle endurance were not measured, so they could not be examined as possible explanations[16].

Since this is a cross-sectional type of study, the relationship between smartphone addiction and proprioceptive deficits can be determined; however, whether smartphone addiction is a cause of proprioceptive deficits is still uncertain. The sample was composed of physiotherapy students who attended only one academic institution, which may impact the ability to generalize results to others outside of physiotherapy or those in the non-academic world. The reliance upon self-reported use of smartphones introduces recall bias and limits the precision of measures to assess how much time people are using their devices.

CONCLUSION

In this cross-sectional study, smartphone addiction among university students was associated with slightly higher cervical joint position error in all planes of motion, with the greatest difference in extension. The differences were small, and causality cannot be inferred from this design. These findings do not support the use of cervical JPE as a diagnostic or screening tool for smartphone-related injury. Future investigations should utilize longitudinal study designs to clarify cause-and-effect relationships, use objective data regarding screen time and postural angle measurements, have broad samples from multiple institutions, and assess whether cervical proprioceptive retraining techniques can help restore sensorimotor deficits in university students as a result of excessive smartphone use. More broadly, preventative strategies and awareness should be created among young adults focusing on improving overall cervical health.

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