

# Smartphone usage and its impact on craniovertebral angle and pulmonary functions among general population: an analytical cross-sectional study

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## ABSTRACT

**Objective:** To determine the association between smartphone usage and its impact on craniovertebral angle (CVA) and pulmonary functions in the general population.

**Methods:** This analytical cross-sectional study was conducted at Imran Idrees Hospital, Sialkot, from January to May 2023. A total of 217 participants aged 18–30 years, using smartphones for over 3 hours daily, were selected through simple random sampling. Smartphone addiction was assessed using the validated Smartphone Addiction Scale-Short Version (SAS-SV). Forward head posture (FHP) was evaluated by measuring the craniovertebral angle (CVA), with values  $\leq 53^\circ$  considered abnormal. Pulmonary functions, including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC ratio, were measured using a spirometer. Data were analyzed using SPSS version 22, applying chi-square and Friedman tests with a significance level of  $p \leq 0.05$ .

**Results:** Among 217 participants (69.1% females, mean age  $25 \pm 3.34$  years), 62.3% used smartphones for 4–8 hours/day and 149 (68.6%) were categorized as smartphone addicted. A significant association was found between smartphone addiction and FHP ( $CVA \leq 53^\circ$ ) ( $p < 0.001$ ). However, no significant differences were observed in pulmonary function parameters between addicted and non-addicted participants: FVC ( $p = 0.230$ ), FEV1 ( $p = 0.470$ ), and FEV1/FVC ( $p = 0.040$ ).

**Conclusion:** Smartphone addiction is prevalent among young adults and is significantly associated with altered cervical posture, particularly forward head posture. However, no significant impact was found on pulmonary function. These findings highlight the musculoskeletal risks of excessive smartphone use and highlight the importance of ergonomic awareness and preventive strategies in youth.

**Keywords:** Craniovertebral Angle (MeSH); Posture (MeSH); Kinesics (MeSH); Forward head posture (Non-MeSH); Pulmonary Functions (MeSH); Spirometry (MeSH); Smartphone (MeSH); Smartphone Usage (Non-MeSH); Smartphone Addiction (MeSH); Internet Addiction Disorder (MeSH).

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## INTRODUCTION

The widespread adoption of smartphones in recent years has led to a significant rise in daily usage, often resulting in dependence and addiction. By 2020, an additional 3.5 billion new smartphone subscriptions had been acquired, bringing the global total to 9.6 billion.<sup>1</sup> Addiction is a maladaptive condition, marked by the persistent inability to regulate a specific behavior, or the continued engagement

in that behavior despite experiencing significant adverse consequences. It can manifest in various forms, including substance addiction, behavioral addiction, and psychological addiction.<sup>2</sup>

An increase in smartphone usage leads to an increase in sedentary lifestyles and other health-related issues. The rapidly increasing frequency and duration of smartphone use has been linked to the development of forward-leaning posture, commonly referred to as

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forward head posture (FHP).<sup>3</sup> This condition is characterized by flexion of the lower cervical vertebrae and extension of the upper cervical vertebrae, leading to muscular imbalances and reduced cervical spine mobility. This postural alteration can lead to reduced mobility of the cervical spine and may significantly impact respiratory health by weakening the respiratory muscles.<sup>4</sup> This impairment is primarily attributed to reduced movement of the lower ribs, which subsequently limits thoracic spine expansion. In individuals with FHP, a craniovertebral angle (CVA) of  $\leq 53^\circ$  is typically considered indicative of abnormal posture, while a CVA greater than  $53^\circ$  is regarded as normal.<sup>5</sup> A smaller CVA reflects a more pronounced degree of forward head positioning.<sup>6</sup> However, Kwon JW, et al., have suggested alternative thresholds, proposing that a CVA of less than  $48^\circ$  or  $50^\circ$  may also serve as an indicator of FHP.<sup>7</sup>

Prolonged smartphone use can lead to forward head positioning, increasing the anterior curvature of the lower cervical spine and the posterior curvature of the thoracic spine as a compensatory mechanism to manage neck muscle strain. These postural adaptations may contribute to upper crossed syndrome, characterized by rounded shoulders, which restrict chest wall expansion and limit both inspiration and expiration during respiration. Activities such as texting, which involve a sustained head-

down posture, can reduce blood flow to the neck muscles, resulting in fatigue and localized discomfort. Altered biomechanics of the cervical and thoracic spine adversely affect chest wall movement and respiratory muscle function, thereby impairing pulmonary performance.<sup>8</sup> Several studies have further established an association between FHP, weakened respiratory muscles, and diminished lung function.<sup>9</sup>

Understanding the relationship between smartphone addiction, postural alterations, and pulmonary health is crucial for developing effective preventive and rehabilitative strategies. To date, this association has not been examined within our local population. This study seeks to address this gap by evaluating the impact of smartphone use on craniocervical angle and pulmonary function, with the aim of informing public health initiatives and promoting ergonomic awareness.

## METHODS

This analytical cross-sectional study was conducted on the general population after obtaining ethical approval from the Imran Idrees Institute of Rehabilitation Sciences, Sialkot, Pakistan (Ref# IIIRS/DPT/PRI/IRB-604), and was carried out from January 23 to May 25, 2023. A sample size of 217 participants was determined through Epitools epidemiological calculators,<sup>10</sup> based on an estimated true proportion of 17% (0.17),<sup>11</sup> with an assumed population size of 20,000, a desired precision (e) of 0.05, and a 95% confidence interval. The sample size was calculated using the formula:  $n = (Z^2 \times P \times (1 - P)) / e^2$ , where Z corresponds to the standard normal value at 95% CI (1.96), P is the expected true proportion, and e is the desired level of precision (half desired CI width).

The data were collected from the general population at Imran Idrees Hospital, with permission from the administration. A simple random sampling technique was used for data collection. Participants were included based on inclusion criteria, i.e. participants ages (18 to 30) both male and female participants from varied socioeconomic backgrounds (classification was done by using a socioeconomic status index that

combines income, education and occupation) and with different BMI categories as mentioned in Table I and included those who use smartphone >3 hours/day.<sup>12</sup> Participants with any other condition, such as epigastric pain, neurological disorders, neck pain, thoracic cage pain, spine deformity (curve, congenital, or postural), other pulmonary diseases, and smokers were excluded from the study.

The outcome tools used were the Smartphone Addiction Scale-Short Version (SAS-SV), with an internal consistency of 0.93 and validity of 0.84,<sup>13</sup> to evaluate smartphone addiction, which consists of 10 questions. The participant responded according to the Likert Scale, Ranging from strongly disagree (1) to strongly agree (6). The total score of this scale is 60, and participants were considered as physiologically addicted if their score was more than 32 and vice versa as non-addicts of smartphones (Score  $\leq 32$ ).<sup>14</sup> The second outcome, FHP (Forwarded head posture), was measured using the craniocervical angle (CVA) that is formed between the line connecting the tragus of the ear to the seventh cervical vertebra and the horizontal plane.<sup>15</sup> reports an average range of this angle from 42° to 54°. In this study, a CVA of more than 53° was considered normal, and one of 53° or less was considered abnormal (5),<sup>5</sup> with a reliability ranging from 0.88 to 0.98.<sup>9</sup> But nowadays, mobile applications simplify the process and make it more acquisition- and cost-effective.

Pulmonary functions were assessed using a calibrated portable spirometer (Spirolab III, MIR Co., Italy)<sup>17</sup> with participants seated in an upright position.<sup>18,19</sup> The measured parameters included Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and the FEV1/FVC ratio.<sup>20</sup> The spirometry test demonstrated a sensitivity of 98% and a specificity of 77%.<sup>21</sup> According to standard reference values, normal pulmonary function is defined as an FEV1/FVC ratio greater than 0.70 (70%) and FVC and FEV1 values above 80% of the predicted values. Final spirometry reports were reviewed by a pulmonologist, who classified pulmonary function as normal (>80%)

or compromised (<80%).<sup>22</sup>

All participants provided written informed consent, confirming their voluntary participation and ensuring the confidentiality of their data throughout the study. Data was analyzed using SPSS version 22. Demographic characteristics were summarized using frequency tables. The association between smartphone addiction and FHP was assessed using the Chi-square test. Additionally, the Friedman test was employed to evaluate the mean, interquartile range (IQR), maximum, and minimum values for smartphone addiction scores and pulmonary function test (PFT) parameters.

## RESULTS

There were 150 (69.1%) females and 67 (30.9%) male participants, with a mean age of  $25 \pm 3.34$ , who participated in the study. Out of 217, 146 participants, 67.3% (n=146,000) were of a healthy weight. In this study, 137 (62.3%) participants use their smartphones for 4-8 hours, 54 (24.5%) from 9-14 hours and 26 (11.8%) from 15-18 hours. (Table I). Out of 217 (100%), 149 (67.7%) were addicted, and 68 (30.9%) were non-addicted on the SAS scale. The mostly addicted population with forwarded head posture (FHP) have CVA of less than 53°. The results show a significant association between smartphone addiction and CVA (P-value <0.05) [Table II].

FVC, FEV1, and FEV1/FVC were among the smartphone-addicted individuals, with mean scores of  $95.42 \pm 11.74$ ,  $94.73 \pm 11.56$ , and  $98.11 \pm 7.91$ , respectively. The maximum score for the smart-addicted population was slightly higher than that of the non-addicted population. But were no significant differences in FVC (P=0.230), FEV1 (0.47) and FEV1/FVC (P=0.04) [Table III].

## DISCUSSION

This study aimed to determine smartphone usage and its effect on craniocervical angles and pulmonary functions in the general population visiting Imran Idrees Teaching Hospital, Sialkot, with a sample of 217 participants. The results stated that

**Table I: Demographic profile of participants (n=217)**

| Demographics                         | Category                      | Frequency (%) |
|--------------------------------------|-------------------------------|---------------|
| Gender                               | Male                          | 67 (30.9)     |
|                                      | Female                        | 150 (69.1)    |
| Body mass index (kg/m <sup>2</sup> ) | Underweight (below 18.5)      | 27 (12.4)     |
|                                      | Healthy weight (18.5 to 24.9) | 146 (67.3)    |
|                                      | Overweight (25 to 29.9)       | 43 (19.8)     |
|                                      | Obese (30 to 39.9)            | 1 (0.5)       |
| Socioeconomic status                 | Upper class                   | 29 (13.4)     |
|                                      | Middle class                  | 174 (80.2)    |
|                                      | Lower class                   | 14 (6.5)      |
| Daily smartphone usage (hours)       | 4-8                           | 137 (62.3)    |
|                                      | 9-14                          | 54 (24.5)     |
|                                      | 15-18                         | 26 (11.8)     |

**Table II: Association of smartphone usage and craniocervical angle**

| Craniocervical Angle | Smartphone addiction (SAS-SV) |                           | P-value |
|----------------------|-------------------------------|---------------------------|---------|
|                      | Addicted (>32 Score)          | Non-addicted (≤ 32 Score) |         |
| Forward head (≤53°)  | 136 (62.6%)                   | 150 46 (21.1%)            | 0.00    |
| Normal angle (>53°)  | 13 (5.99%)                    | 22 (10.1%)                |         |

\*Level of significance was ≤ 0.05, Craniocervical Angle = Forward Head Posture

**Table III: Smart phone addiction and pulmonary functions (Friedman Test)**

| SAS                                      | PFTS         | Minimum | Maximum | Percentiles      |                           |                  |
|--|--------------|---------|---------|------------------|---------------------------|------------------|
|  |              |         |         | 25 <sup>th</sup> | 50 <sup>th</sup> (Median) | 75 <sup>th</sup> |
| Addicted more than 32 (n=149)            | FVC (L)      | 72.00   | 129.00  | 87.00            | 93.00                     | 103.00           |
|  | FEV1 (L)     | 71.00   | 127.00  | 84.00            | 95.00                     | 101.50           |
|  | FEV1/FVC (%) | 80.00   | 119.00  | 93.00            | 99.00                     | 103.00           |
| Non-addicted equal or less than 32(n=68) | FVC (L)      | 73.00   | 125.00  | 90.00            | 94.50                     | 103.75           |
|  | FEV1 (L)     | 70.00   | 124.00  | 89.00            | 98.00                     | 106.75           |
|  | FEV1/FVC (%) | 82.00   | 109.00  | 99.00            | 102.50                    | 105.00           |

\*FVC=forced vital capacity, FEV1=forced expiratory volume in 1 second,

smartphone addicts have larger FHP, which indicates a smaller craniocervical angle, than those non-addicted. This study highlights a significant association between smartphone addiction and the craniocervical angle. In our study, addiction was high compared to a study in Tehran University student's frequency

of smartphone addiction was about 28.8%.<sup>23</sup> In another study, addiction to smartphones was reported to be prevalent among students and may negatively affect mental health.<sup>24</sup> A prolonged forward head posture is frequently adopted by individuals who use smartphones more frequently, which can lower cervical vertebrae

angle (CVA). This postural shift alters proprioceptive feedback and postural stability, increases mechanical strain on the cervical spine, and alters the balance of muscles, particularly weakening the deep neck flexors and tightening the posterior neck muscles.<sup>25</sup>

More usage of smartphones can cause addiction, and that causes a change in the craniocervical angle. Our study found that 62.67% of participants had a forward head posture, as measured by CVA, and a significant association was observed between smartphone addiction and the craniocervical angle (P=0.00). These findings of our study were consistent with the results of the study by Asma A in 2021. Her findings showed that children who were smartphone addicts had lower craniocervical angle.<sup>26</sup> However, their age range differed from that of the current study. The results of our study were not consistent with those of Bhovika. According to this, there is no direct association between forward head posture and smartphone addiction; however, it still has a negative impact on health, particularly in terms of posture.<sup>27</sup>

A reduction in CVA not only affects the musculoskeletal system but also influences respiratory function by altering the overall biomechanics of the spine. Kang JS, et al.,<sup>5</sup> reported that a kyphotic posture can negatively impact lung function. These postural changes often stem from FHP, frequently associated with prolonged smartphone use. FHP and kyphosis contribute to reduced thoracic cage mobility and diaphragmatic restriction, leading to diminished thoracic expansion, decreased inspiratory capacity, and a shift toward shallow upper chest breathing. Consequently, the normal functioning of key respiratory and postural muscles, including the trapezius, pectoralis major, sternocleidomastoid, and scalene, is compromised. This imbalance in cervical alignment further disrupts thoracic spine and rib cage mechanics, potentially reducing both FVC and FEV1. In our study, 22.58% (n = 49) of participants classified as smartphone addicts demonstrated reduced FVC and FEV1 values. Although their current pulmonary function tests (PFTs)

remained within normal limits, the observed reductions may pose a future risk. Similar studies have reported that individuals with smartphone addiction tend to have lower pulmonary function scores.<sup>26</sup> Existing literature supports that FHP is associated with weakened respiratory muscles and a reduction in spirometry readings.<sup>28</sup>

This current study found lower mean pulmonary function scores among individuals addicted to smartphone use compared to non-addicted participants. Although PFTs in addicted individuals were not classified as clinically compromised, a noticeable decline was observed, suggesting a potential risk with prolonged use. When assessed using the SAS-SV scale, previous findings have similarly shown that individuals, particularly children, with smartphone addiction demonstrated lower CVA and reduced pulmonary function. One such study concluded that appropriate guidance on smartphone use is essential to preserve both posture and respiratory health in children.<sup>26</sup>

It is important to highlight that this study specifically examined the relationship between smartphone usage, CVA, and pulmonary functions. However, it was limited to a single-center setting, with data collected only from participants present at the hospital during the spirometry assessment. Although gender distribution and age groups were analyzed, other potential confounding variables, such as occupational posture, were not explored in detail beyond the exclusion of those with known pulmonary conditions. Future studies should incorporate a more detailed biomechanical assessment, including ergonomic analysis of the upper extremities and occupational habits, to better understand the multifactorial impact of prolonged smartphone use.

## CONCLUSION

Smartphone addiction, characterized by excessive and compulsive use that interferes with daily functioning, was prevalent among our study participants. A significant association was observed between smartphone addiction and forward head posture, as indicated by a reduced CVA. However, pulmonary

function parameters, including FVC, FEV1, and FEV1/FVC, did not show statistically significant differences between addicted and non-addicted individuals. While respiratory function remained within normal limits, the observed trend of lower mean values in addicted individuals suggests a potential risk of future compromise. These findings emphasize the need for early ergonomic education and behavioral interventions to mitigate the musculoskeletal and potential respiratory impacts of prolonged smartphone use.

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### AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

**EF:** Study design, acquisition of data, drafting the manuscript, approval of the final version to be published

**SA:** Acquisition of data, drafting the manuscript, approval of the final version to be published

**KJ:** Analysis and interpretation of data, critical review, approval of the final version to be published

**QY, TM & AW:** Conception and study design, critical review, approval of the final version to be published

*Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.*

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Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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### DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request



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