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Original Article

Psychiatry/Mental Health Section

# Problematic Smartphone Use and its Association with Sleep Disturbances: A Cross-sectional Study

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## ABSTRACT

**Introduction:** The widespread integration of smartphones into daily life has raised concerns about their potential impact on Sleep Quality (SQ). Excessive smartphone use, particularly before bedtime, may contribute to sleep disturbances through prolonged screen exposure, cognitive stimulation and night-time interruptions. Given the critical role of sleep in overall health and wellbeing, understanding the association between problematic smartphone use and sleep disturbances is essential.

**Aim:** To examine the association between Problematic Mobile Phone Use (PMPU) and SQ among adults, highlighting its potential impact on sleep patterns and overall wellbeing.

**Materials and Methods:** This cross-sectional study was conducted at Indira Medical College and Hospitals, Tiruvallur, Tamil Nadu, India from January to June 2024. A total of 92 adult participants were included in the study. Problematic Smartphone Use (PSU) was assessed using a modified PMPU Questionnaire, while SQ was evaluated using the Pittsburgh Sleep Quality Index (PSQI). Correlation analysis, multiple regression and logistic regression were performed to examine relationships and identify predictors of SQ.

**Results:** A significant positive correlation was observed between PMPU scores and PSQI scores (r=0.61, p-value <0.001). Multiple regression analysis identified the PMPU score as the strongest independent predictor of poor SQ (β=0.512, p-value <0.001), even after controlling for age, gender and mobile phone use duration. The association was strongest among younger participants (18-25 years: r=0.68, p-value <0.001) and slightly more pronounced in females (r=0.65, p-value <0.001). Logistic regression confirmed that each 10-point increase in PMPU score raised the odds of poor SQ by 2.35 times (OR=2.35, 95% CI: 1.62-3.41, p-value <0.001).

**Conclusion:** This study demonstrates a significant association between PMPU and decreased SQ. Beyond screen time and content, PMPU represents an important factor influencing sleep health.


**Keywords:** Addiction behaviour, Digital health, Mobile phone use, Sleep quality

## INTRODUCTION

Mobile phone technology has become ubiquitous in modern society, with global usage surpassing 5.3 billion users in 2023, representing approximately 67% of the world's population [1]. This technological integration has fundamentally altered daily communication patterns, social interactions and body postures. The widespread adoption of mobile devices has raised concerns regarding their possible impact on physical health, particularly concerning musculoskeletal implications and sleep disturbances [2]. PMPU associated with mobile phone usage is characterised by prolonged neck flexion, rounded shoulders and sustained static postures that deviate from natural anatomical alignment [3]. These non ergonomic positions during mobile device engagement have been linked to a spectrum of musculoskeletal disorders collectively termed "text neck syndrome" or "turtleneck posture" [4]. Studies have demonstrated that typical mobile phone usage involves forward head postures with cervical flexion angles of 15-60°, significantly increasing the mechanical load on cervical vertebrae and the associated musculature [5].

Concurrent with the rise in digital device use, sleep disorders have emerged as a significant public health concern, affecting approximately 10-30% of the global population [6]. SQ, a multidimensional construct encompassing sleep latency, duration, efficiency and restorative value, plays a crucial role in maintaining physical and psychological wellbeing. Compromised SQ has been associated with impaired cognitive function, metabolic dysregulation, cardiovascular morbidity and diminished quality of life [7]. The relationship between mobile phone use and sleep disturbances has been increasingly documented in scientific literature. Several mechanisms have been proposed to explain this association, including exposure to screen-emitted blue light that suppresses melatonin production, psychological arousal from engagement with digital content and electromagnetic field exposure that potentially alters sleep architecture [8]. However, PMPU-characterised by excessive, compulsive and uncontrollable mobile phone engagement leading to negative consequences-remains underexplored in this context. Unlike general mobile phone use, PMPU involves behavioural addiction-like tendencies, such as preoccupation, withdrawal symptoms and difficulty controlling usage, which may further contribute to poor SQ [9].

Despite growing evidence, limited research has specifically examined how PMPU affects SQ while accounting for confounding variables such as age, gender and phone usage duration. Furthermore, studies often focus on screen exposure or general phone use without addressing behavioural dependency and psychological factors unique to PMPU [10]. The present study aimed to fill this gap by evaluating the association between PMPU and SQ among adults, providing insights that may inform public health interventions, ergonomic guidelines and clinical recommendations for optimising both musculoskeletal health and SQ. The secondary objectives of this study were to explore gender-based differences in the association between PMPU and SQ, examine the role of socio-economic status in moderating the effects of PMPU on sleep disturbances and assess the impact of specific PMPU components, such as postural habits and dependence, on different parameters of SQ.

## MATERIALS AND METHODS

This cross-sectional study was conducted at Indira Medical College and Hospitals, Tiruvallur, Tamil Nadu, India from January to June 2024, for a duration of six months, following approval from the

Institutional Ethics Committee (Ref: IEC/2024/01). All participants provided written informed consent before enrollment.

**Inclusion criteria:** Adults aged 18 years and above who owned and regularly used mobile phones were included in the study.

**Exclusion criteria:** Individuals diagnosed with psychiatric disorders (e.g., major depressive disorder, schizophrenia, bipolar disorder, generalised anxiety disorder) due to their established impact on sleep patterns; participants on medications known to affect sleep (e.g., antidepressants, sedatives, beta-blockers, corticosteroids); and individuals with previously diagnosed sleep disorders, such as insomnia, sleep apnoea, restless legs syndrome and narcolepsy, to ensure that sleep disturbances were not pre-existing were excluded from the study.

**Sample size calculation:** The sample size was calculated using G*Power 3.1 software, based on an anticipated medium correlation effect size of r=0.3 between PMPU and SQ, as supported by prior studies [11-13]. The analysis was conducted with a power of 80% (1-$\beta$=0.80) and a significance level of $\alpha$=0.05 (two-tailed). According to these parameters, the minimum required sample size was determined to be 88 participants. To ensure the adequacy of the sample and account for possible dropouts or incomplete data, a total of 92 participants were recruited for the study.

**Data collection:** Data were gathered using a structured questionnaire divided into three sections:

a) **Demographic and lifestyle factors:** This section included age, gender, marital status, occupational status, socio-economic class (as per the Modified Kuppuswamy scale) and religion. These variables were selected to explore potential associations between demographic factors and SQ.

b) **Assessment of Problematic Mobile Phone Use (PMPU):** PMPU was evaluated using a modified version of the PMPU Questionnaire (PMPUQ), which was internally validated [9]. The PMPUQ was adapted to better capture the behavioural aspects of PMPU and its impact on SQ. The modifications considered key factors such as the duration of mobile phone ownership, which helped assess long-term usage patterns, and daily screen time, which quantified the extent of mobile phone use. Additionally, a self-perceived addiction component was included, allowing participants to express their opinion on whether they believed they had a mobile phone addiction. This 30-item questionnaire assessed dangerous use (e.g., using mobile phones while driving), prohibited use (e.g., using mobile phones in restricted areas), dependence (e.g., excessive emotional reliance on mobile phones), financial problems (e.g., overspending on mobile-related expenses) and postural habits during use (e.g., prolonged neck flexion while using the phone). Each item was scored on a 4-point Likert scale ranging from 0 (strongly disagree) to 3 (strongly agree), with appropriate reverse scoring applied to negatively worded items. The total PMPU score ranged from 0 to 90, with higher scores indicating poorer problematic mobile phone habits. Based on their scores, participants were categorised into three risk groups: low-risk (0-30), moderate-risk (31-60), and high-risk (61-90).

c) **Assessment of Sleep Quality (SQ):** SQ was assessed using the PSQI [14], a validated 19-item self-report questionnaire that evaluates seven components of SQ: subjective SQ, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component was scored from 0 to 3, yielding a global PSQI score ranging from 0 to 21. A global score greater than 5 was considered indicative of poor SQ.

**Data collection duration and setting:** Participants completed the assessments within 30-45 minutes, during regular outpatient hours (8 am-3 pm). No compensation was provided for participation.

## STATISTICAL ANALYSIS

Data were analysed using Statistical Package for Social Sciences (SPSS) version 29.02. For PMPU and SQ, descriptive statistics were presented as frequencies, percentages, means±standard deviations. The Chi-square test was conducted to examine the associations between categorical variables, while Pearson's correlation coefficient was calculated to assess relationships between continuous variables. Multiple linear regression was performed to identify independent predictors of PSQI scores, with age, gender, daily mobile phone use, self-reported addiction and PMPU scores as independent variables. Logistic regression analysis was conducted to determine odds ratios for poor SQ (PSQI >5) based on PMPU scores and other relevant variables. For all analysis, a p-value <0.05 (5%) was considered statistically significant.

## RESULTS

A total of 92 participants were enrolled in this study. The demographic profile of the study population is presented in [Table/Fig-1]. The mean age of participants was 30.7±9.4 years, with the majority, 68 (73.9%), being under 35 years of age. Gender distribution was relatively balanced, with a slight male predominance of 48 (52.2%). Nearly half of the participants were married, 45 (48.9%), and most were employed, 53 (57.6%), or students, 27 (29.3%). Socio-economically, the majority belonged to the lower middle class, 38 (41.3%), or upper middle class, 34 (37.0%).

| Parameters | Frequency (%) |
|---|---|
| **Age group (in years)** | |
| 18-25 | 37 (40.2) |
| 26-35 | 31 (33.7) |
| 36-45 | 16 (17.4) |
| >45 | 8 (8.7) |
| **Gender** | |
| Male | 48 (52.2) |
| Female | 44 (47.8) |
| **Marital status** | |
| Single | 43 (46.7) |
| Married | 45 (48.9) |
| Separated/divorced | 3 (3.3) |
| Widowed | 1 (1.1) |
| **Occupational status** | |
| Employed | 53 (57.6) |
| Student | 27 (29.3) |
| Unemployed | 8 (8.7) |
| Retired | 4 (4.3) |
| **Socio-economic class** | |
| Upper | 12 (13.0) |
| Upper middle | 34 (37.0) |
| Lower middle | 38 (41.3) |
| Lower | 8 (8.7) |

**[Table/Fig-1]:** Demographic characteristics of study participants (N=92).

**Mobile phone usage:** Mobile phone usage characteristics are summarised in [Table/Fig-2]. A substantial proportion of participants, 41 (44.6%), reported using mobile phones for more than 10 years, with most participants, 52 (56.5%), using their phones for more than four hours daily. Notably, more than half of the participants, 49 (53.3%), self-identified as being addicted to their mobile phones. The majority, 58 (63.0%), made 0-5 calls per day.

**Problematic mobile phone addiction behaviours:** Detailed analysis of specific PMPU indicators [Table/Fig-3] showed that a substantial proportion of participants reported problematic mobile phone-related behaviours. Most notably, 61 (66.3%) of the participants reported

| Characteristic | Frequency (%) |
|---|---|
| **Usage frequency of mobile phone (in years)** | |
| <5 | 14 (15.2) |
| 5-10 | 37 (40.2) |
| >10 | 41 (44.6) |
| **Daily mobile phone use duration** | |
| <2 hours | 12 (13.0) |
| 2-4 hours | 28 (30.4) |
| 4-6 hours | 31 (33.7) |
| >6 hours | 21 (22.8) |
| **Self-reported mobile phone addiction** | |
| Yes | 49 (53.3) |
| No | 31 (33.7) |
| Maybe | 12 (13.0) |
| **Daily calls made** | |
| 0-5 | 58 (63.0) |
| 06-10 | 24 (26.1) |
| >10 | 10 (10.9) |

**[Table/Fig-2]:** Mobile phone usage characteristics (N=92).

| Problematic addiction behaviour | Always/ often (%) | Sometimes (%) | Rarely/ never (%) | Total (%) |
|---|---|---|---|---|
| Use mobile phone while driving | 38 (41.3) | 26 (28.3) | 28 (30.4) | 92 (100.0) |
| Hard to turn off mobile phone | 53 (57.6) | 24 (26.1) | 15 (16.3) | 92 (100.0) |
| Feel lost without mobile phone | 61 (66.3) | 19 (20.7) | 12 (13.0) | 92 (100.0) |
| Use mobile phone in dangerous situations | 27 (29.3) | 42 (45.7) | 23 (25.0) | 92 (100.0) |
| Mobile conversations longer than intended | 59 (64.1) | 21 (22.8) | 12 (13.0) | 92 (100.0) |

**[Table/Fig-3]:** Key PMPU indicators (N=92).

feeling lost without their mobile phones, 59 (64.1%) had mobile conversations longer than intended, and 53 (57.6%) found it hard to turn off their phones. Additionally, 38 (41.3%) reported using their mobile phones while driving, and 27 (29.3%) used their phones in dangerous situations.

**Risk categories of PMPU:** The PMPU questionnaire, a 30-item instrument, was scored on a 4-point Likert scale, ranging from 0 (strongly disagree) to 3 (strongly agree), with appropriate reverse scoring applied to negatively worded items. The total PMPU score ranged from 0 to 90, with higher scores indicating problematic mobile phone habits. Based on their scores, participants were categorised into three risk groups: low-risk (0-30), moderate-risk (31-60), and high-risk (61-90). Analysis of PMPU risk categories [Table/Fig-4] revealed that the majority of participants, 48 (52.2%), exhibited moderate-risk, while 23 (25.0%) demonstrated high-risk patterns. The mean PMPU score across all participants was 51.3±20.0.

| PMPU category | Frequency (%) |
|---|---|
| Low-risk (0-30) | 21 (22.8) |
| Moderate-risk (31-60) | 48 (52.2) |
| High-risk (61-90) | 23 (25.0) |

**[Table/Fig-4]:** PMPU Score Distribution (N=92).

**Sleep Quality (SQ):** The assessment of SQ using the PSQI revealed a mean global PSQI score of 9.1±3.4 [Table/Fig-5], with 68.5% of participants experiencing poor SQ (PSQI >5) [Table/Fig-6].

| PSQI component | Mean±SD score |
|---|---|
| Subjective sleep quality | 1.7±0.8 |
| Sleep latency | 1.8±1.0 |
| Sleep duration | 1.2±1.1 |
| Habitual sleep efficiency | 0.9±1.0 |
| Sleep disturbances | 1.5±0.7 |
| Use of sleep medication | 0.6±1.0 |
| Daytime dysfunction | 1.4±0.9 |
| Global PSQI score | 9.1±3.4 |

**[Table/Fig-5]:** Pittsburgh Sleep Quality Index (PSQI) components (N=92).

| Sleep Quality (SQ) | Frequency (%) |
|---|---|
| Good Sleep Quality (PSQI ≤5) | 29 (31.5) |
| Poor Sleep Quality (PSQI >5) | 63 (68.5) |

**[Table/Fig-6]:** Sleep Quality (SQ) categories (N=92).

**Mobile phone addiction on effect of problematic Sleep Quality (SQ):** Analysis of specific sleep problems [Table/Fig-7] revealed that the most common sleep difficulties were waking up in the middle of the night, with 54 (58.7%) reporting this at least once weekly; difficulty falling asleep within 30 minutes, with 46 (50.0%) reporting this at least once weekly; and having to use the bathroom, with 31 (33.7%) reporting this at least once weekly. These prevalence rates reflect participants who experienced the respective disturbances at least once per week, calculated by aggregating responses from the categories 'once or twice a week' and 'three or more times a week' as presented in the table. While these composite values are not shown as a separate column, they were derived to provide a more clinically meaningful summary.

| Sleep problem | Not during the past month (%) | Less than once a week (%) | Once or twice a week (%) | Three or more times a week (%) | Total (%) |
|---|---|---|---|---|---|
| Cannot fall asleep within 30 minutes | 17 (18.5) | 29 (31.5) | 32 (34.8) | 14 (15.2) | 92 (100.0) |
| Wake up in middle of night | 12 (13.0) | 26 (28.3) | 35 (38.0) | 19 (20.7) | 92 (100.0) |
| Have to use bathroom | 23 (25.0) | 38 (41.3) | 21 (22.8) | 10 (10.9) | 92 (100.0) |
| Cannot breathe comfortably | 52 (56.5) | 24 (26.1) | 11 (12.0) | 5 (5.4) | 92 (100.0) |
| Cough or snore loudly | 48 (52.2) | 26 (28.3) | 14 (15.2) | 4 (4.3) | 92 (100.0) |
| Feel too cold | 56 (60.9) | 23 (25.0) | 9 (9.8) | 4 (4.3) | 92 (100.0) |
| Feel too hot | 32 (34.8) | 37 (40.2) | 16 (17.4) | 7 (7.6) | 92 (100.0) |
| Have bad dreams | 39 (42.4) | 33 (35.9) | 15 (16.3) | 5 (5.4) | 92 (100.0) |
| Have pain | 45 (48.9) | 28 (30.4) | 14 (15.2) | 5 (5.4) | 92 (100.0) |

**[Table/Fig-7]:** Specific sleep problems (N=92).

**Association between PMPU risk categories and sleep quality:** Chi-square analysis revealed a significant association between PMPU risk categories and SQ (p-value <0.001) [Table/Fig-8]. Among participants with high PMPU risk, 21 (91.3%) experienced poor SQ, compared to 36 (75%) in the moderate-risk group and only 6 (28.6%) in the low-risk group.

| PMPU risk category | Good Sleep Quality (SQ) (PSQI ≤5) | Poor Sleep Quality (SQ) (PSQI >5) | Total | p-value |
|---|---|---|---|---|
| Low-risk (0-30) | 15 (71.4%) | 6 (28.6%) | 21 (100.0%) | <0.001* |
| Moderate-risk (31-60) | 12 (25.0%) | 36 (75.0%) | 48 (100.0%) | |
| High-risk (61-90) | 2 (8.7%) | 21 (91.3%) | 23 (100.0%) | |
| **Total** | **29 (31.5%)** | **63 (68.5%)** | **92 (100.0%)** | |

**[Table/Fig-8]:** Association between PMPU risk categories and Sleep Quality (SQ) (N=92).
*Chi-square test

**Correlation between PMPU score and PSQI components:** Further analysis using Pearson's correlation [Table/Fig-9] demonstrated strong positive correlations between PMPU scores and various PSQI components. The strongest correlations were observed for daytime dysfunction (r=0.63, p-value <0.001) and subjective SQ (r=0.58, p-value <0.001), while the weakest correlation was with the use of sleep medication (r=0.22, p-value=0.034). Overall, a strong positive correlation was observed between PMPU scores and global PSQI scores (r=0.61, p-value <0.001).

| PSQI component | Pearson's correlation coefficient (r) | p-value |
|---|---|---|
| Subjective Sleep Quality (SQ) | 0.58 | <0.001* |
| Sleep latency | 0.45 | <0.001* |
| Sleep duration | 0.39 | <0.001* |
| Habitual sleep efficiency | 0.32 | 0.002* |
| Sleep disturbances | 0.47 | <0.001* |
| Use of sleep medication | 0.22 | 0.034* |
| Daytime dysfunction | 0.63 | <0.001* |
| Global PSQI score | 0.61 | <0.001* |

**[Table/Fig-9]:** Correlation between PMPU Score and PSQI Components (N=92).
*Statistically significant (p<0.05)

**Identifying predictor variables of poor SQ:** To identify how different predictor variables (PMPU score, daily mobile phone use, age, gender, self-reported addiction) contribute to poor SQ, multiple linear regression analysis was conducted. This analysis [Table/Fig-10] identified PMPU score (β=0.512, p-value <0.001) and daily mobile phone use duration (β=0.257, p-value=0.003) as significant independent predictors of poor SQ (higher PSQI scores) after controlling for potential confounders. The overall model explained 45.3% of the variance in global PSQI scores (adjusted $R^2$=0.453).

| Variable | Unstandardised β | Standardised β | p-value |
|---|---|---|---|
| PMPU score | 0.087 | 0.512 | <0.001* |
| Age | 0.018 | 0.054 | 0.521 |
| Gender (female) | 0.743 | 0.109 | 0.178 |
| Daily mobile phone use (in hours) | 0.312 | 0.257 | 0.003* |
| Self-reported addiction (Yes) | 0.968 | 0.142 | 0.069 |

**[Table/Fig-10]:** Multiple linear regression analysis for predictors of poor Sleep Quality (SQ) (N=92).
*Statistically significant (p<0.05); Dependent variable: Global PSQI Score; $R^2$=0.482; Adjusted $R^2$=0.453

**Logistic regression analysis for predictors of poor SQ:** To analyse the predictors of poor SQ (PSQI >5), logistic regression analysis was performed. This analysis [Table/Fig-11] further confirmed that each 10-point increase in PMPU score was associated with 2.35 times higher odds of poor SQ (OR=2.35, 95% CI: 1.62-3.41, p-value <0.001). Similarly, each additional hour of daily mobile phone use increased the odds of poor SQ by 41% (OR=1.41, 95% CI: 1.13-1.76, p-value=0.002).

| Variable | Odds ratio | 95% CI | p-value |
|---|---|---|---|
| PMPU score (per 10-point increase) | 2.35 | 1.62-3.41 | <0.001* |
| Age (per 10-year increase) | 1.12 | 0.78-1.61 | 0.534 |
| Gender (Female vs. Male) | 1.87 | 0.92-3.81 | 0.087 |
| Daily mobile phone use (per hour increase) | 1.41 | 1.13-1.76 | 0.002* |
| Self-reported addiction (Yes vs. No) | 2.15 | 0.98-4.72 | 0.057 |

**[Table/Fig-11]:** Logistic regression analysis for predictors of Poor Sleep Quality (PSQI >5) (N=92).
*Statistically significant (p<0.05); CI: Confidence interval

**Subgroup analysis for confounding factor age:** Subgroup analysis by age [Table/Fig-12] revealed that both PMPU scores and PSQI scores decreased with increasing age, with the strongest correlation between PMPU and SQ observed in the youngest age group (18-25 years, r=0.68, p-value <0.001).

| Age group (in years) | Mean±SD PMPU | Mean±SD PSQI | Correlation (r) | p-value (5%) |
|---|---|---|---|---|
| 18-25 (n=37) | 57.3±18.7 | 9.8±3.5 | 0.68 | <0.001* |
| 26-35 (n=31) | 52.1±20.3 | 9.3±3.2 | 0.59 | <0.001* |
| 36-45 (n=16) | 43.6±19.6 | 8.2±3.3 | 0.53 | 0.034* |
| >45 years (n=8) | 35.9±16.8 | 7.1±3.0 | 0.47 | 0.242 |

**[Table/Fig-12]:** PMPU and Sleep Quality (SQ) by age group (N=92).
*Statistically significant (p<0.05)

**Subgroup analysis for confounding factor gender:** Gender-specific analysis [Table/Fig-13] showed that females had slightly higher mean PMPU scores (53.6±19.3 vs. 49.3±20.4) and PSQI scores (9.7±3.5 vs. 8.5±3.2) compared to males. The correlation between PMPU and SQ was stronger in females (r=0.65) than in males (r=0.57).

| Gender | Mean±SD PMPU | Mean±SD PSQI | Correlation (r) | p-value |
|---|---|---|---|---|
| Male (n=48) | 49.3±20.4 | 8.5±3.2 | 0.57 | <0.001* |
| Female (n=44) | 53.6±19.3 | 9.7±3.5 | 0.65 | <0.001* |
| Total | 51.3±20.0 | 9.1±3.4 | 0.61 | <0.001* |

**[Table/Fig-13]:** PMPU and Sleep Quality (SQ) by gender (N=92).
*Statistically significant (p<0.05)

## DISCUSSION

This study investigated the relationship between PMPU related to mobile phone habits and SQ among adults. The findings revealed a strong positive correlation between PMPU scores and PSQI scores (r=0.61, p-value <0.001), indicating that individuals with problematic mobile habits and poor posture during mobile phone use experience significantly poorer SQ. This relationship persisted after controlling for potential confounding variables, including age, gender and duration of mobile phone use.

The prevalence of poor SQ (PSQI >5) in this study population was 68.5%, which was considerably higher than the general population estimates, ranging from 10 to 30% reported in previous epidemiological studies [15,16]. This elevated prevalence might be attributed to the high proportion of participants with moderate to high PMPU risk (77.2%) in the current study. The finding that 91.3% of participants with high PMPU risk experienced poor SQ supports the emerging literature on technology-related behaviours and sleep disturbances. Comparable results were observed by Alshobaili FA and AlYousefi NA, who reported that 67.2% of smartphone users with intensive night-time use exhibited poor SQ [17].

The correlation between PMPU and specific PSQI components provides insights into potential mechanisms underlying this relationship. The strongest correlations were observed for daytime dysfunction (r=0.63) and subjective SQ (r=0.58), suggesting that poor postural habits during mobile phone use may primarily impact these aspects of sleep. These findings align with those of Mohammadbeigi A et al., who demonstrated that excessive smartphone use was associated with daytime dysfunction and subjective SQ, but had less impact on sleep duration [18].

Multiple regression analysis identified PMPU score as the strongest independent predictor of poor SQ (β=0.512, p-value <0.001), followed by daily mobile phone use duration (β=0.257, p-value=0.003). This finding expands upon previous research by Lemola S et al., who reported that smartphone use before bedtime was associated with later bedtimes and shorter sleep duration, but did not specifically examine the postural components of device use [19]. The study results suggest that, beyond the established effects of screen time and blue light exposure, the physical posture adopted during mobile phone use may represent an additional pathway through which digital device use impacts SQ.

The logistic regression analysis demonstrated that each 10-point increase in PMPU score was associated with 2.35 times higher odds of poor SQ. This dose-response relationship between PMPU and sleep disturbance was consistent with findings by Yang J et al., who reported a similar dose-dependent association between smartphone addiction scores and SQ, with an odds ratio of 2.05 for poor SQ among heavy smartphone users [11]. However, this study specifically highlights the importance of the postural aspects of phone use rather than general usage patterns or addiction metrics.

Although age was not identified as a confounder (p-value=0.521), subgroup analysis revealed that it functioned as an effect modifier. Both PMPU scores and PSQI scores decreased with increasing age, with the strongest correlation between these variables observed in the youngest age group (18-25 years, r=0.68). This age-dependent pattern aligns with research by Kwon M et al., who found that younger adults were more likely to adopt problematic mobile phone postures and experience associated health consequences [20]. The stronger correlation among younger participants may reflect their higher intensity of use, greater susceptibility to postural strain, or different patterns of device engagement compared to older adults.

Gender-specific analysis indicated slightly higher mean PMPU and PSQI scores among females compared to males, with a stronger correlation between these variables in females (r=0.65 vs. r=0.57). This gender difference was consistent with findings by Wang PY et al., who reported greater smartphone-related neck pain and sleep disturbances among female university students [21]. Additionally, psychosocial factors, including higher levels of stress, anxiety and emotional responsiveness in females, could contribute to a greater susceptibility to sleep disturbances. Biological differences, such as hormonal influences on sleep regulation, are also considered potential explanations [22,23].

Several physiological mechanisms may explain the observed association between PMPU and SQ. First, sustained non ergonomic postures during mobile phone use can induce musculoskeletal pain and discomfort, which are known to interfere with sleep initiation and maintenance [24]. Second, prolonged static loading of cervical musculature may lead to sympathetic nervous system activation and elevated cortisol levels, potentially disrupting normal sleep-wake regulation [25]. Third, proprioceptive alterations resulting from chronic poor posture may affect central nervous system functioning and subsequent sleep architecture [26]. The study's focus on postural factors in PMPU could be elaborated upon by explaining how these factors influence SQ in addition to screen time and addiction-related issues. While previous studies have primarily emphasised screen exposure and blue light effects [27], the current study suggests that poor posture during mobile phone use may contribute to sleep disturbances through musculoskeletal discomfort, increased sympathetic activation and potential disruptions in circadian rhythm. The study has several strengths, including the comprehensive assessment of both PMPU and SQ using validated instruments, the examination of specific components of SQ and the consideration of multiple potential confounding variables such as age, gender, duration of daily mobile use and the self-reported addiction scale.

### Limitation(s)

The cross-sectional design precludes the establishment of causal relationships between PMPU and sleep disturbances; therefore, longitudinal studies should be conducted in the future to better establish causality. Self-reported measures may be subject to recall bias and social desirability effects. Additionally, while we excluded individuals with diagnosed sleep disorders and undiagnosed conditions, some factors, such as lifestyle (caffeine intake, work schedules, or stress) of the participants, which were not included in the study, might have influenced present study findings.

## CONCLUSION(S)

This study demonstrates a significant association between PMPU and decreased SQ. Individuals with higher PMPU risk exhibited substantially poorer sleep outcomes, with the relationship between addictive mobile phone use and sleep disturbances persisting after controlling for demographic variables and usage patterns. The findings suggest that PMPU represents an important factor influencing sleep health. Healthcare providers should incorporate awareness of PMPU into sleep hygiene recommendations.

To mitigate the impact of PMPU on SQ, public health interventions should focus on promoting ergonomic mobile phone use and establishing digital wellness guidelines. Strategies for reducing PMPU include implementing screen time limits, encouraging regular breaks and promoting posture-friendly device use through public awareness campaigns. Clinical recommendations should include patient education on the musculoskeletal effects of poor posture, behavioural interventions for reducing screen exposure before bedtime, and ergonomic modifications such as holding devices at eye level to minimise cervical strain.

Future longitudinal and intervention studies are needed to establish causal relationships and evaluate whether improving limited mobile phone use can enhance sleep outcomes. This research highlights the importance of considering limited technology engagement when addressing technology-related sleep disturbances.

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