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Electronic device use and depressive symptoms in college students mediated by sleep onset time

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This study aimed to examine the association between electronic device use duration and depressive symptoms among Chinese college students, while also exploring the mediating role of sleep onset time. Data were collected from university students in Xuzhou City, Jiangsu Province, China. Statistical analyses were conducted using STATA 17.0. Ordinary least squares (OLS) regression was employed for both univariate and multivariate analyses. Additionally, a stepwise regression approach was used to assess the mediating effect of sleep onset time. A total of 1,160 valid cases were included in the final analysis. The regression results indicated a significant positive association between electronic device use duration and depressive symptoms, even after adjusting for all control variables. Furthermore, stepwise regression analysis confirmed that sleep onset time partially mediated the relationship between electronic device use and depressive symptoms. Sleep onset time serves as a mediating factor in the link between electronic device use and depressive symptoms. Interventions aimed at promoting healthier lifestyle habits, such as reducing screen time and encouraging physical activity, may help improve the mental well-being of college students.

Keywords Electronic device use, College students, Depressive symptoms, Sleep onset time

The COVID-19 pandemic has profoundly altered daily life, impacting physical health, economic stability, and mental well-being across all age groups¹. Among these populations, college students—a highly educated demographic and a crucial driving force in future societal development—have faced unique health challenges. Their well-being is of significant social concern, as their transition from academia to the workforce is a critical period that shapes their long-term development. Health, as a fundamental prerequisite, directly or indirectly influences efficiency and return on human capital investment. The university years serve as a pivotal stage for physical development and knowledge acquisition, where students' health status not only affects future productivity but also determines their ability to successfully complete their education and achieve personal and professional aspirations. Notably, depressive symptoms can severely impact mood, quality of life, and physical health² and are recognized as independent risk factors for increased mortality in adults^{3,4}.

With the rapid expansion of the electronic information industry, the prevalence of smart electronic devices—such as smartphones, tablets, and laptops—has significantly increased among college students. According to the “2024 White Paper on Sleep Health of Chinese Residents”, 56% of college students spend over eight hours per day on their mobile phones, with more than half staying up past midnight and 19% remaining awake past 2:00 AM. This pattern aligns with the anticipated trends of the electronic information industry in 2025, where technological advancements, such as AI integration and computing-network fusion, are expected to enhance user engagement and deepen students' dependence on electronic devices. This reliance on digital technology has intensified since the COVID-19 pandemic, as remote learning and social distancing measures normalized prolonged screen exposure. Reports indicate that daily screen time increased from an average of 2.67 h pre-pandemic to 4.38 h post-pandemic^{5,6}. Excessive screen time has been associated with multiple adverse health outcomes, including obesity, chronic diseases, and mental health disorders such as depression^{7–10}. Hamshari's study revealed a significant increase in adolescents' screen time during the COVID-19 pandemic, with prolonged device usage demonstrating positive associations with depressive and anxiety symptoms¹¹. Anhedonia, a core

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diagnostic criterion for both anxiety and depressive disorders, has been systematically linked to excessive digital media use in adolescents. Cangelosi et al.'s review confirmed this association, demonstrating that prolonged screen exposure predicts subsequent increases in affective symptom severity¹². Chronic preoccupation with virtual networks and detachment from physical social interaction may exacerbate perceived social isolation, consequently elevating vulnerability to suicidal ideation and behaviors¹³. These findings collectively demonstrate the significant adverse impacts of the COVID-19 pandemic on university students' psychological well-being and overall life satisfaction, with anxiety and depressive symptoms emerging as particularly prominent manifestations¹⁴.

Current literature frequently examines pairwise relationships among university students' electronic device usage duration, sleep onset time, and depressive symptoms^{15–17}. However, triadic investigations within the Chinese cultural context remain scarce, with limited exploration of the underlying mechanisms through which prolonged device usage influences depressive symptom. It is crucial to recognize that the relationship between electronic device use and depressive symptoms extends beyond direct effects. Behavioral patterns act as mediating factors: excessive nighttime screen use delays sleep onset, reduces total sleep duration, and leads to sleep deprivation. This, in turn, leads to daytime fatigue among college students, which gradually develops into persistent energy depletion and ultimately contributes to the onset of depressive symptoms. Concurrently, excessive electronic device use may lead to compulsive engagement with virtual environments, potentially resulting in internet addiction, which is a well-established risk factor for depression. Given the growing prevalence of this issue, a comprehensive analysis of the impact of electronic device use on depressive symptoms and the underlying mechanisms is of both theoretical and practical significance. Based on this theoretical framework, the present study proposes a mediation model with electronic device use duration as the independent variable, depressive symptom as the dependent variable, and sleep onset time as the mediating variable (Fig. 1).

Methods

Study population

This study employed a convenience sampling method, selecting participants from a university in Xuzhou City, Jiangsu Province, China. Recruitment was conducted by contacting faculty members across various disciplines through the Academic Affairs Office and the Student Affairs Office. With institutional approval from the university administration, we employed a two-stage sampling procedure: (a) random selection of departmental colleges, followed by (b) in-class questionnaire distribution by faculty members during regular sessions. Participants received standardized explanations of research objectives prior to survey completion, with a total of 1,200 questionnaires administered.

All participants will be informed before filling out the questionnaire that they are free to do so voluntarily. During the answering process, if the research subjects are unwilling to complete the answers, they can quit at any time without any penalty. In this study, students are deemed to have given their informed consent once they have completed the questionnaire. The system cannot trace back to individuals to ensure the privacy of the participants. A total of 1,194 responses were collected, of which 1,160 were deemed valid, and the response rate was 96.7%.

To ensure the accuracy and validity of the questionnaire design, multiple revisions and pre-tests were conducted to refine question clarity and comprehensibility. After data collection, initial screening procedures were implemented to eliminate outliers and incomplete responses, thereby ensuring the representativeness of the sample and the reliability of the data. These quality control measures provided a robust foundation for subsequent statistical analyses.

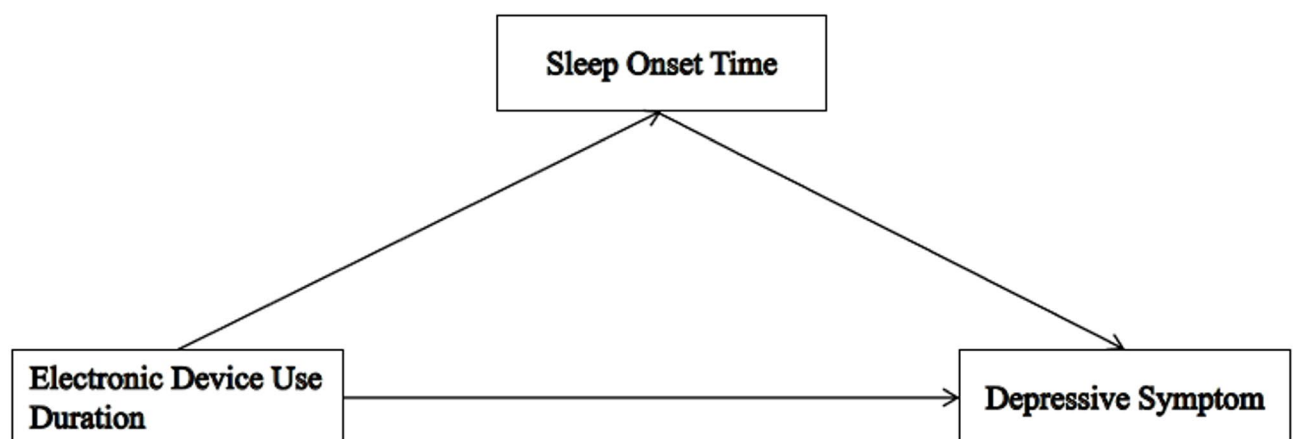


Fig. 1. The hypothesis mediation model.

Questionnaire design

The questionnaire consisted of two primary components:

Basic information and health-related behaviors

This section collected demographic characteristics, including gender, age, academic year, and place of residence. Additionally, it gathered information on health-related behaviors such as smoking status, alcohol consumption, electronic device usage duration, sleep duration, presence of chronic diseases, and average weekly exercise time.

Depressive symptoms assessment

Depressive symptoms were assessed using the Chinese version of the Center for Epidemiologic Studies Depression Scale (CES-D), a widely validated tool for evaluating depressive symptoms in Chinese adolescents and college students. This scale was proved to have good screening accuracy for depressive symptoms¹⁸. The CES-D comprises 20 items corresponding to depressive symptoms, with participants self-reporting symptom frequency over the past week. Responses were rated on a four-point Likert scale (0–3), with items 4, 8, 12, and 16 reverse-scored. The total score ranged from 0 to 60, with higher scores indicating greater levels of depressive symptoms.

To maximize the response rate and ensure participant confidentiality, the questionnaire did not request any personally identifiable information.

Variable definitions and measurement

Hours of electronic device use

The key independent variable in this study is the duration of electronic device use. Participants were asked to respond to the following questionnaire item: “On an average day, how many hours do you spend using electronic devices (e.g., smartphones, tablets, computers)?” Responses were recorded as a continuous variable, representing the total daily usage in hours.

Sleep duration

Sleep duration was considered the mediating variable in this study. Participants were asked: “At what time do you typically go to sleep at night?” Response options included:

- Before 21:00 (coded as 1); 21:00–22:00 (coded as 2); 22:00–23:00 (coded as 3).
 - 23:00–00:00 (coded as 4); after 00:00 (coded as 5)
- Higher values indicated later sleep onset times.

Covariates

To control potential confounding factors, a set of covariates was included based on prior research. These variables encompassed:

- Demographic characteristics: Age, gender, and place of residence.
- Health-related factors: Self-reported health status, smoking behavior, alcohol consumption, and the presence of chronic diseases.

These covariates were incorporated into the analysis to ensure robustness in estimating the association between electronic device use, sleep duration, and depressive symptoms (Table 1).

Ethical statement

The study was conducted according to the guidelines of Declaration of Helsinki and received approval from the Institutional Review Board of the Affiliated Hospital of Xuzhou Medical University.

Research methods

Data analysis was conducted using STATA 17.0 software. Ordinary least squares (OLS) regression was employed for both univariate and multivariate analyses, while stepwise regression was utilized to examine the mediating effects of variables. The forward stepwise regression method we took in this study. In the inclusion of variables,

Variable name	Coding
Depression	0–60
Electronic device use duration	≥ 0
Sleep onset time	Before 21:00 = 1, 21:00–22:00 = 2, 22:00–23:00 = 3, 23:00–00:00 = 4, After 00:00 = 5
Weekly exercise frequency	0–7
Gender	Male = 1, Female = 2
Age	18–30
Place of residence	Urban = 1, Rural = 2
Smoking status	No = 0, Yes = 1
Alcohol consumption	No = 0, Yes = 1
Self-rated health status	Very Good = 1, Good = 2, Average = 3, Poor = 4, Very Poor = 5
Chronic disease status	No = 0, Yes = 1

Table 1. Variables and operational definitions.

in addition to the model variables, we included variables that had a significant effect on depressive symptoms in the univariate analysis as control variables. In forward regression, control variables were included one by one. A significance level of $P < 0.05$ was used to indicate statistical significance.

Results

Preliminary analysis

Table 2 presents a summary of the descriptive statistics. The mean depression score among college students was 19.21, with a standard deviation (SD) of 2.5. Regarding electronic device usage, the average duration was 6.7 h per day (SD = 2.8), indicating substantial individual variability. Sleep time distribution analysis revealed that the highest proportion of participants (39.57%) went to bed between 23:00 and 00:00, whereas only 29 individuals (2.5%) reported sleeping before 21:00. The highest proportion of participants ($n = 288$, 24.8%) reported engaging in physical exercise twice weekly.

In terms of demographic characteristics, female participants accounted for 59.7%, slightly exceeding the proportion of males. The average age was 20.2 years (SD = 2.2). The distribution of participants between urban (56.29%) and rural (43.71%) areas was relatively balanced. Concerning lifestyle habits, 94.05% of participants reported being non-smokers, and 61.12% indicated they did not consume alcohol, both of which were in the majority.

Variable	Frequency	Percentage (%)	p-value
Depression score	19.2 ± 2.5		
Electronic device use duration	6.7 ± 2.8		<0.001
Sleep onset time			
Before 21:00	29	2.5	<0.001
21:00–22:00	102	8.79	
22:00–23:00	303	26.12	
23:00–00:00	459	39.57	
After 00:00	267	23.02	
Weekly exercise frequency			
0	109	9.4	<0.001
1	195	16.8	
2	288	24.8	
3	251	21.6	
4	64	5.5	
5	131	11.3	
6	24	2.1	
7	98	8.4	
Gender			
Male	469	40.3	0.155
Female	691	59.7	
Age	20.2 ± 2.2		<0.05
Place of residence			
Urban	653	56.29	0.091
Rural	507	43.71	
Smoking status			
Yes	69	5.95	0.303
No	1091	94.05	
Alcohol consumption			
Yes	451	38.8	0.503
No	709	61.12	
Self-rated health status			
Very good	345	29.74	<0.001
Good	426	36.72	
Average	261	31.12	
Poor	20	1.72	
Very poor	8	0.69	
Chronic disease status			
Yes	193	16.64	<0.001
No	967	83.36	

Table 2. Descriptive statistics and univariate analysis.

Variable	Model 1 (Y = Dep)	Model 2 (Y = SOT)	Model 3 (Y = Dep)
	B	B	B
Constant	14.501***	2.332***	13.470***
Chronic disease status	−2.372***	0.021	−2.423***
Self-rated health status	2.271***	0.174***	2.194***
Age	0.017	0.021	0.008
Weekly exercise frequency	0.041	−0.035***	0.056
EDUD(X)	0.232***	0.090***	0.442**
SOT (M)	–	–	0.193**

Table 3. Model characteristics for mediation analysis of electronic device use duration on depressive symptoms through sleep onset time. *Dep* depressive symptom, *EDUD* electronic device use duration, *SOT* sleep onset time. The covariates in Model 1, 2 and 3 include chronic disease status, self-rated health status, age and weekly exercise frequency. ** $p < 0.01$, *** $p < 0.001$.

For self-rated health status, 36.72% of participants considered their health to be “good,” while 29.74% rated it as “very good.” Conversely, the proportion of individuals who perceived their health as “poor” or “very poor” was relatively low. Regarding chronic disease prevalence, 16.64% of participants reported having a chronic illness, whereas 83.36% did not. In terms of life satisfaction, the majority of participants (53.10%) rated their life as “average.” Meanwhile, 16.72% and 24.57% rated their life satisfaction as “very good” and “good,” respectively.

Regression analysis

Univariate regression analysis revealed that the duration of electronic device use ($p < 0.001$), sleep time ($p < 0.001$), exercise frequency ($p < 0.001$), age ($p < 0.05$), self-rated health status ($p < 0.001$), and the presence of chronic diseases ($p < 0.001$) were significantly associated with depression levels (Table 2). These findings suggest that variations in these factors may have a notable impact on depression and severity. In contrast, gender, place of residence, smoking status, and alcohol consumption were not significantly correlated with depression ($p > 0.05$), indicating that changes in these variables may not have a substantial effect on the dependent variable.

We included demographic variables that were significant in the univariate analysis as covariates in the regression equation for mediation analysis. The results of mediation analysis presented in Table 3 indicate that the duration of electronic device use exhibited a significant positive association with depression levels in Model 1. This finding suggests that prolonged use of electronic devices may increase the risk of depression. However, after controlling sleep time, the coefficient for electronic device use duration decreased, implying a potential mediating effect of sleep duration on this relationship. In other words, the impact of electronic device use on depression may be partially explained by its influence on sleep onset time.

Furthermore, bedtime remained significantly and positively associated with depression in both Model 1 and Model 3, indicating that a later bedtime may serve as a critical risk factor for depression. Additionally, self-rated health status and the presence of chronic diseases were consistently and significantly correlated with depression severity across different models. These results suggest that poorer self-rated health and the presence of chronic diseases may contribute to an increased risk of depression.

Mediation analysis

To further examine whether sleep onset time mediates the relationship between electronic device use duration and depression, we employed the stepwise regression method. As shown in Table 3, Model 1 demonstrates a significant positive association between the duration of electronic device use and depression, suggesting that prolonged electronic device use may increase the risk of depression when other factors are not considered.

However, upon introducing sleep onset time as an additional variable in Model 3, the coefficient for electronic device use duration decreased, while sleep onset time exhibited a significant positive correlation with depression. This change implies that sleep onset time may serve as a mediating factor in the relationship between electronic device use duration and depression. In other words, the adverse impact of electronic device use on depression may not be entirely direct but rather operate through its influence on sleep onset time, thereby contributing to depression.

To validate this hypothesis, we further analyzed the regression results in Model 2. The findings indicate that electronic device use duration has a significant positive effect on sleep onset time. This result provides additional support for the proposed mediation mechanism, suggesting that prolonged electronic device use may increase the risk of depression by delaying sleep onset. The estimated mediating effect of sleep onset time accounted for 17.08% of the total effect ($a \times b = 0.0397$), highlighting its part partial mediation role in the relationship between electronic device use and depression.

Discussion

This study examined the impact of electronic device use duration on depressive symptoms among college students, with a particular focus on the mediating role of sleep onset time. Through multifactor regression analysis, stepwise regression, and subsequent mediation effect tests, we derived several important findings. The results indicate that prolonged electronic device use is significantly and positively associated with depressive symptoms,

consistent with previous research. However, after accounting for sleep onset time in the regression model, the direct effect of electronic device use duration on depression weakened, suggesting a potential mediating role of sleep. Specifically, increased electronic device use may elevate the risk of depression by delaying sleep onset or impairing sleep quality. These findings elucidate a critical pathway through which excessive electronic device use negatively affects mental health and provide empirical evidence for future intervention strategies.

Globally, the prevalence of mental health disorders among children and young adults is approximately 15%¹⁹, with depression being the most common psychiatric disorder in this population²⁰. In our study, the prevalence of depressive symptoms among university students was 31.29%, exceeding the global average. Existing literature suggests that this elevated prevalence may be associated with the COVID-19 pandemic^{21–23}.

On one hand, prolonged isolation measures during the pandemic restricted social interactions and mobility, potentially triggering feelings of loneliness and social disconnection, which pose significant risks to mental health. The prolonged homebound status may have led to a sense of entrapment and monotony, further increasing the risk of depression. On the other hand, the uncertainty, economic stress, and future concerns brought about by the pandemic are also non-negligible contributing factors. Many students faced multiple stressors, including disruptions in their education, uncertain career prospects, and financial strain on their families, all of which may have exacerbated depressive symptoms.

Moreover, while the widespread adoption of online education ensured academic continuity, it also introduced new challenges. The lack of face-to-face communication, alterations in the learning environment, and the increased demand for self-regulation and time management skills may have negatively impacted students' mental well-being. These findings highlight the complex interplay between digital behavior, sleep patterns, and external stressors in shaping mental health outcomes, emphasizing the need for targeted interventions to mitigate the adverse effects of excessive electronic device use on students' psychological well-being.

Research findings have demonstrated a strong correlation between electronic device use duration and the incidence of depressive symptoms. Excessive engagement with electronic devices, particularly prolonged screen exposure, has been associated with a range of negative psychological and physiological effects among college students. These adverse effects extend beyond temporary distress, often manifesting as long-term and profound consequences.

One major concern is that young individuals frequently compromise their sleep needs due to extended screen use, leading to sleep disturbances that, in turn, negatively impact their overall health and cognitive performance. Furthermore, excessive reliance on electronic devices can interfere with academic engagement, making it difficult for students to sustain attention and effectively absorb knowledge. Compounding this issue, prolonged screen time reduces face-to-face interactions with peers and family members, thereby weakening social skills and exacerbating feelings of loneliness and social isolation.

Beyond academic and social consequences, excessive electronic device use has also been linked to increased engagement in risk-taking behaviors and a heightened likelihood of exhibiting aggressive tendencies. These behavioral changes may increase exposure to various risks, including substance abuse²⁴. Additionally, prolonged sedentary behavior and insufficient physical activity contribute to weight gain and other physical health concerns, further compounding the negative effects on well-being. Collectively, these interconnected factors create a reinforcing cycle that may culminate in the onset of depressive symptoms.

The widespread use of electronic devices was further intensified by school closures during the COVID-19 pandemic. To maintain educational continuity, students became increasingly dependent on online learning platforms, resulting in even greater screen exposure²⁵. However, this shift also exacerbated social isolation, as students spent prolonged hours engaging with screens rather than participating in traditional face-to-face interactions²⁶.

Our findings also highlight the critical mediating role of sleep onset time in the relationship between electronic device use and depression. These findings align with previous research. Alam et al. demonstrated through studies on blue light exposure from electronic devices that prolonged exposure affects ipRGCs, inhibits melatonin secretion, and directly disrupts the SCN-regulated circadian rhythm, consequently impacting sleep onset time²⁷. A review article further highlighted that digital addiction behaviors can influence sleep through physiological mechanisms such as neurotransmitter imbalance and melatonin suppression. Poor sleep quality subsequently triggers a series of negative consequences, including depression and social withdrawal²⁸. Our study extends this understanding by demonstrating through mediation analysis of college students' daily electronic device usage that even non-addictive device use can increase depression risk.

These findings underscore the need for targeted interventions to mitigate the negative effects of excessive electronic device use on both sleep health and mental well-being. At the institutional level, universities should implement mental health literacy programs with sleep hygiene components, while expanding extracurricular activities to facilitate offline socialization and reduce digital overreliance. Individually, students are advised to: (a) maintain regulated sleep patterns, (b) practice mindful technology use, and (c) develop emotion regulation competencies through in-person interactions. Early professional intervention is critical when self-management of depressive symptoms proves ineffective.

By investigating the mediating role of sleep onset time in the relationship between electronic device use duration and depression, this study provides novel insights into the impact of electronic device use on mental health. However, several limitations should be acknowledged. First, this study utilized cross-sectional data, which precludes the establishment of causal relationships. Future research could employ longitudinal study designs or experimental approaches to further validate the causal links between electronic device use duration, sleep onset time, and depressive symptoms. Longitudinal tracking would allow for a more comprehensive understanding of how changes in electronic device use over time influence sleep patterns and mental health outcomes. Second, this study did not differentiate between types of electronic devices. Different devices—such as smartphones, computers, and tablets—serve distinct functions and may be associated with varying usage patterns, which could

differentially affect sleep onset and depression. Future research should consider disaggregating electronic device types to explore their specific impacts on sleep quality and mental health, thereby providing a more nuanced understanding of the relationship between screen exposure and depressive symptoms. Third, the present study's exclusive reliance on one academic institution necessarily limits population-level inferences. Subsequent research should address this through deliberately stratified sampling across multiple university settings.

Conclusion

In conclusion, our findings indicate that, among Chinese college students, electronic device use duration is significantly associated with an increased risk of depressive symptoms, with sleep onset time serving as a full mediator in this relationship. These findings have important implications for the prevention and management of mental health issues in college populations. Future interventions should focus on promoting healthier lifestyle behaviors, such as reducing screen time and increasing physical activity, as potential strategies for mitigating depressive symptoms. Encouraging better sleep hygiene and limiting electronic device use before bedtime may serve as effective approaches to improve both psychological well-being and behavioral health among college students.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

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Author contributions

LX, CZ and SX participated in the study conception and design. SX and YY participated in the acquisition of data. LX and SX participated in the analysis and interpretation of data. SX participated in the drafting of the manuscript. JW, YZ, YY, CZ and LX, SX participated in the critical revision of the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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