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ORIGINAL RESEARCH

# Association Between the Time of Exposure to Electronic Screen and Anxiety and Depression After Controlling Demographics, Exercises, and Lifestyles Among University Students

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**Background:** The use of electronic screens has become ubiquitous in modern society, but the specific relationship between hours of electronic screen exposure and mental health outcomes needs to be further investigated. Hence, this study aims to examine the detailed relationship between electronic screen exposure time and mental health status.

**Methods:** A sample of 2896 university students were recruited and their baseline characteristics, including demographics, lifestyle habits, and mental health status, were collected. The association between electronic screen exposure time and mental health status was investigated using linear regression analysis. The predictive performance of electronic screen exposure time for predicting mental health status, including severe anxiety and depression was, also analyzed using the area under the curve (AUC) analysis.

**Results:** The time of exposure to electronic screen was significantly associated with anxiety ($p < 0.001$) and depression ($p < 0.001$). The AUC value was 0.641 (95% CI: 0.571–0.712) for severe anxiety and 0.665 (95% CI: 0.613–0.716) for severe depression. The optimal cut-off value for predicting anxiety and depression based on electronic screen exposure time was found to be both 6.5 hours. A subgroup analysis confirmed that participants with higher exposure time to electronic screens had significantly higher anxiety ($p < 0.001$) and depression scores ($p < 0.001$). The association between the hours of exposure to electronic screen and severe anxiety ($p = 0.042$) and severe depression ($p < 0.001$) remained significant after controlling for demographics, exercises, and other lifestyle factors.

**Conclusion:** The findings suggest that excessive electronic screen exposure time is associated with increased risk of anxiety and depression among university students. These findings highlight the need for interventions targeting electronic screen use to improve mental health outcomes, and less than 6.5 hours per day of exposure to electronic screen are recommended among university students.

**Keywords:** university students, exposure to electronic screen, mental health, anxiety, depression

## Introduction

The mental health of university students is a serious concern worldwide, with a significant portion experiencing mental distress, such as anxiety and depression. Studies have shown that 23.6% to 41.8% university students had anxiety,[1–3] and 27.2% to 51.3% had depression.[4–6] These problems can have a devastating impact on academic performance, social life, and overall well-being among university students.[7–9] However, the exact factors contributing to the development of these problems are not fully understood.

Identifying the risk factors associated with mental distress presents an opportunity for the prevention of anxiety and depression.[10] Lifestyle factors play a crucial role in this regard, as they are easily modifiable variables.[11,12] Among the various lifestyle factors, such as exercise routines, which has been found to be a favorable measure to

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mitigate mental distress,[11,13] the influence of hours of exposure to electronic screens on mental distress remains unclear and warrants further investigation. While some studies have explored the association between smartphone or internet addiction and mental health problems,[14,15] a significant gap remains in the literature concerning the specific relationship between hours of electronic screen exposure and mental health outcomes, particularly among university students. For instance, further research is needed to explore the impact of screen time on mental health, with a particular emphasis on establishing clear thresholds or cut-off values that could inform evidence-based recommendations for safe screen use.

In the modern context, university students heavily rely on computers for academic work, completing assignments, and engaging in recreational activities such as watching short videos on their smartphones. However, the specific relationship between hours of exposure to electronic screens and anxiety and depression has not been extensively studied. Given that the current generation of university students spends a significant amount of time using computers for homework, entertainment, and social media,[16] it was plausible to speculate that hours of exposure to electronic screens might play a role in the development of mental health problems. By exploring this relationship, researchers can potentially identify a cut-off value associated with anxiety and depression in terms of the exposure time to electronic screen, enabling personalized recommendations for daily computer usage. This approach holds significance in promoting mental well-being among university students.

Therefore, the primary objective of this study was to delve into the detailed relationship between electronic screen exposure time and mental health status specifically among university students. Additionally, the study aimed to pinpoint both risk factors and protective factors influencing severe anxiety and depression within this population. Through this investigation, valuable insights can be gained to inform preventive strategies and interventions aimed at fostering mental health resilience among university students. We hypothesize that excessive exposure to electronic screens is significantly associated with higher levels of anxiety and depression among university students.

# Methods

## Participants

This study conducted a comprehensive analysis of 2896 university students from three institutions in China, namely Xiamen University of Technology, Chongqing Normal University, and North University of China, during the period spanning January 2024 to February 2024. The sampling method involved collaboration with university administrative staff and faculty members. Specifically, online questionnaires were distributed to student groups through university teacher. The research protocol was designed to ensure voluntary participation, with stringent measures in place to safeguard participant anonymity and confidentiality. Prior to their involvement, all potential participants were explicitly informed about the study's objectives and procedures, and their written informed consent was obtained. Only those who voluntarily agreed to participate were granted access to the online questionnaire.

The primary objective of this investigation was to examine the complex interplay between various psychosocial factors and mental health outcomes among the university student population. The inclusion criteria were strictly limited to currently enrolled students who voluntarily completed the survey instrument. Participants who chose not to participate or failed to complete the survey were systematically excluded from the final analysis. This approach ensured the reliability and validity of the collected data while maintaining the highest ethical standards in research involving human subjects.

The research methodology strictly adhered to the ethical principles outlined in the Declaration of Helsinki, with particular emphasis on participant autonomy and data protection. In addition, this study has adhered to the STROBE checklist to ensure transparent and comprehensive reporting of the methods and findings. The study protocol received ethical approval from the Academic Committee and Ethics Board of Xiamen University of Technology. To maintain data integrity and participant confidentiality, all collected information was anonymized, ensuring that no individual could be identified through the research data.

## Sample Size Calculation

Based on literature reports, the incidence rates were set at 33% for anxiety and 39% for depression. The significance level (α) was set at 0.05, and the power (1-β) was set at 0.80. The number of predictors was approximately 20, including electronic screen exposure time, demographics, exercise, and lifestyle factors. Using the commonly applied empirical formula for sample size calculation in logistic regression:

$$n = \frac{10}{p \cdot (1 - p)}$$

Applying this formula, the estimated sample size for anxiety is approximately 905 participants, while for depression, it is approximately 841 participants. This study included a total of 2,896 university students, which fully meets the requirements of the sample size calculation.

## Data Collection

The study collected a wide range of individual characteristics, including (1) basic demographics such as gender, age, grade, and marital status, (2) dietary habits such as low salt food, oily food, barbecue, meat, vegetables, and fruits, (3) personal addiction such as smoking and alcohol use, (4) lifestyles such as sedentary time, and physical activity. The hours of exposure to electronic screen were also collected. The hours of exposure to electronic screen per day was a self-reported metric which quantified the total time spent using electronic devices, such as computers, smartphones, or televisions, for a particular individual during a specific day. This metric was collected using self-reporting methods, where individuals recorded their own use of electronic devices. Dietary habits were assessed through self-reporting by participants based on their dietary practices, and this approach aligns with methods used in previous studies.[17] Life stress events were defined as breakup, bereavement, or financial difficulties within the past three months.

## Definition of Anxiety and Depression

Anxiety was evaluated using the GAD-7 scale, and depression was evaluated using the PHQ-9 scale. Participants were categorized into different severity categories based on their scores on these scales. The GAD-7 is a validated instrument designed to quantify the severity of anxiety symptoms,[6,18,19] utilizing a scoring range from 0 to 21. This scale categorizes symptom severity into four distinct levels: minimal (0–4), mild (5–9), moderate (10–14), and severe (15–21), based on the frequency and intensity of anxiety manifestations. Similarly, the PHQ-9 serves as a robust diagnostic tool for evaluating depressive symptoms,[6,18,19] employing a scoring system from 0 to 27. It classifies depression severity into analogous categories: minimal (0–4), mild (5–9), moderate (10–14), and severe (15–27). Both the GAD-7 and PHQ-9 have demonstrated strong psychometric properties, including high reliability and validity, making them clinically reliable instruments for accurately assessing and quantifying anxiety and depression symptoms in both research and clinical settings. Their widespread adoption in mental health assessment is attributed to their ability to provide precise measurements that correlate well with clinical diagnostic criteria. Notably, the GAD-7 and PHQ-9 scales were used to assess symptoms of anxiety and depression, which may overlap with stress-related symptoms. However, it should be emphasized that stress itself was not directly measured in this study, and we have not characterized stress as a disorder. This study calculated the Cronbach's alpha values for both the GAD-7 and the PHQ-9 scales, and the results indicated excellent internal consistency, with a Cronbach's alpha of 0.94 for GAD-7 and 0.93 for PHQ-9.

## Statistical Analysis

The qualitative data in this research paper were presented in the form of proportion. The quantitative data were presented in the form of mean and standard deviation. In this study, linear regression analysis was used to assess the association between electronic screen exposure time and anxiety and depression scores. AUC analysis was used to evaluate the model performance for predicting anxiety and depression based on hours of exposure to electronic screens. Subgroup analysis was conducted to compare the effect of exposure time on anxiety and depression scores between different subgroups of participants. Multiple logistic regression analysis was conducted to control for demographics, exercises, and

other lifestyles while assessing the association between hours of exposure to electronic screen and severe anxiety and depression, as well as identify risk and protective factors. All analysis was performed using R programming software (R version 4.1.2), with a P value of less than 0.05 indicating statistical significance.

# Results

## Participant's Baseline Characteristics

The sample consisted of 2896 participants, with a majority being female (55.5%) aged around 19.5 (SD: 1.76) years old (Table 1). Most students were single (77.2%) and had relatively normal dietary habits, with a majority reporting no low salt (71.1%) and oily (69.0%) food intake. In addition, 48.9% of participants reported that they had vegetables diet, and 60.2% of participants had fruits diet. Smoking (6.8%) and drinking (22.3%) were relatively uncommon, with only a small percentage of students reporting current use. Sedentary behavior and exposure to electronic device screens were also reported, 33.8% of participants had 6 or above hours of sedentary time, and the

**Table 1** Baseline Characteristics Among University Students

| Characteristics | Participants |
|---|---|
| n | 2896 |
| Gender (male/female, %) | 1606/1290 (55.5/44.5) |
| Age (years, mean [SD]) | 19.54 (1.76) |
| Grade (%) | |
| First | 1243 (42.9) |
| Second | 1227 (42.4) |
| Third | 233 (8.0) |
| Fourth | 171 (5.9) |
| Delayed | 22 (0.8) |
| Marital status (%) | |
| Single | 2235 (77.2) |
| Dating | 642 (22.2) |
| Married | 19 (0.7) |
| Low salt food (no/yes, %) | 2060/836 (71.1/28.9) |
| Oily food (no/yes, %) | 1999/897 (69.0/31.0) |
| Barbecue (no/yes, %) | 1843/1053 (63.6/36.4) |
| Meat (no/yes, %) | 929/1967 (32.1/67.9) |
| Vegetables (no/yes, %) | 1481/1415 (51.1/48.9) |
| Fruits (no/yes, %) | 1153/1743 (39.8/60.2) |
| Smoking (%) | |
| None | 2608 (90.1) |
| Previous | 91 (3.1) |
| Current | 197 (6.8) |

(*Continued*)

**Table 1** (Continued).

| Characteristics | Participants |
|---|---|
| Drinking (%) | |
| None | 2149 (74.2) |
| Previous | 100 (3.5) |
| Current | 647 (22.3) |
| Sedentary time (hours, %) | |
| < 1 hour | 219 (7.6) |
| ≧1 and <3 hours | 716 (24.7) |
| ≧3 and <6 hours | 982 (33.9) |
| ≧6 hours | 979 (33.8) |
| Exposure time of electronic device screens per day (hours, mean [SD]) | 6.46 (2.67) |
| Life stress event (yes/no, %) | 982/1914 (33.9/66.1) |
| Sport frequency (per week, %) | |
| None | 617 (21.3) |
| 1–2 | 1463 (50.5) |
| 3–4 | 529 (18.3) |
| ≧5 | 287 (9.9) |
| GAD-7 score (mean [SD]) | 3.97 (4.33) |
| Severity of anxiety | |
| None | 1750 (60.4) |
| Mild | 877 (30.3) |
| Moderate | 191 (6.6) |
| Severe | 78 (2.7) |
| PHQ-9 score (mean [SD]) | 4.74 (5.07) |
| Severity of depression | |
| None | 1616 (55.8) |
| Mild | 935 (32.3) |
| Moderate | 208 (7.2) |
| Severe | 137 (4.7) |
| Chronic disease (yes/no, %) | 109/2787 (3.8/96.2) |

**Abbreviations**: SD, Standard Deviation; GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient's Health Questionnaire-9.

mean exposure time of electronic screens was 6.46 (SD: 2.67) hours. Additionally, the majority of students reported anxiety (39.6%) and depression (44.2%), with a small percentage experiencing severe anxious (2.7%) or depressive (4.7%) symptoms.

## Multiple Analysis of Risk Factors for Severe Anxiety and Depression

After controlling demographics, exercises, and other lifestyles, the hours of exposure to electronic screen were still significantly associated with severe anxiety (p = 0.042, Table 2). It also found that low salt diet (p = 0.038) and barbecue (p = 0.031) were risk factors for severe anxiety, and no life stress event (p < 0.001), sport (p = 0.001), and no chronic disease (p = 0.037) were protective factors for severe anxiety (Figure 1). In addition, after controlling demographics,

**Table 2** Multiple Logistic Regression Analysis for Variables to Predict Severe Anxiety

| Characteristics | OR | 95% CI | | P value |
|---|---|---|---|---|
| | | LL | UL | |
| (Intercept) | 0.015 | 0.000 | 0.477 | 0.017 |
| Gender | | | | |
| Male | Ref. | | | |
| Female | 0.828 | 0.489 | 1.402 | 0.481 |
| Age | 1.064 | 0.904 | 1.253 | 0.454 |
| Grade | | | | |
| First | Ref. | | | |
| Second | 0.956 | 0.544 | 1.678 | 0.874 |
| Third | 1.581 | 0.664 | 3.766 | 0.301 |
| Fourth | 0.385 | 0.067 | 2.205 | 0.284 |
| Delayed | 2.186 | 0.231 | 20.719 | 0.495 |
| Marital status | | | | |
| Single | Ref. | | | |
| Dating | 0.621 | 0.329 | 1.173 | 0.142 |
| Married | 0.570 | 0.061 | 5.356 | 0.623 |
| Low salt diet | | | | |
| No | Ref. | | | |
| Yes | 1.774 | 1.032 | 3.050 | 0.038 |
| Oily food diet | | | | |
| No | Ref. | | | |
| Yes | 1.134 | 0.669 | 1.921 | 0.641 |
| Barbecue | | | | |
| No | Ref. | | | |
| Yes | 1.806 | 1.054 | 3.095 | 0.031 |
| Meat | | | | |
| No | Ref. | | | |
| Yes | 1.464 | 0.802 | 2.671 | 0.214 |

(*Continued*)

**Table 2** (Continued).

| Characteristics | OR | 95% CI | | P value |
|---|---|---|---|---|
| | | LL | UL | |
| Vegetable | | | | |
| No | Ref. | | | |
| Yes | 1.027 | 0.594 | 1.775 | 0.925 |
| Fruit | | | | |
| No | Ref. | | | |
| Yes | 0.789 | 0.453 | 1.373 | 0.402 |
| Smoking | | | | |
| None | Ref. | | | |
| Previous | 1.106 | 0.285 | 4.288 | 0.884 |
| Current | 1.452 | 0.537 | 3.920 | 0.462 |
| Drinking | | | | |
| None | Ref. | | | |
| Previous | 0.730 | 0.193 | 2.768 | 0.644 |
| Current | 0.670 | 0.345 | 1.302 | 0.238 |
| Sedentary time (hours, per day) | | | | |
| < 1 hour | Ref. | | | |
| ≧1 and <3 hours | 1.575 | 0.410 | 6.043 | 0.508 |
| ≧3 and <6 hours | 1.786 | 0.498 | 6.407 | 0.373 |
| ≧6 hours | 3.356 | 0.981 | 11.484 | 0.054 |
| Exposure time of electronic screen (hours, per day) | | | | |
| ≦7.5 | Ref. | | | |
| >7.5 | 1.682 | 1.019 | 2.778 | 0.042 |
| Life stress event | | | | |
| Yes | Ref. | | | |
| No | 0.186 | 0.108 | 0.319 | 0.000 |
| Sport frequency (per week) | | | | |
| None | Ref. | | | |
| 1–2 | 0.407 | 0.235 | 0.706 | 0.001 |
| 3–4 | 0.427 | 0.186 | 0.982 | 0.045 |
| ≧5 | 0.662 | 0.279 | 1.568 | 0.348 |
| Chronic disease | | | | |
| Yes | Ref. | | | |
| No | 0.440 | 0.203 | 0.953 | 0.037 |

**Abbreviations**: OR, Odds Rate; CI, Confident Interval; LL, Lower Limit; UL, Upper Limit.


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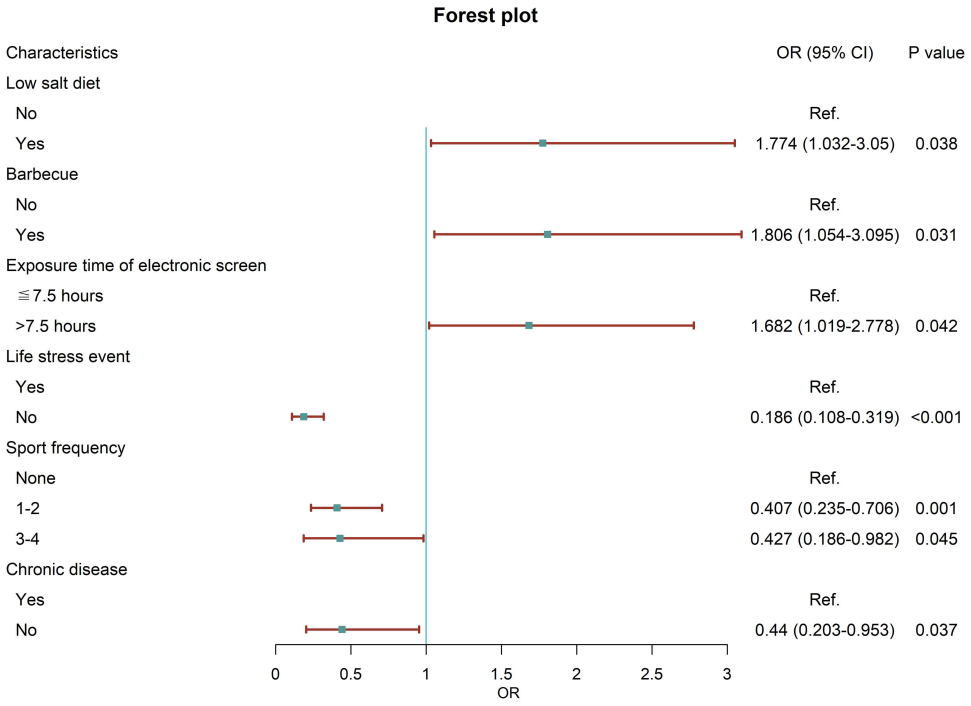


**Figure 1** The forest plot of significant variables for predicting severe anxiety.
**Abbreviations**: OR, Odds Ratio; Ref., Reference.

exercises, and other lifestyles, the hours of exposure to electronic screen were still significantly associated with severe depression ($p < 0.001$, Table 3). Oily food diet ($p = 0.041$), barbecue ($p = 0.041$), current smoking ($p = 0.011$), and a sedentary time of 6 or above hours ($p = 0.017$) were risk factors for severe depression, and no life stress event ($p < 0.001$), sport ($p < 0.001$), and no chronic disease ($p < 0.001$) were protective factors for severe depression (Figure 2).

**Table 3** Multiple Logistic Regression Analysis for Variables to Predict Severe Depression

| Characteristics | OR | 95% CI | | P value |
|---|---|---|---|---|
| | | LL | UL | |
| (Intercept) | 0.054 | 0.004 | 0.654 | 0.022 |
| Gender | | | | |
| Male | Ref. | | | |
| Female | 0.732 | 0.483 | 1.109 | 0.141 |
| Age | 1.079 | 0.961 | 1.211 | 0.200 |
| Grade | | | | |
| First | Ref. | | | |
| Second | 0.765 | 0.501 | 1.169 | 0.215 |
| Third | 0.728 | 0.343 | 1.548 | 0.410 |
| Fourth | 0.389 | 0.120 | 1.264 | 0.116 |
| Delayed | 1.387 | 0.272 | 7.081 | 0.694 |

(*Continued*)

**Table 3** (Continued).

| Characteristics | OR | 95% CI | | P value |
|---|---|---|---|---|
| | | LL | UL | |
| Marital status | | | | |
| Single | Ref. | | | |
| Dating | 0.621 | 0.381 | 1.014 | 0.057 |
| Married | 1.691 | 0.433 | 6.611 | 0.450 |
| Low salt diet | | | | |
| No | Ref. | | | |
| Yes | 1.165 | 0.752 | 1.806 | 0.494 |
| Oily food diet | | | | |
| No | Ref. | | | |
| Yes | 1.522 | 1.018 | 2.273 | 0.041 |
| Barbecue | | | | |
| No | Ref. | | | |
| Yes | 1.538 | 1.017 | 2.325 | 0.041 |
| Meat | | | | |
| No | Ref. | | | |
| Yes | 0.881 | 0.573 | 1.356 | 0.566 |
| Vegetable | | | | |
| No | Ref. | | | |
| Yes | 1.023 | 0.670 | 1.561 | 0.916 |
| Fruit | | | | |
| No | Ref. | | | |
| Yes | 0.793 | 0.515 | 1.219 | 0.290 |
| Smoking | | | | |
| None | Ref. | | | |
| Previous | 0.809 | 0.275 | 2.386 | 0.702 |
| Current | 2.453 | 1.233 | 4.881 | 0.011 |
| Drinking | | | | |
| None | Ref. | | | |
| Previous | 1.008 | 0.403 | 2.521 | 0.987 |
| Current | 0.633 | 0.378 | 1.061 | 0.083 |

(*Continued*)


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**Table 3** (Continued).

| Characteristics | OR | 95% CI | | P value |
|---|---|---|---|---|
| | | LL | UL | |
| Sedentary time (hours, per day) | | | | |
| < 1 hour | Ref. | | | |
| ≧1 and <3 hours | 1.822 | 0.692 | 4.800 | 0.225 |
| ≧3 and <6 hours | 1.871 | 0.734 | 4.772 | 0.190 |
| ≧6 hours | 2.991 | 1.212 | 7.378 | 0.017 |
| Exposure time of electronic screen (hours, per day) | | | | |
| ≦8.5 | Ref. | | | |
| >8.5 | 2.103 | 1.424 | 3.106 | 0.000 |
| Life stress event | | | | |
| Yes | Ref. | | | |
| No | 0.167 | 0.110 | 0.253 | 0.000 |
| Sport frequency (per week) | | | | |
| None | Ref. | | | |
| 1–2 | 0.417 | 0.269 | 0.647 | 0.000 |
| 3–4 | 0.591 | 0.326 | 1.069 | 0.082 |
| ≧5 | 0.709 | 0.363 | 1.387 | 0.315 |
| Chronic disease | | | | |
| Yes | Ref. | | | |
| No | 0.322 | 0.178 | 0.582 | 0.000 |

**Abbreviations**: OR, Odds Rate; CI, Confident Interval; LL, Lower Limit; UL, Upper Limit.

## Association Between the Hours of Exposure to Electronic Screen and Mental Health

This study further investigated the relationship between electronic screen exposure time and mental health status, including anxiety and depression. Linear regression analysis revealed a significant association between electronic screen exposure time and anxiety score (R square=0.17, $p < 0.001$, Figure 3A) and depression score (R square=0.20, $p < 0.001$, Figure 3B). Figure 4 exemplifies the increasing anxiety and depression scores concomitant with increasing exposure time to electronic screens.

## Analysis of the Hours of Exposure to Electronic Screen for Predicting Mental Health

This study tested the prediction performance of the hours of exposure to electronic screen to predict mental health status (Table 4). The AUC value was 0.568 (95% CI: 0.547–0.589) for predicting anxiety (Figure 5A) and 0.641 (95% CI: 0.571–0.712) for predicting severe anxiety (Figure 5B). Moreover, the AUC was 0.590 (95% CI: 0.570–0.611) for predicting depression (Figure 5C) and 0.665 (95% CI: 0.613–0.716) for predicting severe depression (Figure 5D). The optimal cut-off value (threshold) for predicting severe anxiety and depression based on electronic screen exposure time was found to be 7.5 hours and 8.5 hours, respectively. To further corroborate this finding, a subgroup analysis was conducted according to the hours of exposure to electronic screen (≦7.5 vs >7.5 hours) and (≦8.5 vs >8.5 hours). The results revealed that participants with higher exposure time to electronic screens had significantly higher anxiety ($p <$

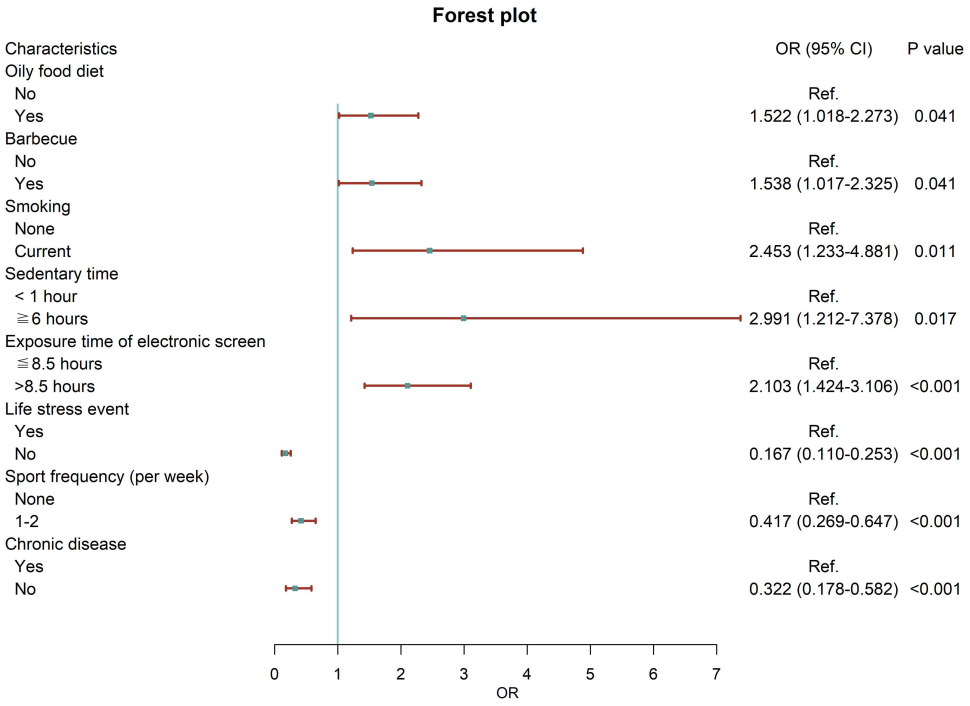


**Figure 2** The forest plot of significant variables for predicting severe depression.
**Abbreviations**: OR, Odds Ratio; Ref., Reference.

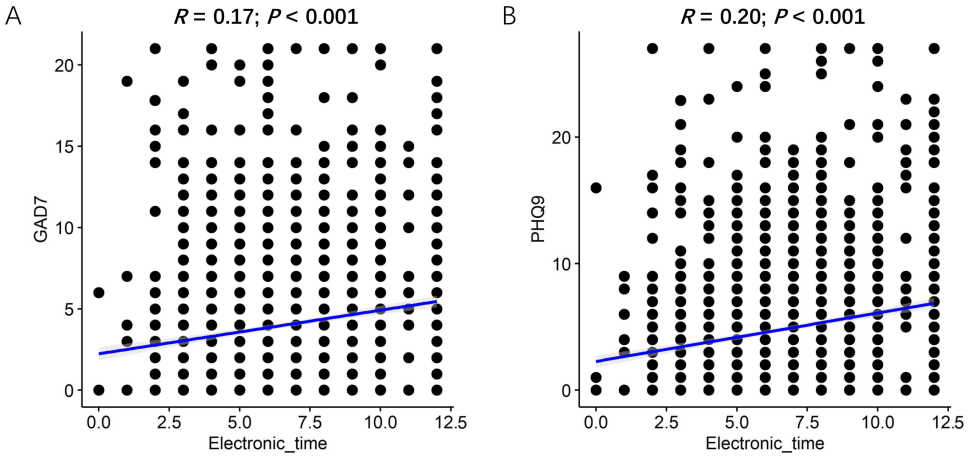


**Figure 3** Association between the exposure time of electronic screen and mental health status among university students. (**A**) GAD-7; (**B**) PHQ-9.
**Abbreviations**: GAD-7, General Anxiety Disorder 7; PHQ-9, Patient's Health Questionnaire 9.

0.001) and depression scores ($p < 0.001$) (Table 5 and Table 6). These findings provide further evidence to support the relationship between electronic screen exposure time and the severity of anxiety and depression.

# Discussion

## Main Findings

The study found that exposure time to electronic screens was significantly associated with anxiety and depression scores among university students. The association remained significant after controlling for demographics, exercises, and other lifestyle factors. In addition, the study also identified risk factors and protective factors for severe anxiety and depression. The findings suggest that interventions targeting electronic screen use could improve mental health outcomes among


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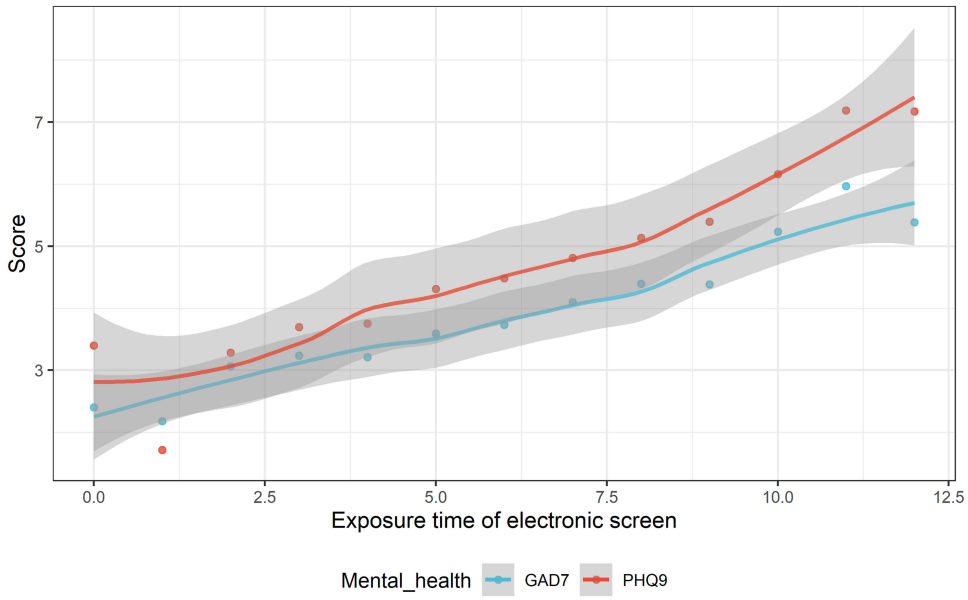


**Figure 4** Dynamic changes of the exposure time of electronic screen with the score of anxiety and depression.
**Abbreviations**: GAD-7, General Anxiety Disorder 7; PHQ-9, Patient's Health Questionnaire 9.

university students. Notably, this study revealed that the optimal cut-off value for predicting anxiety and depression based on electronic screen exposure time was found to be both 6.5 hours, suggesting that a less than 6.5 hours of exposure to electronic screen was recommended to university students to prevent mental distress.

## Detailed Analysis of Screen Exposure and Mental Health

In recent years, there has been growing concern about the potential mental health effects of electronic screen use among university students, as people's dependence on electronic devices is increasing. There were several studies that reported smartphone or internet addiction was significantly associated with mental health problems.[14,15] For example, Seki et al[15] found that internet addition was an independent variable for depression. Meanwhile, Demirci et al[20] revealed that the high smartphone use students had higher scores on measures of depression, anxiety, and daytime dysfunction than the low smartphone use individuals after analyzing 319 university students, and the study also pointed out that there were also positive correlations between smartphone addiction scale scores and depression, anxiety, and sleep quality scores.

**Table 4** Analysis of Exposure Time of the Electronic Screen to Predict Mental Health Status Among University Students

| Metrics | Prediction Outcome | | | |
|---|---|---|---|---|
| | Anxiety | Severe Anxiety | Depression | Severe Depression |
| AUC | 0.568 (0.547–0.589) | 0.641 (0.571–0.712) | 0.590 (0.570–0.611) | 0.665 (0.613–0.716) |
| Threshold | 6.500 | 7.500 | 6.500 | 8.500 |
| Specificity | 0.617 | 0.671 | 0.636 | 0.801 |
| Sensitivity | 0.484 | 0.590 | 0.497 | 0.460 |
| Accuracy | 0.565 | 0.669 | 0.574 | 0.785 |
| Precision | 0.453 | 0.047 | 0.519 | 0.103 |
| Youden | 1.101 | 1.261 | 1.132 | 1.261 |

**Abbreviation**: AUC, Area Under the Curve.

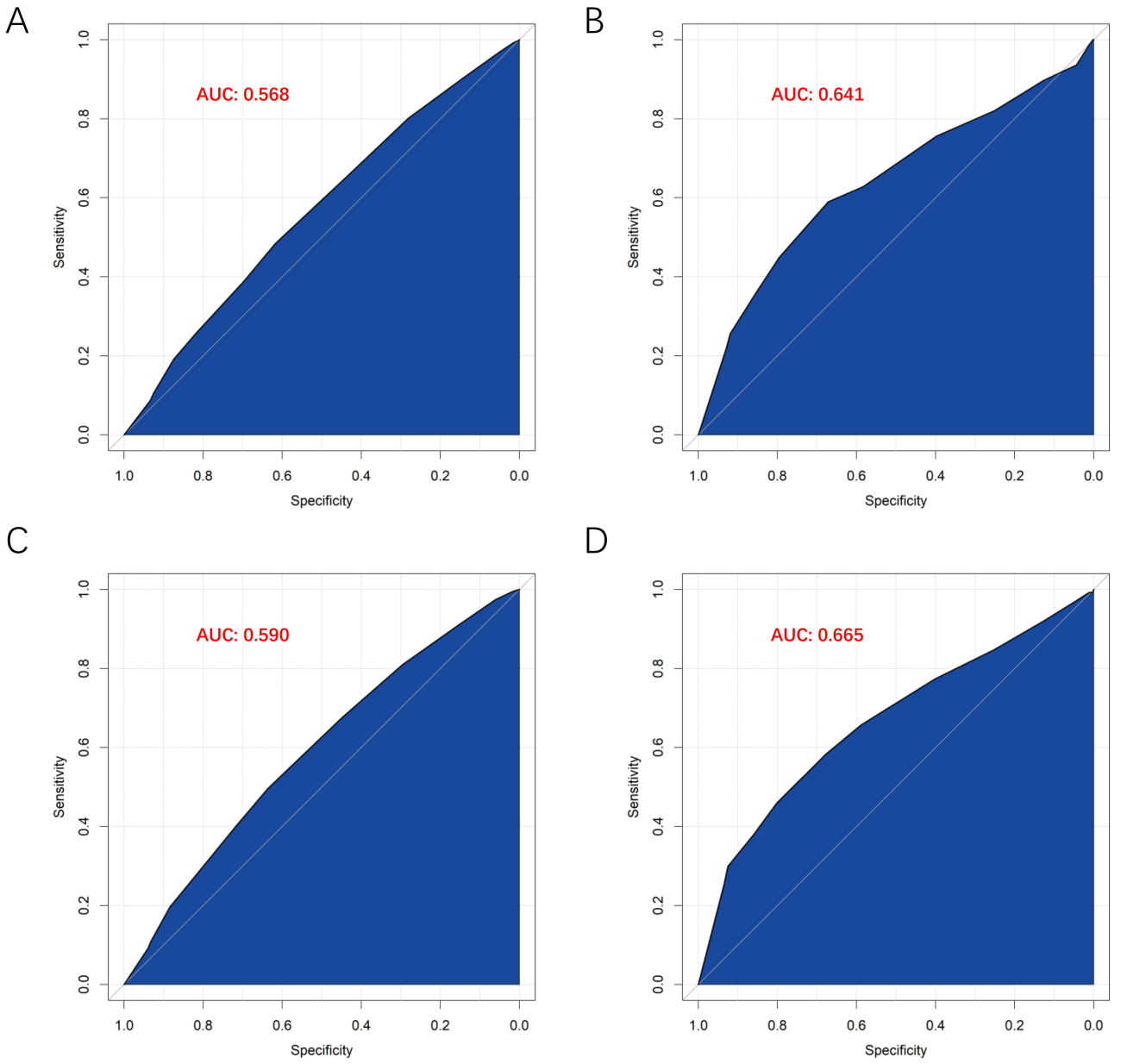


**Figure 5** The area under the curve analysis of the exposure time of electronic screen to predict mental health. (**A**) No anxiety vs anxiety; (**B**) No severe anxiety vs severe anxiety; (**C**) No depression vs depression; (**D**) No severe depression vs severe depression.
**Abbreviation**: AUC, Area Under the Curve.

Koly et al[21] found that university students who spent more than 6 hours a day on social media were 4.6 times more likely to develop depression. In addition, Matar Boumosleh et al[14] found that personality type A, class year, younger age at first smartphone use, excessive use during a weekday, using it for entertainment rather than calling family members, and having depression or anxiety were associated with smartphone addiction after analyzing 688 undergraduate university students in a cross-sectional study. Thus, the findings of the above studies revealed a substantial association between smartphone or internet addiction and the presence of mental health problems among university students.

Our study examined the association between the hours of exposure to electronic screens and mental health status. The findings indicated that with increasing hours of exposure to electronic screens, anxiety and depression scores correspondingly increased. Specifically, individuals who spent more time using electronic screens exhibited higher levels of anxiety and depression than those who spent less time using electronic screens. Additionally, our study found that the optimal


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**Table 5** Subgroup Analysis of Mental Health According to the Exposure Time of Electronic Screen (≦7.5 vs >7.5 hours)

| Characteristics | Overall | Exposure Time of Electronic Screen (Hours) | | p |
|---|---|---|---|---|
| | | ≦7.5 | >7.5 | |
| n | 2896 | 1924 | 972 | |
| GAD-7 (mean [SD]) | 3.97 (4.33) | 3.53 (3.96) | 4.83 (4.87) | <0.001 |
| Severity of anxiety | | | | <0.001 |
| None | 1750 (60.4) | 1222 (63.5) | 528 (54.3) | |
| Mild | 877 (30.3) | 566 (29.4) | 311 (32.0) | |
| Moderate | 191 (6.6) | 104 (5.4) | 87 (9.0) | |
| Severe | 78 (2.7) | 32 (1.7) | 46 (4.7) | |
| PHQ-9 (mean [SD]) | 4.74 (5.07) | 4.16 (4.53) | 5.90 (5.82) | <0.001 |
| Severity of depression | | | | <0.001 |
| None | 1616 (55.8) | 1158 (60.2) | 458 (47.1) | |
| Mild | 935 (32.3) | 590 (30.7) | 345 (35.5) | |
| Moderate | 208 (7.2) | 119 (6.2) | 89 (9.2) | |
| Severe | 137 (4.7) | 57 (3.0) | 80 (8.2) | |

**Abbreviations**: SD, Standard Deviation; GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient's Health Questionnaire-9.

**Table 6** Subgroup Analysis of Mental Health According to the Exposure Time of Electronic Screen (≦8.5 vs 8.5 hours)

| Characteristics | Overall | Exposure Time of Electronic Screen (Hours) | | p |
|---|---|---|---|---|
| | | ≦8.5 | >8.5 | |
| n | 2896 | 2285 | 611 | |
| GAD-7 (mean [SD]) | 3.97 (4.33) | 3.67 (4.06) | 5.08 (5.07) | <0.001 |
| Severity of anxiety | | | | <0.001 |
| None | 1750 (60.4) | 1433 (62.7) | 317 (51.9) | |
| Mild | 877 (30.3) | 675 (29.5) | 202 (33.1) | |
| Moderate | 191 (6.6) | 134 (5.9) | 57 (9.3) | |
| Severe | 78 (2.7) | 43 (1.9) | 35 (5.7) | |
| PHQ-9 (mean [SD]) | 4.74 (5.07) | 4.31 (4.62) | 6.36 (6.22) | <0.001 |
| Severity of depression | | | | <0.001 |
| None | 1616 (55.8) | 1341 (58.7) | 275 (45.0) | |
| Mild | 935 (32.3) | 722 (31.6) | 213 (34.9) | |
| Moderate | 208 (7.2) | 148 (6.5) | 60 (9.8) | |
| Severe | 137 (4.7) | 74 (3.2) | 63 (10.3) | |

**Abbreviations**: SD, Standard Deviation; GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient's Health Questionnaire-9.

cut-off value for the exposure time to electronic screens to predict anxiety and depression was 6.5 hours, suggesting that a more than 6.5-hour exposure of electronic screens was more likely to develop mental health problems among university students. Furthermore, our study demonstrated that a more than 7.5-hour exposure of electronic screens tended to be linked to more severe anxiety, and 8.5 hours tended to be associated with more severe depression. This may be thought to be due to the fact that electronic screens emit blue light, which can disrupt the body's production of melatonin, a hormone that helps regulate sleep-wake cycles.[22,23] Additionally, the use of electronic screens can lead to sedentary behavior, which can also contribute to anxiety and depression.[24] In a word, our study provided evidence that excessive hours of exposure to electronic screens were associated with higher levels of anxiety and depression among university students. The findings suggest that limiting the use of electronic screens, particularly those exceeding 6.5 hours, may be beneficial for improving mental health outcomes. Our study contributed to a deeper understanding of the potential impact of electronic screen use on mental health and could help establish a foundation for the development of interventions to mitigate its negative effects.

## Addressing Confounding Factors and Identifying Detailed Relationship Between Screen Exposure and Mental Health

The impact of the time of exposure to electronic screens on mental health has been studied, but the detailed relationship is inconclusive. It is important to note that the above studies have not been able to control for a number of confounding factors, such as age, gender, and socioeconomic status. Our study examined the detailed relationship between electronic screen exposure time and mental health status, as well as to identify risk factors and protective factors for severe anxiety and depression. We found that after controlling for individual's demographics, eating habits, and exercises, the time of exposure to electronic screens still held significance with anxiety and depression. In addition, this study also pointed out that a healthy eating habit (such as no low salt diet, no barbecue, and no oily food diet), no smoking, more exercise, less sedentary time, no life stress event, and no chronic disease were significantly associated with less anxiety and depression scores.

## Implications for Education and Future Research

Based on above findings, therefore, effective measures to address student anxiety and depression can include lifestyle interventions such as regular exercise, a balanced diet, smoking quitting, and stress reduction techniques like mindfulness meditation and cognitive behavioral therapy. Additionally, seeking professional help from counselors and therapists can be beneficial for individuals experiencing significant mental health difficulties.[25] Other studies also provided evidence that cognitive, behavioral, and mindfulness interventions were effective in reducing stress in university students.[26] Furthermore, the findings of this study have important implications for university students and policymakers. To improve the mental health of university students, interventions targeting electronic screen use should be implemented. These interventions could include limiting screen time, providing educational resources about the health effects of electronic screen use, and promoting healthy lifestyle behaviors. The findings also suggest that universities could consider implementing policies that encourage students to reduce their electronic screen use, such as mandatory breaks during classes or designated screen-free hours in residence halls. By incorporating these evidence-based interventions into university programs and student support services, universities can foster a more supportive and inclusive environment for all students.

Future research should build on these findings to further explore the relationship between electronic screen exposure and mental health outcomes. Longitudinal studies are needed to examine the causal relationships between screen use and mental health over time, helping to determine whether excessive screen use is a risk factor for the development of anxiety and depression or a consequence of pre-existing mental health conditions. Additionally, research should investigate the underlying mechanisms linking screen exposure to mental health outcomes, such as the role of disrupted sleep patterns, reduced physical activity, and increased social isolation, as understanding these pathways could inform targeted interventions. Intervention studies are also critical to design and evaluate programs aimed at reducing screen time and promoting healthy screen use habits, such as mindfulness-based programs, digital detox initiatives, or educational campaigns. Expanding the scope of research to include diverse populations, such as students from different cultural backgrounds, age groups, and academic disciplines, would

help determine whether the observed associations are generalizable across different contexts. Furthermore, future studies should examine the differential impacts of various types of screen use (eg, social media, gaming, academic work) on mental health, as this could provide insights into which forms of screen use are most detrimental and inform more tailored interventions, particularly as we navigate an increasingly digital world and the rapid integration of various artificial intelligence into daily life.[27] Incorporating validated stress-specific scales, such as the Perceived Stress Scale or the Depression, Anxiety, and Stress Scale-21, would also help disentangle the effects of stress from anxiety and depression symptoms. Meanwhile, it is crucial to sensitize both students and teachers to the potential mental health risks associated with excessive screen use, Finally, evaluating the effectiveness of university-level policies and environmental changes, such as screen-free zones, mandatory breaks, or wellness programs, could provide valuable evidence for reducing screen time and improving mental health outcomes. By addressing these research gaps, future studies can further elucidate the complex relationship between screen exposure and mental health, ultimately contributing to the development of more effective prevention and intervention strategies.

## Strengths and Limitations

This study has several limitations. First, the study participants were recruited from university students, which limits the generalizability of the findings to other populations. Second, the study did not control for all potential confounding factors, such as socioeconomic status and family history of mental illness. Third, the study did not assess the impact of different types of electronic screen use on mental health, such as social media use or gaming use. Fourth, the study did not assess the long-term effects of electronic screen use on mental health. Lastly, while the GAD-7 and PHQ-9 provide valuable insights into anxiety and depression symptoms, they do not capture stress as a separate dimension. Considering that the GAD-7 and PHQ-9 scores reflect symptoms that may be influenced by stress, it should be cautioned against interpreting these scores as definitive indicators of clinical disorders without further evaluation. Hence, although our study shielded an important light on the association between the time of exposure to electronic screen and mental distress, further research was still needed to explore the above issues and to develop effective interventions.

## Conclusions

The findings of this study suggest that prolonged exposure to electronic screens is associated with increased risk for experiencing anxiety and depression among university students. Less than 6.5 hours of exposure to electronic screen are recommended among university students to largely avoid anxiety and depression. This study highlights the need to intervene and manage effectively the use of electronic screens in order to promote mental well-being in university students. Additionally, raising awareness about the potential negative impacts of excessive electronic screen use and promoting healthier lifestyle behaviors may serve as effective tools for managing mental health challenges among university students.

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## Disclosure

The authors declare that they have no conflict of interest.

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