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Predictors of sleep modifiable factors and the correlation with non-suicidal self-injury: the important role of problematic mobile phone use and mental health

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Abstract

Backgrounds Non-suicidal self-injury (NSSI) has long affected people's lives and is an important and serious public health issue, especially among college students. This study aims to identify modifiable factors, including problematic mobile phone use (PMPU) and mental health (MH), etc. Only a few studies have mentioned the correlation between PMPU and NSSI, this study focus on its association with suicide, and whether this association is moderated by chronotype and MH needs to be confirmed by research.

Methods A cross-sectional study design investigated the association between PMPU, chronotype and MH and NSSI. We collected information from participants using an electronic questionnaire that included general demographics, PMPU, NSSI, and sleep-related variables (chronotype, weekday and weekend sleep duration). Participants completed standardized questionnaires, including mobile phone addiction tendency scale (MPATS) for PMPU, the Morningness-Eveningness Questionnaire (MEQ) for chronotype, Patient Health Questionnaire (PHQ-9) for depression symptoms, Generalized Anxiety Scale (GAD-7) for anxiety symptoms, and the non-suicidal self-injury (NSSI) for suicide risk. A multivariable linear regression model measure these variables, and moderation model which using the PROCESS method examined the relationship of PMPU, chronotype and MH and NSSI.

Results A total of 5639 adolescents were included in the study, with a mean age of 19.64 [±0.90] years), and 46.3% of the participants were male. The prevalence of NSSI was 12.1%, in multivariate linear regression, high levels of PMPU (β = 0.362), eveningness (β = 0.665), depression (β = 1.183), and anxiety (β = 1.308) were all associated with higher NSSI, indicating a significant association. In the analysis results of moderation, chronotype and MH also moderated the relationship between PMPU and NSSI, indicating that there was a relationship between PMPU, chronotype, MH and NSSI.

Conclusions This study highlights the important role of PMPU and mental health in predicting NSSI. Interventions targeting these modifiable factors may help reduce the prevalence of NSSI among young adults. Improving sleep hygiene, reducing mobile phone abuse, and providing appropriate psychological support are effective strategies to prevent NSSI. Educational institutions and society should strengthen guidance on the proper use of digital media

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by young people, especially among college students, promote healthy lifestyles, and establish early identification and support systems to help those individuals at risk.

Keywords Non-suicidal self-injury, Problematic mobile phone use, Mental health, Chronotype, Young adults

Introduction

Adolescence is an important period in a person's life, the transition from childhood to early adulthood, and it is also a sensitive developmental period, a time of great psychological and physical changes, especially college students. According to the World Health Organization (WHO) [1], one in eight people worldwide suffers from a mental disorder, with an even higher prevalence among children and adolescents, improving mental health care is a target that has been targeted by the sustainable development goals [2] and is constantly changing. Providing adequate support for young people's mental health should follow the transformation path outlined and will be approved by WHO in July 2022 [1]. Non-suicidal self-injury (NSSI), as a serious but neglected mental problem, has been troubling most adolescent students and correlated with suicide, are also growing and serious public health concerns [3]. According to the statistics, the overall average prevalence of NSSI in the studies was 16% among 11.00 to 18.53 years according to 97 high quality studies [4]. Moreover, some researchers have identified trends in NSSI among adolescents, throughout development, the frequency of NSSI increased in younger adolescents, decreased in older adolescents, and remained stable in adolescents between younger and older adolescents [5]. From previous studies, it is evident that NSSI has shown a clear upward trend [4], and suicide may also result from harm caused by mental health issues [6]. Reviewing past research to explore and clarify potential factors that can control and prevent NSSI is crucial, we should pay attention to the culture shock of new risk factors as well as the factors previously studied. Many previous studies have shown that factors leading to various psychological and behavioral problems in adolescents are often not isolated, but clustered together and interrelated [7, 8], so it is necessary to explore their interrelationships.

With the rapid development of high technology, mobile phones have become increasingly important in people's lives, providing convenience and enhancing the management of interpersonal relationships, smart devices such as computers, tablets and mobile phones have penetrated into human life and become an important part, especially the use of mobile phones. It is reported that as of April 2023, China has more than 1.7 billion mobile phone users [9], and the mobile Internet penetration rate has reached 99.8% [10]. The reason to focus on the topic of mobile phone use is that video teaching is becoming more common due to COVID-19; Indeed, it saves everyone's time to a great extent, including many college courses are video courses, and the second is that mobile phones are very powerful, including a lot of learning and entertainment apps, coupled with the pressure of their studies, many people are willing to choose to relax themselves on the Internet, and it is easy to overuse and even addiction. Addiction is very common for teenagers and college students, especially addiction to electronic products, which has aroused widespread concern from all walks of life. The harm of mobile phone addiction includes many aspects. On the one hand, the richness and guidance of mobile phone content will make teenagers full of curiosity about external things, which will drive them to lose interest in learning; on the other hand, learning is a burden for teenagers, but mobile phone use is a manifestation of pressure release, and over time, they will gradually become addicted. Some studies have confirmed the hazardous impact of prolonged mobile phone use on NSSI [11, 12]; furthermore, negative behaviors induced by mobile phone use, particularly PMPU [6], have attracted attention from researchers both domestically and internationally. Previous study have concerned the duration of phone and media use, focusing only on mobile phone time can indeed find some problems, but the addiction phenomenon caused by mobile phone use deserves our attention.

The use of electronic devices can also affect adolescents'sleep, especially excessive mobile phone use before bedtime, which can lead to a series of problems [13]. A systematic literature review has evaluated the correlation between PMPU and mental health [14]. In addition, depressive symptoms partially mediated the association between suicide and duration of mobile phone use [6]. However, there is still little research on the association between PMPU and NSSI, with most studies focusing on the association with suicide. Excessive mobile phone use is not only a problem among adolescents but also among older adults [15], indicating that it is a widespread phenomenon. A large-scale study in China demonstrated the correlation between problematic smartphone use and NSSI; this study also found that evening chronotype sleep habits and PMPU independently interact to influence NSSI [16]. Regarding the relationship between sleep chronotype and PMPU, excessive mobile phone use before bedtime can alter sleep patterns [17]. Middle school students and college students are in

the transition stage from adolescence to early adulthood. At the beginning of adolescence, circadian rhythm disorder occurs due to heavy learning tasks, irregular social schedules, and can peak at the end of adolescence. This is likely related to disruptions in the biological clock, including exposure to electronic devices and light at night, which can trigger risky behaviors [18]. Sleep timing (the degree to which a person prefers the morning or evening) is that the circadian phase, circadian cycle, and waking duration determined by circadian processes are highly correlated with early and late sleep or self-reported morning or evening preferences [19, 20]. It is generally divided into three types, namely, early morning type (morningness), intermediate type (N type) and evening type (eveningness). Sleep duration and sleep preferences, as independent but related constructs, are part of the etiology of psycho-psychological problem risk behaviors and outcomes [21]. According to previous study, there was an association between chronotype and NSSI [16, 22], moreover, there was also interaction effect between problematic smartphone use, eveningness and NSSI [16].

Long-term improper use of electronic devices and poor sleep habits can negatively impact psychological and behavioral issues [23, 24]. However, blindly restricting the use of mobile phones will bring bad effects to people, especially college students. Therefore, how to better control the use of mobile phones needs some investigation and observation; for example, improving sleep patterns. Timely identification and implementation of effective interventions are crucial. A randomized clinical trial found that, compared to a waitlist control group, intervention participants showed recovery from depression [25]. This suggests that reasonable scheduling of mobile phone use and adjusting sleep habits can improve subsequent psychological issues, including NSSI. Previous studies have also investigated the correlations between smartphone use, sleep quality, and depression [26]. Few studies have focused on the association between PMPU and NSSI, indicating that attention is still insufficient, and even fewer studies have been conducted on the complex relationship between PMPU, chronotype, mental health, and NSSI. In addition, while individual studies have explored the links between sleep, PMU, chronotype, and suicide, few have examined their interconnected relationships. For instance, PMPU may disrupt sleep quality, which in turn could worsen chronotype misalignment and elevate suicide risk. The aforementioned studies have confirmed the moderating role of chronotype in the relationship between PMPU and NSSI. This study aims to identify modifiable factors, including sleep parameters, PMPU and mental health, and their associations with NSSI. Specifically, we hypothesize that PMPU and poor mental health will be significant predictors of NSSI, and that mental health variables will moderate the relationship between PMPU and NSSI.

Methods

Study design

This study was a cross-sectional survey conducted among college students, covering 4 universities located in Anhui Province and Shanghai city. The specific survey methods have been described in previous studies [27, 28]. We selected the 4 universities based on the intention to cooperate. The surveyed schools adopted cluster sampling, including students from all grades and majors. Data were collected through the distribution of electronic questionnaires. Nearly 6000 college students were recruited. Then, after participants completed the questionnaire, they submitted it via mobile phone, and a supervisor was present at the survey site to ensure quality control. The survey period was from May to June 2022, and 361 participants (6.0%) were excluded due to refusal to answer the questionnaire. The study design and data collection procedures were approved by the Ethics Committee of Anhui Medical University, and all methods were conducted in accordance with relevant guidelines.

Exposure

Problem mobile phone use (PMPU)

In this study, mobile phone usage was measured using the Mobile Phone Addiction Type Scale (MPATS) [29]. The scale consists of 16 items, divided into four subscales: withdrawal symptoms, overt behavior, social comfort, and emotional changes. We used a Likert-type 5-point self-rating scale to evaluate responses ranging from 1="strongly disagree"to 5="strongly agree."Higher total scores indicate a more severe tendency toward mobile phone addiction. In this study, we used the continuous variable score for analysis. Previous research has found that the Cronbach's alpha coefficient for the total scale is 0.83, and the alpha coefficients for the four factors range from 0.55 to 0.80.

Sleep parameters

1) Sleep duration: In the past 1 month, on school days/rest days, how many hours of you generally actually slept per day (including nap time)? Participants could enter the time directly into the questionnaire.
2) Chronotype refers to an individual's natural activity pattern throughout the day, which is characterized by a tendency to be morning (morning type) or evening (evening type). The chronotype used in this study is MEQ, a classic scale designed by Horne and Ostberg in 1976 to assess an individual's circadian pref-

erence [30]. The questionnaire consists of five questions covering daily sleep habits and the time when you feel most awake. A total score is given based on the responses, with higher scores indicating a more morning type; On the contrary, it is night type. The scale is simple and easy to understand and suitable for large-scale epidemiological investigation.

Non-suicidal self-injury (NSSI)

NSSI was collected by a homemade questionnaires according to previous study [27, 28], such as "In the past 12 months, have you ever harmed yourself in a way that was deliberate, but not intended to take your life?", which included hit yourself, pulled your own hair, banged your head or fist against something, pinched or scratched yourself, bitten yourself, cut or pierced yourself and burned yourself. Then we collect the answers to calculate total score, if there was "yes" answer, we think participants ever experience NSSI.

Depression

(1) The Patient Health questionnaire-9 (PHQ-9) is a widely used self-assessment Questionnaire designed to screen for, diagnose, and assess the severity of depressive symptoms [31]. The PHQ-9 contained nine items in which participants were asked to rate how much each symptom affected them over the past two weeks, with options ranging from 0: not at all, 1 = a few days, 2 = more than half the time, and 3 = almost every day. The total score is calculated after the survey is completed, and the total score is the sum of the scores of all items, ranging from 27 points. As an initial screening tool to help identify patients who may be suffering from depression. According to the scoring criteria, the total score determines the severity of depressive symptoms. In this study, we used both the continuous and categorical variables of the total score for analysis.

Anxiety

(2) Similarly, to assess anxiety symptoms in this study, the Generalized Anxiety Disorder 7-item scale (GAD-7) [32] was used. The questionnaire consists of 7 items, each with four response options: 0="not at all,"1 ="several days,"2 ="more than half the days,"and 3="nearly every day."After completing the questionnaire, the total score for each participant was calculated by summing the responses to all items (range: 0–21). According to the scoring criteria, the total score determines the severity of anxiety symptoms. In this study, we used both the continuous and categorical variables of the total score for analysis.

Statistics analysis

To examine the association between general demographic information (e.g., age, gender, parental education level) and NSSI, a chi-square test was conducted. This analysis aimed to identify any significant relationships between categorical demographic variables and the presence of NSSI. The chi-square statistic, degrees of freedom (df), and p-values were reported for each variable. To explore the relationships between PMPU, chronotype, mental health, and NSSI, linear regression models were constructed. Each model included one predictor at a time while controlling for potential confounders. For each model, standardized beta coefficients (β), t-values, and p-values were reported. Additionally, R-squared (ΔR^2) values were provided to indicate the proportion of variance in NSSI explained by each predictor. To investigate whether the interaction among PMPU, chronotype, and mental health influences NSSI, moderation analyses were performed using PROCESS. For each step, changes in ΔR^2 and F-change statistics were reported to assess the significance of adding new predictors. Standardized beta coefficients, t-values, and p-values for the interaction terms were also presented. All data were analyzed using SPSS (Windows Version 23.0).

Results

General demographic statistics

There were 5639 students in the questionnaire survey, including 2613 male students (46.3%) and 3026 female students. Age was (19.64 ± 0.90) years old; In addition, among the demographic results, 2,761 people (49.0%) lived in rural areas, 1,090 people (19.3%) lived in urban areas, and 1,788 people (31.7%) lived in urban areas. The number of children in the family was also concerned, with 1,614 (28.6%) only children and 4,025 (71.4%) non-only children. In this study, the prevalence of NSSI was 12.1%. The results of the association between specific demographic characteristics and NSSI are shown in Table 1.

The linear correlation between independent variables and NSSI

In order to further observe the correlation between independent variables and outcome variables, linear regression method was adopted to present the results of independent variables and outcome variables, as shown in Table 2. In our results, eveningness was correlated with NSSI (β = 0.665), PMPU (β = 0.362), depression (β

Table 1 The distribution of demographic characteristics on NSSI

Variables	Total (N, %)	No (n,%)	Have (n,%)	t/χ^2 value
Age	5639	19.61 ± 1.25	19.66 ± 0.11	9.52**
Gender				0.005
Male	2613	2297 (87.9)	316 (12.1)	
Female	3026	2662 (88.0)	364 (12.0)	
Residential areas				13.774**
Country	1788	1531 (85.6)	257 (14.4)	
Town	1090	977 (89.6)	113 (10.4)	
Rural area	2761	2451 (88.8)	310 (11.2)	
Only child				1.934
Yes	1614	1404 (87.0)	210 (13.0)	
No	4025	3555 (88.3)	470 (11.7)	
Father's education				11.018
Not clear	270	238 (88.1)	32 (11.9)	
Below primary	493	436 (88.4)	57 (11.6)	
Primary	749	669 (89.3)	80 (10.7)	
Junior high	2170	1921 (88.5)	249 (11.5)	
High school or technical secondary school	1090	957 (87.8)	133 (12.2)	
Junior college	439	381 (86.8)	58 (13.2)	
University	428	357 (83.4)	71 (16.6)	
Mother's education				9.925
Not clear	328	290 (88.4)	38 (11.6)	
Below primary	964	846 (87.8)	118 (12.2)	
Primary	977	875 (89.6)	102 (10.4)	
Junior high	1890	1673 (88.5)	217 (11.5)	
High school or technical secondary school	844	735 (87.1)	109 (12.9)	
Junior college	354	304 (85.9)	50 (14.1)	
University	282	236 (83.7)	46 (16.3)	
Family economic conditions				22.959**
Bad	473	403 (85.2)	70 (14.8)	
Worse	1457	1245 (85.4)	212 (14.6)	
Medium	3370	3021 (89.6)	349 (10.4)	
Better	295	252 (85.4)	43 (14.6)	
Good	44	38 (86.4)	6 (13.6)	
Friends number				29.679**
No	177	140 (79.1)	37 (20.9)	
1–2	1956	1676 (85.7)	280 (14.3)	
3–5	2189	1936 (88.4)	253 (11.6)	
6 or more	943	858 (91.0)	85 (9.0)	

* $P < 0.05$, ** $P < 0.01$

=0.1.183) and anxiety (β =1.308) also associated with NSSI, respectively.

The impact of the moderation analysis between PMPU and mental health, chronotype on adolescent NSSI

Moderation analyses were performed with PMPU and mental health, chronotype and NSSI. The results are presented in Table 3. First, PMPU was associated with NSSI (β =0.9722), depression was associated with NSSI (β =4.9438), PMPU × depression significantly correlated with NSSI, PMPU × chronotype also significantly correlated NSSI, and depression × chronotype was correlated with NSSI. In the moderating effect analysis, we found that PMPU, mental health and chronotype had significant interactive effects on NSSI in adolescents. Specifically, PMPU was associated with poorer mental health and later sleep chronotype to significantly increase the risk of NSSI (β =0.1195, $p < 0.01$). Similar results were

Table 2 The multilevel linear regression between independent variables and NSSI

	NSSI						
	R^2	β	t	P	F	LLCI	ULCI
Chronotype							
Model 1	0.007	0.665	6.264	< 0.01	39.242	0.457	0.873
Model 2	0.009	0.724	6.318	< 0.01	5.805	0.499	0.949
PMPU							
Model 1	0.026	0.362	12.205	< 0.01	148.962	0.304	0.420
Model 2	0.028	0.387	12.060	< 0.01	19.013	0.324	0.450
Depression							
Model 1	0.04	1.183	15.405	< 0.01	237.305	1.032	1.333
Model 2	0.044	1.295	15.337	< 0.01	30.248	1.129	1.460
Anxiety							
Model 1	0.039	1.308	15.095	< 0.01	227.848	1.138	1.478
Model 2	0.042	1.418	14.949	< 0.01	28.777	1.232	1.603
Workday sleep duration							
Model 1	0.002	−1.077	−3.749	< 0.01	14.055	−1.640	−0.514
Model 2	0.004	−1.160	−3.704	< 0.01	2.526	−1.774	−0.546
Weekday sleep duration							
Model 1	0.002	−0.640	−3.213	< 0.01	10.325	−1.030	−0.249
Model 2	0.003	−0.654	−3.053	< 0.01	1.975	−1.074	−0.234

Model 1: crude model; Model 2: controlled gender, residential areas, only child, parental education, family economic conditions, friends number

Table 3 Association between PMPU, depression, chronotype and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	0.9722	0.1524	6.3787	< 0.01	0.6734	1.2710
Depression	4.9438	0.5586	8.8501	< 0.01	3.8487	6.0389
Chronotype	17.7105	1.8426	9.6116	< 0.01	14.0983	21.3227
Int_1	−0.1602	0.0141	−11.3710	< 0.01	−0.1878	−0.1326
Int_2	−0.6975	0.0686	−10.1698	< 0.01	−0.8319	−0.5630
Int_3	−3.4989	0.2571	−13.6084	< 0.01	−4.0029	−2.9948
Int_4	0.1195	0.0061	19.4547	< 0.01	0.1074	0.1315

Int 1: PMPU × depression; Int 2: PMPU × chronotype; Int 3: chronotype × depression; Int 4: PMPU × depression × chronotype

shown among PMPU and anxiety, chronotype and NSSI (Table 4).

The impact of the moderation analysis between PMPU and mental health, sleep duration on adolescent NSSI

Moderation analyses were performed with PMPU and mental health, chronotype and NSSI. The results are presented in Table 5. First, PMPU predicted the severity of NSSI (β = 0.16, $P > 0.05$), depression was associated with NSSI (β = 0.18, $P < 0.01$), PMPU × depression significantly predicted the severity of NSSI, PMPU × weekday sleep duration also significantly predicted the severity of NSSI, and depression × weekday sleep duration was correlated with NSSI. There was significant three-way interaction effect between PMPU and mental health, weekday sleep duration (β = −0.0214, $P < 0.01$). After controlling for covariates, these results were also significant. Similar results were shown among PMPU and anxiety, workday sleep duration and NSSI (Table 6). In addition, there was an association between PMPU, anxiety, weekday sleep duration (Table 7)/workday sleep duration (Table 8) in NSSI.

Discussion

Main findings

In our study, the prevalence of NSSI was 12.1%, which was lower than previous study [33] and was similar to

Table 4 Association between PMPU, anxiety, chronotype and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	0.7162	0.1447	4.9502	< 0.01	0.4326	0.9998
Anxiety	6.5850	0.7200	9.1455	< 0.01	5.1735	7.9966
Chronotype	12.4307	1.7522	7.0941	< 0.01	8.9956	15.8658
Int_1	−0.197	0.0174	−11.4986	< 0.01	−0.2337	−0.1656
Int_2	−0.4848	0.0649	−7.4696	< 0.01	−0.6121	−0.3576
Int_3	−4.3620	0.3288	−13.2653	< 0.01	−5.0066	−3.7174
Int_4	0.1397	0.0076	18.4555	< 0.01	0.1249	0.1546

Int 1: PMPU × anxiety; Int 2: PMPU × chronotype; Int 3: chronotype × anxiety; Int 4: PMPU × anxiety × chronotype

Table 5 Association between PMPU, depression, weekday sleep duration and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	−1.9099	0.2070	−9.2259	< 0.01	−2.3157	−1.5041
Depression	−9.7497	0.6775	−14.3907	< 0.05	−11.0778	−8.4215
Weekday sleep duration	−4.1289	0.6084	−6.7866	< 0.05	−5.3216	−2.9362
Int_1	0.3468	0.0144	24.0884	< 0.01	0.3186	0.3751
Int_2	0.1748	0.0237	7.3805	< 0.01	0.1284	0.2212
Int_3	0.9154	0.0789	11.5974	< 0.01	0.7606	1.0701
Int_4	−0.0311	0.0017	−17.8328	< 0.01	−0.0346	−0.0277

Int 1: PMPU × depression; Int 2: PMPU × weekday sleep duration; Int 3: Depression × weekday sleep duration; Int 4: PMPU × depression × weekday sleep duration

Table 6 Association between PMPU, depression, workday sleep duration and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	−2.1326	0.2399	−8.8884	< 0.01	−2.6029	−1.6622
Depression	−10.8684	0.8061	−13.4821	< 0.05	−12.4487	−9.2880
Workday sleep duration	−5.5242	0.8052	−6.8608	< 0.05	−7.1027	−3.9457
Int_1	0.3562	0.0170	21.0027	< 0.01	0.3229	0.3894
Int_2	0.2219	0.0317	6.9902	< 0.01	0.1597	0.2842
Int_3	1.1695	0.1079	10.8360	< 0.01	0.9579	1.3811
Int_4	−0.0360	0.0023	−15.4431	< 0.01	−0.0405	−0.0314

Int 1: PMPU × depression; Int 2: PMPU × workday sleep duration; Int 3: Depression × workday sleep duration; Int 4: PMPU × depression × workday sleep duration

the results of other study [34]. Although the incidence of NSSI is slightly different, there are high and low, which also indicates that it should be paid attention to, as a important psychological problem, its influencing factors involve many aspects. The research on the relationship between social science and psychological problems has been recognized by most researchers [35], and relatively little attention has been paid to the psychological sleep patterns mechanism of environmental factors affecting NSSI problems. To fill in the limitations of previous study, we conducted a cross-sectional study of college students and found that mental health is a key moderated mechanism between PMPU and NSSI in college students, and sleep patterns can also moderate this process. This study systematically studied the psychological reasons that lead to the development of NSSI. We chose to put PMPU, chronotype, and mental health issues together because the three affect each other, in particular PMPU

Table 7 Association between PMPU, anxiety, weekday sleep duration and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	−1.4895	0.1962	−7.5901	< 0.01	−1.8742	−1.1048
Anxiety	−12.2594	0.8465	−14.4820	< 0.01	−13.9189	−1.1048
Weekday sleep duration	−3.2557	0.5819	−5.5953	< 0.01	−4.3964	−2.1150
Int_1	0.4208	0.1962	23.6449	< 0.01	0.3859	0.4557
Int_2	0.1404	0.0222	6.3147	< 0.01	0.0968	0.1840
Int_3	1.1717	0.0987	11.8680	< 0.01	0.9782	1.3652
Int_4	−0.0387	0.0021	−18.2544	< 0.01	−0.0428	−0.0345

Int 1: PMPU × anxiety; Int 2: PMPU × weekday sleep duration; Int 3: Anxiety × weekday sleep duration; Int 4: PMPU × anxiety × weekday sleep duration

Table 8 Association between PMPU, anxiety, workday sleep duration and NSSI in adolescent

Variables	NSSI					
	coeff	SE	*t* value	*P* value	LLCI	ULCI
PMPU	−1.2938	0.2302	−5.6202	< 0.01	−1.7450	−0.8425
Anxiety	−13.4096	1.0618	−12.6291	< 0.05	−15.4911	−11.3281
Workday sleep duration	−3.4905	0.7848	−4.4479	< 0.05	−5.0290	−1.9521
Int_1	0.4030	0.0214	18.8323	< 0.01	0.3611	0.4450
Int_2	0.1325	0.0305	4.3439	< 0.01	0.0727	0.1923
Int_3	1.4825	0.1431	10.3632	< 0.01	1.2021	1.7630
Int_4	−0.0416	0.0029	−14.1479	< 0.01	−0.0474	−0.0358

Int 1: PMPU × anxiety; Int 2: PMPU × workday sleep duration; Int 3: Anxiety × workday sleep duration; Int 4: PMPU × anxiety × workday sleep duration

and chronotype, where overuse of mobile phones takes time away from sleep or causes circadian rhythm disruption, while lack of sleep can further affect mental health issues.

We first focused on the harm of excessive use of mobile phones, which is associated with the mental health [36, 37] and NSSI [38, 39], and then we observed the correlation between psychological problems and chronotypes through complex analysis results [23]. A RCT study based on mindfulness-based cognitive therapy (MBCT) intervention found the relationship between PMPU and depression [37]. Our study provide evidence that PMPU and poor mental health (depression, anxiety) are significant predictors of NSSI in young adults. Higher levels of PMPU and poorer mental health were associated with increased odds of engaging in NSSI; Furthermore, mental health variables moderated the relationship between PMPU and NSSI, suggesting that PMPU may contribute to NSSI through its impact on mental health. Overall, in this sample based study of college students, we found an association between PMPU and NSSI under different mental health and sleep patterns. In addition, previous study have verified that sleep problems including too long or too short sleep duration, social jet lag (SJL), evening chronotype, and other sleep abnormalities (e.g., daytime dysfunction, low sleep efficiency) were associated with NSSI and suicide-related variables [22].

With the economic development, the use of mobile phones has become more and more common. While bringing convenience, it will inevitably bring negative effects. The popularity of smart phones has changed our way of life so much that they have become an indispensable part of our daily life. However, smartphone use also has a complex impact on mental health, it can also have a certain impact on eyesight in the near future, and the most important is the long-term psychological impact. Besides, the influence of mobile phone content on adolescents also affects sleep [13]. Previous study found moderating effects of PER3 gene DNA methylation on the association between PMPU and chronotype among Chinese young adults [40]. The previous follow-up study of our research group found that there was a positive correlation between PMPU of different tracks and chronotype, that is, the continuously rising PMPU was related to evening type [17], this study demonstrated that overuse of mobile phones has been linked to disrupted circadian rhythms. Another study explore the correlation between phone use and

health-related quality of life (HRQoL), through chain mediation model, chronotype and sleep quality play an important role, moreover, phone use also correlated with chronotype [41].

Among large scale participants study with six universities, results shown that mobile phone addiction was significantly associated with increased odds of suicide ideation and suicide attempt [42]. Moreover, the role of smart phone use was also important among sleep patterns and mental health [26, 43], maybe circadian clock play an important role between these variables [18]. Therefore we also concerned the effect of sleep patterns on NSSI [44]. An insights from computational causal analysis examined some possible factors and NSSI, Nine factors, including sleep duration, were found to be strongly associated with NSSI by the PC (Peter and Clark) method, the Fast Causal reasoning (FCI) method, and the GAE (Graphic Autoencoder) method [45]. A large-scale study evidence in China also verified the correlation between problematic smartphone use, chronotype and NSSI among adolescents, eveningness and problematic smartphone use (PSU) can increase the risk of NSSI both independently and interactively [16]. From the above evidence, it is clear that excessive use of mobile phones can not only affect sleep, but also further affect mental health, so as to produce more severe NSSI behavior. Although a large number of previous studies focused on the association between PMPU and suicide, the mechanism of sleep as a mediator was also mentioned [46, 47], because the use of mobile phones in the transitional zone not only occupied the study time, but also occupied the sleep time and changed the sleep habits, which further led to the occurrence of adverse psychological problems.

In addition, from a biological perspective, clock genes play an important role in suicidal self-injury behavior [48], from a social perspective, chronobiological rhythm disturbances were significantly associated with the severity of depressive symptoms, mood disorders, and suicide in bipolar patients. In particular, non-rhythmical sleep/wake patterns were significantly associated with manic symptoms, non-rhythmical daily activities with depressive symptoms and mood disorders, and non-rhythmical social life with suicidal behavior [49]. These findings highlight the importance of addressing PMPU and mental health in prevention and intervention efforts for NSSI. Interventions aimed at reducing PMPU, such as digital detox programs and promoting healthy technology use, may help mitigate the risk of NSSI. Additionally, mental health services, including counseling and psychotherapy, should be readily available to support young adults experiencing emotional distress.

Implications for future study

The strong link between PMPU, chronotype, and mental health disorders and NSSI highlights the importance of addressing lifestyle and sociological factors in prevention and treatment strategies. Improving mental health literacy and providing accessible support services on the one hand can help mitigate the risks associated with NSSI, and on the other hand, further understanding of mental health problems caused by excessive mobile phone use and poor sleep habits to better understand the interactions between them involved and develop targeted interventions to effectively address these interrelated issues.

Limitations

This study has several limitations. First, the cross-sectional design, while observing an association, limits the generalization of causal inference, and future longitudinal studies are needed to explore the specific temporal relationship between PUMP, mental health, and NSSI. Second, self-reporting may bring recall bias, and future studies should incorporate objective research methods, such as the use of accelerometers and the use time recorded by mobile phones, to improve the validity of research results and to compare data. Thirdly, only male and female were recorded in our study, we will discuss other gender difference in the future study. Finally, the sample was primarily composed of young adults from native student, which may limit the generalizability of the results.

Conclusion

In conclusion, this study demonstrates that problematic mobile phone use and poor sleep habits are significant predictors of psychological issues and NSSI in young adults. Sleep habit variables play a crucial role in moderating the relationship between PMPU and NSSI, while mental health issues serve as a mediating factor. These findings provide guidance for developing targeted interventions to reduce the prevalence of NSSI among young people, highlighting their significant importance. Additionally, focusing on the assessment of mobile device use, often in combination with tools such as wearable devices, neuroimaging, and social media data, can provide a foundation for the development of interventions and offer personalized feedback.

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Dear editor, our manuscript is not a clinical study. thank you very much.

Clinical trial number

Not applicable.

Authors' contributions

All authors have contributed significantly to the study and have approved the final version of the manuscript. Yi Zhang, Qingqing Kang and Li Zhu were

responsible for the study design and data collection. Keyan Hu, Li Gong and Yijing Chen conducted the statistical analyses. Yi Zhang and Qiu Zhang contributed to the interpretation of the results and the writing of the manuscript.

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Data availability
The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethics Committee of Anhui Medical University. All focus group participants provided signed informed consent prior to the start of the focus groups. Our study also are compliance with the Helsinki Declaration.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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