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# Depression and suicidal ideation among Chinese college students during the COVID-19 pandemic: the mediating roles of chronotype and sleep quality

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## Abstract

**Background** This study was intended to investigate the correlation between depression and suicidal ideation among Chinese college students during the COVID-19 pandemic and the potential mediating roles of chronotype and sleep quality in this relationship .

**Methods** A sample of 4,768 college students was selected from four institutions in Anhui Province, China, and the study was conducted during the COVID-19 pandemic (November to December 2020) using a stratified, cluster, multi-stage sampling method. This study used the two-item Patient Health Questionnaire (PHQ-2) to assess depressive symptoms, the Morningness-Eveningness Questionnaire 19 (MEQ-19) to determine individual sleep chronotypes (i.e., morning or evening preference), and the Pittsburgh Sleep Quality Index (PSQI) to evaluate sleep quality. Participants were asked about suicidal ideation. MPLUS 8.3 software was used to analyze the mediating effect of chronotype and sleep quality on the relationship between depression and suicidal ideation.

**Results** During the COVID-19 pandemic, the prevalence of suicidal ideation among Chinese college students was 5.4%. Depression was inversely correlated with chronotype (beta = − 0.346, $P < 0.01$) and positively correlated with sleep quality (beta = 0.846, $P < 0.001$), indicating that students experiencing depressive symptoms were more likely to have a later chronotype and poor sleep quality. A later chronotype (beta = − 0.019, $P < 0.05$) and poor sleep quality (beta = 0.066, $P < 0.01$) predicted suicidal ideation. Depression emerged as a direct and significant risk factor for suicidal ideation (effect value = 0.535, 95% confidence interval: 0.449 ~ 0.622). Chronotype and sleep quality were

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found to have potential mediating effects on the relationship between depression and suicidal ideation; however, the chain-mediating effect of chronotype and sleep quality was not statistically significant.

**Conclusions** Our findings suggest that during the COVID-19 pandemic, depression can precipitate suicidal ideation through its influence on sleep chronotype and quality. These compelling findings highlight the urgency of early intervention strategies intended to mitigate suicidal thoughts, particularly among students exhibiting depressive symptoms, who experience disrupted sleep patterns and poor sleep quality.

**Keywords** Depression, Suicidal ideation, Chronotype, Sleep quality, College students

## Background

Suicide is a major public health issue and the second leading cause of death among college students [1, 2]. Furthermore, suicide is currently the primary cause of death among those between the ages of 15 and 34 in China [3], leading to significant concerns both in schools and in society as a whole. Suicidal ideation can predict suicide risk at the early stages of the suicide process. Suicidal ideation refers to a situation in which a person conceives of a plan and/or forms a desire to commit suicide without taking suicidal measures [4]. The coronavirus disease 2019 (COVID-19) pandemic, as a major public health crisis, has influenced the predisposition among college students to develop suicidal ideation. Suicidal ideation has become particularly widespread among college students since the beginning of the COVID-19 pandemic. For example, a meta-analysis of 113 studies from 31 countries found that approximately 20.6% of university students experienced suicidal ideation [5]. Another systematic review and meta-analysis found a prevalence of 15.0% for suicidal ideation among medical students [6]. Furthermore, a three-wave repeated survey conducted among Chinese college students during the outbreak, remission, and prevention periods of the pandemic reported the prevalence of suicidal ideation to be 7.3%, 9.4%, and 12.6%, respectively [7]. Thus, given the increasing prevalence of suicidal ideation among college students since the COVID-19 pandemic began, a better understanding of the factors that may predispose this population to suicidal ideation is crucial.

Studies have highlighted the pivotal roles of depression and sleep problems in the development of suicidal ideation. Neurotransmitter theory proposes strong correlations among suicidal thoughts, depression, and poor sleep, all stemming from abnormalities in neurotransmitter function [8–10]. Imbalances in these crucial neurotransmitters can disrupt mood regulation and cognitive processes, subsequently affecting sleep chronotype and quality. Consequently, depression and sleep disorders may increase the risk of suicidal thoughts, underscoring the intricate interplay among neurotransmitters in modulating mood, cognition, and sleep. Ultimately, neurotransmitter imbalances can concurrently affect mood, cognition, and sleep among individuals with depression, thereby fostering an environment conducive to suicidal ideation.

### Depression and suicidal ideation

As the most prevalent mental health disorder among college students, depression has emerged as a significant predictive risk factor for suicidal ideation both before and during the COVID-19 pandemic [11–16]. For example, a meta-analysis of medical students underscored the predictive power of depression for suicidal ideation, with an odds ratio of 6.87 [17]. Furthermore, a systematic review focusing on university students suggested that depression is an underlying risk factor for the development of suicidal thoughts [18]. However, despite robust evidence establishing the link between depression and suicidal ideation among college and university students, the intricate mechanisms underlying this association remain largely unknown. Consequently, it is vital to identify the influencing factors and elucidate the precise mechanisms by which depression influences suicidal ideation, as this can help facilitate the development of more targeted interventions and support systems.

### Potential mediating effect of chronotype

The COVID-19 pandemic significantly disrupted college students' sleep habits, as manifested by delayed sleep onset and offset timing, consequently promoting a shift toward eveningness (i.e., later sleep chronotype) [19, 20]. Chronotype refers to individual preferences regarding the timing of activities and sleep patterns [21] and is an important indicator for assessing individual circadian rhythms [22]. An intricate biological clock system, notably the Suprachiasmatic Nucleus, orchestrates the circadian rhythms in the human body. However, depressive moods can disrupt the functionality of this nucleus, thereby disturbing sleep rhythms, which in turn exacerbates emotional distress and suicidal thoughts. Depression is an important predictor of circadian rhythms [23, 24] and partially mediates the relationship between psychopathy and evening chronotype preference [25]. According to one longitudinal study, adolescents with a history of depressive symptoms or a depression diagnosis exhibited a stronger evening chronotype preference [26]. This trend extended to both American and Chinese

adolescents, for whom depressive symptoms predicted delayed sleep wake patterns and subsequent sleep difficulties [27, 28]. Furthermore, research has consistently indicated that chronotype serves as a predictor of suicidal ideation [29–32]. Specifically, nocturnal wakefulness is positively correlated with suicidal thoughts, whereas morning wakefulness is inversely related to them [33]. Notably, the feelings of depression and despair that often accompany early awakening are closely tied to heightened suicidal ideation. Therefore, we posited that depression may serve as a precursor to the development of a particular chronotype, which, in turn, may precipitate suicidal ideation among college students. Accordingly, we hypothesized that chronotype mediates the relationship between depression and suicidal ideation.

#### Potential mediating effect of sleep quality

The COVID-19 pandemic had a detrimental effect on college students' sleep quality [34]. Sleep quality encompasses various aspects of an individual's daily slumber, including sleep duration and the presence of sleep-related problems. Individuals with depression often experience poor sleep quality, which can worsen their emotional distress and make them more vulnerable to feelings of despair and hopelessness, potentially leading to suicidal thoughts. Depression is an important predictor of sleep quality [24, 35]. For example, one study conducted among patients with cirrhosis revealed strong links between major depression and both inadequate nighttime sleep and excessive daytime drowsiness [36]. Comparable associations have been observed among university and college students in both cross-sectional and follow-up studies [37–40]. Furthermore, several investigations have underscored the predictive role of sleep quality in suicidal thoughts among college students [41, 42]. Thus, we posited that depression is an antecedent to sleep quality, which, in turn, may mediate the development of suicidal ideation among college students. Therefore, in this study, we tested the hypothesis that sleep quality mediates the relationship between depression and suicidal ideation.

#### Potential chain mediating effect of chronotype and sleep quality

As hypothesized, a plausible pathway exists through which chronotype and sleep quality mediate the relationship between depression and suicidal ideation. Furthermore, these two factors are intimately intertwined when examined as joint mediators, with chronotype orchestrated by both circadian rhythms and homeostatic mechanisms to uphold sleep quality regularity. Disruptions in circadian rhythms can disrupt the body's internal clock, triggering issues such as shortened sleep duration and compromised sleep quality [43, 44]. Studies conducted on college students reinforced the connection between chronotype disruptions and suboptimal sleep quality [28, 45–48]. Their findings suggest that chronotype and sleep quality may have a chain-mediating effect on depression and suicidal ideation.

In summary, this study investigated the relationship between depression and suicidal ideation among college students, while also exploring the pivotal mediating effects of chronotype and sleep quality, to offer insights and guidance for improving college students' mental health. Therefore, the theoretical hypothesis was modeled and the following four hypotheses were formulated: (1) depression can positively predict suicidal ideation among college students; (2) depression can indirectly predict suicidal ideation among college students via chronotype; (3) depression can indirectly predict suicidal ideation among college students via sleep quality; and (4) depression can indirectly predict suicidal ideation in college students via chronotype and sleep quality.

## Methods

#### Study designs and participants

This large cross-sectional study was conducted during the COVID-19 pandemic (November to December 2020). The participants came from four colleges and universities in Anhui Province, eastern China. Located in the midstream and downstream regions of the Yangtze River and Huaihe River, Anhui is nestled deep within the Yangtze River Delta. It borders Jiangsu Province to the east, Hubei provinces to the west, Zhejiang Province to the southeast. A stratified, cluster, multi-stage sampling method was used in our study. First, schools were stratified into medical schools and non-medical schools. Second, two institutions within medical schools and two institutions within non-medical schools were selected using convenience sampling. Then, convenience sampling was used to select a number of majors in each of the four schools. Following this, whole cluster random sampling was used to select a number of classes in each major based on the composition of the classes within each major. Finally, each student in the selected classes was surveyed.

Participants were students who were engaged in learning at school and willing to take part in our survey. We excluded participants who were on probation or doing internship or unwilling to take part in the survey.

Prior to the formal survey, a pilot survey was conducted to validate the comprehensibility and validity of the questionnaire. Based on the feedback, some measures for improvement were taken to bolster the quality of the questionnaire. This included incorporating explanatory notes to clarify queries that had caused confusion, and ensuring that the content of the questionnaire was precisely aligned with the comprehension level of the respondents. Furthermore, we revised expressions that had inadvertently caused discomfort or even distress to

participants, fostering a more sensitive and receptive survey environment. The pre-survey found a detection rate of suicidal ideation was 8.0%. Meanwhile, the investigators (graduate and undergraduate students majoring in preventive medicine) were trained uniformly. During the formal survey, the investigators, guided by the counsellor, entered the classroom and read out the instructions prior to distributing the questionnaires. They then instructed the students to complete the questionnaire on the spot and collected them immediately afterwards. Any incorrect or incomplete responses were promptly identified, notified to the students, and corrected.

5,400 students were selected to complete the paper-and-pencil survey, 5,063 were recovered (recovery rate: 93.8%), and 295 unqualified were eliminated because of a large number of unanswered questions, or discernible patterns in the responses (such as consistently selecting the same answer for all questions or regularity), and finally, 4,768 college students participated in the study (effective rate: 94.2%).

In accordance with the Declaration of Helsinki, all students were aware of the purpose of the study, participated in it voluntarily, and signed the written informed consent. Ethical approval for this study was granted by the Ethics Committee of School of Public Health, Wannan Medical College (NO. LL-2020BH8003).

### Instruments

The questionnaire included five parts: sociodemographic characteristics (such as gender and age), the two-item Patient Health Questionnaire (PHQ-2), the Morningness-Eveningness Questionnaire 19 (MEQ-19), the Pittsburgh Sleep Quality Index (PSQI) and suicidal ideation.

### The two-item Patient Health Questionnaire (PHQ-2)

The PHQ-2 [49] is a screening tool designed to assess symptoms of depression over the past two weeks. It consists of two items (.i.e, "Little interest or pleasure in doing things" and "Feeling down, depressed, or hopeless"). Participants rate each question on a Likert scale ranging from 0 (not at all) to 3 (nearly every day), resulting in a total score from 0 to 6, with higher scores indicating more severe depressive symptoms.

The PHQ-2 is widely used self-rating scale and has been reported to have good psychometric properties in Chinese populations [50]. The Cronbach's α coefficient of this study was 0.769.

#### *Morningness-eveningness questionnaire 19 (MEQ-19)*

The Chinese version of MEQ-19 was used to evaluate the chronotype among university students [51]. This self-assessment scale comprises 19 items, with a total score ranging from 16 to 86. A higher score indicates a more pronounced characteristic of early bedtime and early wake-up, whereas a lower score, indicates a more pronounced characteristic of late bedtime and late wake-up. The MEQ-19 has been reported to have good psychometric characteristics in Chinese populations and has been extensively used in diverse populations [45, 52, 53]. The Cronbach's α coefficient of the current study was 0.708. Furthermore, the Kaiser-Meyer-Olkin (KMO) value of 0.825, coupled with a significant Bartlett's Test of Sphericity ($P<0.001$), suggests that the scale exhibits good construct validity and that the data are suitable for factor analysis.

### Pittsburgh Sleep Quality Index (PSQI)

The PSQI was used to evaluate the sleep quality of college students [54]. It consists of 19 items, including seven dimensions: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disorders, use of sleeping medication and daytime dysfunction. Each dimension is scored on a 0–3 point scale, resulting in a total score ranging from 0 to 21, where a higher score indicates poorer sleep quality. The PSQI is widely used both in China and internationally for screening sleep disorders, and its Chinese version has been proven reliable in Chinese populations [55–57]. The Cronbach's coefficient of the current study was 0.675. Additionally, the KMO value of 0.828, coupled with a significant Bartlett's Test of Sphericity ($P<0.001$), suggests that the scale exhibits good construct validity and that the data are suitable for factor analysis.

### Suicidal ideation

Participants were asked a single question related to suicidal ideation in the past year: "In the past year, have you ever seriously thought about attempting suicide?" [58, 59]. This question is widely used to screen for suicidal ideation. The response options were "yes" or "no", with "yes" indicating that participants had thoughts of suicide and "no" indicating that participants did not have thoughts of suicide.

### Data analysis

Analyses were performed using SPSS 26.0 and MPLUS 8.3 software. We conducted the Harman univariate analysis using SPSS 26.0 software to examine the common method bias. The normality of the distribution of depression, chronotype, and sleep quality scores was tested using Kolmogorov-Smirnov tests, which showed that none followed a normal distribution ($P<0.05$). Descriptive analysis was performed using mean (standard deviation, SD) or median ($P_{25}$, $P_{75}$) for quantitative data and number (percentage) for qualitative data. Spearman rank correlation analyses were used for correlation analyses. Chi-squared ($\chi^2$) tests were used to compare the difference between the categorical variables with and without

**Table 1** Demographic characteristics of study participants ($n=4768$)

| Characteristic | *N* or mean/median | % or SD or ($P_{25}$, $P_{75}$) |
|---|---|---|
| Age (years) | 19.14 | 1.11 |
| Gender | | |
| Male | 2,059 | 43.2 |
| Female | 2,709 | 56.8 |
| School | | |
| Medical | 3,195 | 67.0 |
| Non-medical | 1,563 | 33.0 |
| Depression (PHQ global score) | 1.00 | (0.00, 2.00) |
| Chronotype (MEQ-19 score) | 49.00 | (44.00, 54.00) |
| Sleep quality (PSQI global score) | 5.00 | (3.00, 7.00) |
| Suicidal ideation | | |
| Yes | 259 | 5.4 |
| No | 4,509 | 94.6 |

suicidal ideation. The Mann-Whitney U tests were performed to compare the difference between different quantitative variables with and without suicidal ideation. Mplus 8.3 software was used to examine whether chronotype and sleep quality mediated the relationship between depression and suicidal ideation. We assessed the total, direct, and indirect effects of depression on suicidal ideation, and compared the differences in mediating effects across pathways. The 95% confidence intervals (*CIs*) for all indirect effects were calculated using bias-corrected bootstrapping with 5000 samples. Statistical significance level was set at $P<0.05$ (two-tailed).

### Common method biases

The Harman single-factor test was conducted to assess the common method deviation. The results of factor analysis showed that there were 10 factors with characteristic roots greater than 1, and the variance explained by the first factor alone was 17.70% (<40%) [60]. Hence, there were no obvious common method biases.

## Results

### Descriptive analysis

A total of 4,768 college students participated in this study, including 2,059 males (43.2%) and 2,709 females (56.8%), with a mean age of 19.14 years (SD=1.11). The median score ($P_{25}$, $P_{75}$) for depression, chronotype, and sleep quality among all the participants was 1.00 (0.00, 2.00), 49.00 (44.00, 54.00), and 5.00 (3.00, 7.00), respectively. The overall prevalence of suicidal ideation among the students was 5.4%. The detailed results are presented in Table 1.

### Correlation analysis

The results of the correlation analysis showed that the depression score was negatively correlated with the chronotype score ($r_s=-0.085$, $P<0.01$) and positively correlated with the sleep quality score ($r_s = 0.420$, $P<0.01$).

**Table 2** Correlations between scores of depression, chronotype, and sleep quality

| | Depression | Chronotype | Sleep quality |
|---|---|---|---|
| Depression | 1.000 | | |
| Chronotype | −0.085** | 1.000 | |
| Sleep quality | 0.420** | −0.175** | 1.000 |

Note: **$P<0.01$ (two-tailed)

Additionally, a negative correlation was observed between the chronotype score and sleep quality score ($r_s=-0.175$, $P<0.01$) (Table 2).

### Univariate analysis

Univariate analyses revealed statistically significant differences in scores for depression, chronotype and sleep quality between students with and without suicidal ideation ($P<0.01$) (Table 3). However, no statistically significant difference was observed in age and gender between these two groups ($\chi^2=0.575$, $P=0.565$; $\chi^2=3.821$, $P=0.051$). Similarly, there was no statistically significant difference in suicidal ideation between medical and non-medical college students ($\chi^2=2.465$, $P=0.116$).

### Regression analysis and chain mediating effects tests

Based on the results of correlation and univariate analyses, a multiple mediation analysis was conducted to examine the mediating roles of chronotype and sleep quality in the relationship between depression and suicidal ideation among college students. Depression was inversely associated with chronotype (beta=−0.346, $P<0.01$) and positively associated with sleep quality (beta=0.846, $P<0.001$), indicating that students with depressive symptoms were more likely to have a later chronotype and experience poor sleep quality. Furthermore, a later chronotype (beta=−0.019, $P=0.025$) and poor sleep quality (beta=0.066, $P=0.004$) predicted suicidal ideation. Additionally, a later chronotype

**Table 3** Comparison of different characteristics of students with and without suicidal ideation

| Variables | with suicidal ideation | without suicidal ideation | $\chi^2$/Z | *P* |
|---|---|---|---|---|
| Gender | | | 3.821 | 0.051 |
| Male | 127 | 1932 | | |
| Female | 132 | 2577 | | |
| School | | | 2.465 | 0.116 |
| Medical | 162 | 3033 | | |
| Non-medical | 97 | 1476 | | |
| Depression | 2.00(2.00, 4.00) | 1.00(0.00, 2.00) | −13.86 | < 0.001 |
| Chronotype | 48.00(43.00, 52.00) | 49.00(44.00, 54.00) | −2.901 | 0.004 |
| Sleep quality | 7.00(5.00, 8.00) | 5.00(3.00, 7.00) | −8.593 | < 0.001 |

**Table 4** Path coefficients in the model of depression and suicidal ideation, mediated by chronotype and sleep quality

| Effect | Estimate | SE | 95% CI |
|---|---|---|---|
| Suicidal ideation on chronotype | −0.019 | 0.008 | (−0.035 ~ −0.003) |
| Suicidal ideation on sleep quality | 0.066 | 0.023 | (0.021 ~ 0.109) |
| Sleep quality on depression | 0.846 | 0.034 | (0.781 ~ 0.913) |
| Sleep quality on chronotype | −0.058 | 0.006 | (−0.069 ~ - 0.048) |
| Chronotype on depression | −0.346 | 0.101 | (−0.547 ~ - 0.145) |
| Total effect | 0.598 | 0.041 | (0.519 ~ 0.680) |
| Direct effect | 0.535 | 0.043 | (0.449 ~ 0.622) |
| Total indirect effect | 0.063 | 0.019 | (0.026 ~ 0.101) |
| Indirect effect via chronotype | 0.006 | 0.003 | (0.001 ~ 0.014) |
| Indirect effect via sleep quality | 0.056 | 0.019 | (0.018 ~ 0.094) |
| Indirect effect via chronotype then sleep quality | 0.001 | 0.001 | (0.000 ~ 0.003) |
| Difference in mediating effects mediated by chronotype and sleep quality | −0.050 | 0.021 | (−0.090 ~ −0.009) |

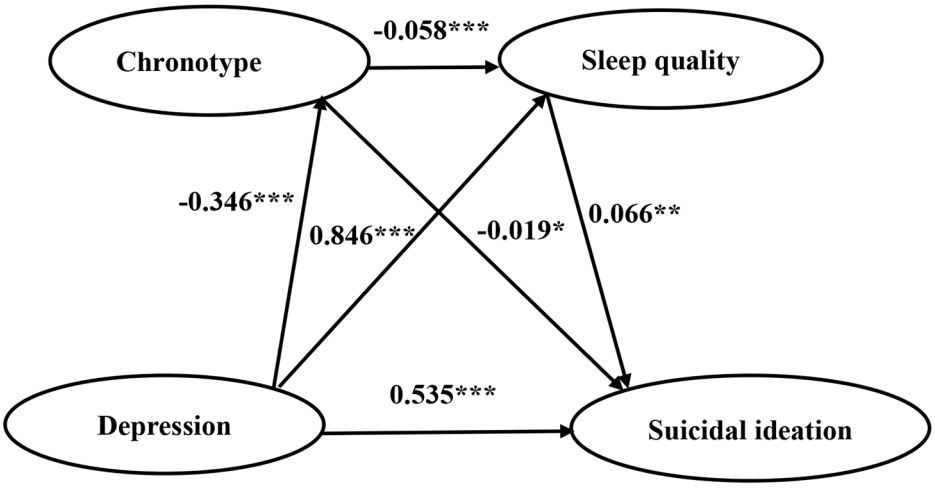


**Fig. 1** Model of mediating roles of chronotype and sleep quality between depression and suicidal ideation *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

was associated with poor sleep quality (beta = −0.058, $P < 0.001$) (Table 4).

The mediation path model is illustrated in Fig. 1, while the path coefficients, as well as the direct, indirect, and total effects, along with their 95% *CI*s, are presented in Table 4. Depression emerged as a direct and significant risk factor for suicidal ideation (effect value = 0.535, 95% *CI*: 0.449 ~ 0.622). Notably, chronotype and sleep quality partially mediated the effect of depression on suicidal ideation through two significant pathways: (1) chronotype (effect value = 0.006, 95% *CI*: 0.001 ~ 0.014), accounting for 1.00% of the total effect, and (2) sleep quality (effect value = 0.056, 95% *CI*: 0.018 ~ 0.096), accounting for 9.4% of the total effect. However, the chain mediation effect of chronotype through sleep quality was not statistically significant (effect value = 0.001, 95% *CI*: 0.000 ~ 0.003, inclusive of 0). Furthermore, there was a statistically significant difference in the mediating

effect between chronotype and sleep quality (difference = −0.050, 95% CI:−0.090 ~ −0.009, exclusive of 0).

## Discussion

To the best of our knowledge, this large cross-sectional study represents the first comprehensive examination of the associations among depression, chronotype, sleep quality, and suicidal ideation in a sample of college students. Furthermore, this study explored the mediating roles of chronotype and sleep quality in these relationships. Our findings underscore the profound impact of depression on suicidal ideation, revealing both the direct and indirect pathways mediated by chronotype and sleep quality. Notably, although chronotype and sleep quality both partially mediate the relationship between depression and suicidal ideation, the combined chain mediation effect was not statistically significant.

This study found the prevalence of suicidal ideation among college students to be 5.4%, which is notably lower than the 15% prevalence reported in a systematic review and meta-analysis conducted during the COVID-19 pandemic [6]. This is lower than the rates observed in a three-wave repeated survey conducted during the outbreak period, remission period, and normalized prevention and control period, which reported prevalence rates of 8.5%, 11.0%, and 12.6%, respectively [16]. Furthermore, this rate was lower than the 17.1% reported by Xue et al. [61] but higher than the 3.89% reported by Yu et al. [62], who conducted their study one year after the current study. Differences in student demographics, variations in survey instruments and the different stages of the COVID-19 pandemic may contribute to the different prevalence of suicidal ideation among college students. This study was conducted one year after the outbreak of the COVID-19 pandemic, during a period of normalized prevention and control. During this time, college students had developed a greater understanding of the pandemic and adopted a more optimistic attitude toward it, leading to a reduction in suicidal ideation among this demographic [62]. Furthermore, colleges and universities in China have placed significant emphasis on the mental health of college students, actively engaging in various forms of activities aimed at promoting their mental well-being. These efforts have had a positive impact on the mental health of college students [63]. Additionally, factors such as the social stigmatization of suicide, interpersonal relationships, and individual feelings of shame or embarrassment may also contribute to the under-reporting of suicidal ideation [64, 65]. Some college students with suicidal thoughts may be reluctant to participate in surveys or honestly express their feelings due to these factors, resulting in a lower reported rate of suicidal ideation.

Studies have documented a high prevalence of suicidal ideation among medical students [66, 67]. However, our study did not reveal a statistically significant difference in the prevalence of suicidal ideation between medical and non-medical college students. Similarly, unlike previous studies, we did not observe a statistically difference in suicidal ideation between male and female college students [68, 69]. This could be attributed to the comparable pressures faced by both medical and non-medical students, as well as men and women, during the COVID-19 pandemic, including academic, occupational, interpersonal, and familial stresses. Moreover, with the growing popularity of mental health education and heightened awareness among students of their mental well-being, both medical and non-medical students, irrespective of gender, are now equipped with relevant mental health education that empowers them to manage psychological pressures and negative emotions effectively [68].

### Effect of depression on suicidal ideation

Studies have unequivocally established a direct link between depression and suicidal ideation [70, 71]. One Bangladeshi study conducted during the COVID-19 pandemic revealed that university students experiencing depression were 4.1 times more likely to report suicidal thoughts than their peers without depression [71]. These findings align with ours, suggesting that suicidal ideation stems from the severity of depressive symptoms. One plausible explanation for this association is the comorbidity of depression with other mental health issues such as anxiety, stress, panic, and pessimism, which collectively heighten the risk of suicidal thoughts [18]. Another pivotal factor is emotional regulatory self-efficacy (ERSE), which may mediate the relationship between depression and suicidal ideation. Depressive symptoms often signify maladaptive emotional regulation strategies that diminish ERSE by fostering negative emotions and hindering emotional regulation. Consequently, individuals with low ERSE may struggle to harness their emotional regulation skills to manage negative emotions, potentially resorting to avoidance, and fostering suicidal thoughts [13]. However, the relationship between depression and suicidal ideation may be complex, and further research is required on the underlying mechanisms. Our study underscores the heightened vulnerability to suicidal thoughts among students with high depression scores, emphasizing the importance of prioritizing students' mental health, particularly among those with pronounced depressive symptoms. Accordingly, society as a whole, schools, and families must collaborate to offer attention and support to students with depression, with the goal of preventing and mitigating the occurrence of suicidal ideation.

### Mediating role of chronotype

Individuals with depression frequently experience disruptions in their sleep–wake cycles and circadian rhythms. Adolescents with depression encounter a range of sleep issues, including difficulties in initiating and maintaining sleep, poor sleep quality, early morning awakenings, excessive daytime sleepiness or hypersomnia, irregular sleep–wake patterns, nightmares, and persistent sleep complaints [72–75]. These disturbances in sleep rhythms among individuals with depression may be closely associated with hyperactivity of the HPA axis [76–78]. Furthermore, diminished melatonin levels may provide a biological basis for sleep disturbances [79]. Moreover, emotional dysregulation has emerged as a plausible explanation for the influence of chronotype on the relationship between depression and suicidal ideation. When college students' chronotypes are disturbed, emotional regulation mechanisms that rely on adequate nighttime sleep falter, leading to emotional dysregulation and heightened emotional arousal, which, in turn, intensifies psychological distress and fosters suicidal ideation [80]. Functional brain connectivity is a pivotal factor in elucidating the link between chronotype-mediated depression and suicidal ideation. As depressive symptoms intensify, sleep patterns tend to shift toward nocturnality. This is accompanied by abnormal activation and connectivity within the brain regions associated with nocturnal emotion processing, particularly heightened amygdala activation. Additionally, the functional connectivity between the amygdala and cingulate gyrus is diminished, thereby inhibiting the regulatory influence of the cingulate cortex on the amygdala. This impairment may further compromise an individual's emotional regulation capabilities, exacerbate depressive symptoms, and ultimately increase suicidal ideation [81]. Furthermore, when facing depressive moods, individuals with a night chronotype often resort to maladaptive coping strategies, such as self-blame, rumination, and expressive inhibition. These strategies perpetuate feelings of profound depression, which may increase suicidal thoughts [82].

#### *Mediating role of sleep quality*

Individuals with depression frequently experience poor sleep quality, a phenomenon that may be intricately linked to the volume of gray matter in the right insula [83]. From a neurocognitive perspective, this relationship is further nuanced by the influence of cognitive impairment on the links among depression, sleep quality, and suicidal ideation. Specifically, young individuals' negative perceptions of academic or occupational pressures can foster excessive worry and ruminative thoughts before sleep, thereby heightening arousal levels and disrupting sleep patterns. This in turn impairs cognitive functioning, exacerbates difficulties in coping with life challenges, and potentially fosters suicidal thoughts [84–86]. Moreover, emotional regulation mechanisms play a pivotal role in this intricate interplay. Individuals with depression often exhibit extended periods of rapid eye movement (REM) sleep, which is associated with reduced emotional regulation and contributes to further sleep disturbances [87]. The emotional dysregulation triggered by poor sleep quality can intensify an individual's negative emotional experiences and psychological distress. This heightened vulnerability to feelings of hopelessness and helplessness could then lead to suicidal ideation [88]. Additionally, poor sleep quality may lead to dysfunction in the inferior frontal gyrus, which impairs cognitive abilities and sensitizes individuals to negative emotions, thus further amplifying the risk of suicidal ideation [88]. The intricate interplay among depression, sleep quality, cognitive functioning, and emotional regulation forms a vicious cycle that can significantly contribute to the development of suicidal ideation.

This large cross-sectional study demonstrates the impact of depression on suicidal ideation and validates chronotype and sleep quality as mediators in this relationship. This suggests that we need to pay attention to students' chronotypes and sleep quality, and their depressive mood to reduce suicidal ideation. Parents, schools, and relevant educators should promptly attend to, guide, and relieve students' negative emotions. Simultaneously, they should assist students in improving their chronotype and sleep quality, thereby reducing suicidal ideation, enhancing students' mental well-being, and promoting overall high-quality development during students' university years.

### Limitations and future directions

Despite its contributions, this study has several notable limitations. First, because this was a cross-sectional study, a causal relationship between depression and suicidal ideation could not be established. Therefore, future prospective cohort studies should be conducted to determine causal and temporal relationships.

Second, using a single binary question to assess suicidal ideation did not fully or adequately capture suicidal thoughts, nor can it provide model-fit metrics. Thus, future studies should use more advanced statistical methods. Additionally, subjective assessments of sleep quality present challenges in terms of accuracy. Incorporating objective measures such as polysomnography, could enhance our understanding of college students' sleep patterns, including duration and efficiency.

Furthermore, the current study's focus on chronotype and sleep quality overlooked the intricate interplay among various sleep behaviors. To gain a more holistic view, future research should investigate a broader range of sleep problems, such as snoring, insomnia, and

daytime sleepiness, to better reflect an individual's overall sleep status and identify specific sleep patterns that contribute to depression and suicidal ideation.

Moreover, the study overlooked some potential confounding factors, such as personality traits, family history of mental health issues, family and class environment, and early-life adversity. Future studies should incorporate a wider range of potential confounders to ensure a more comprehensive and accurate assessment of this relationship.

Finally, the experimental results obtained in this study, which included participants from only one province and was conducted during the COVID-19 pandemic, may not fully capture the diversity in the college student population across different regions, ethnicities, and time periods. Therefore, caution should be exercised when generalizing our findings to broader populations and contexts. Future research should aim to validate these findings by using larger and more representative samples encompassing students from diverse geographical regions, survey times, and demographic backgrounds.

## Conclusions

This study examined the relationship between depression and suicidal ideation among Chinese college students, emphasizing the pivotal mediating roles of chronotype and sleep quality. This underscores the profound influence of depression in fostering suicidal thoughts, while shedding light on the underlying mechanisms that govern this phenomenon. The identification of chronotype as a mediator offers a fresh perspective on suicide prevention and intervention strategies. This study suggests a novel approach to enhancing mental health and potentially mitigating suicidal ideation among college students by adjusting circadian rhythms. This study also underscores the crucial mediating effect of sleep quality and emphasizes the need to prioritize sleep improvement in both prevention and treatment efforts. Furthermore, this study provides a robust theoretical basis for developing prevention and intervention strategies. It underscores the relationship among depression, chronotype, sleep quality, and suicidal ideation, offering practical insights such as modifying work schedules and optimizing sleep environments to promote mental wellness and reduce suicidal thoughts.

Overall, this study provides a new perspective for understanding the relationship between depression and suicidal ideation among Chinese college students and emphasizes the mediating roles of chronotype and sleep quality. The findings not only deepen the current understanding of this complex issue but also contribute invaluable knowledge to inform effective prevention and intervention efforts.

### Abbreviations

| | |
|---|---|
| PHQ-2 | the two-item Patient Health Questionnaire |
| MEQ-19 | Morningness-Eveningness Questionnaire 19 |
| PSQI | Pittsburgh Sleep Quality Index |
| COVID-19 | Coronavirus disease 2019 |
| KMO | Kaiser-Meyer-Olkin |
| SD | Standard deviation |
| $\chi^2$ | Chi-squared |
| CI | Confidence interval |
| ERSE | Emotional regulatory self-efficacy |
| REM | Rapid eye movement |

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### Author contributions

WLY and CWW designed the study. SJG, WAS, TYJ, LHQ and FY contributed to literature searching, data collection and analysis. CWW, JYL and SH assessed study quality. WLY, ZL, and ZLJ wrote the manuscript. WLY, ZL and JYL revised the manuscript. All authors read and approved the final manuscript.

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### Data availability

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

## Declarations

### Ethics approval and consent to participate

All students were aware of the purpose of the study, and participated in it voluntarily. Informed consent was obtained from all the participants. Ethical approval for this study was granted by the Ethics Committee of School of Public Health, Wannan Medical College (NO. LL-2020BH8003).

### Consent for publication

Not Applicable.

### Competing interests

The authors declare no competing interests.

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