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The Relationship Between Insufficient Sleep and Depressive Symptoms in Chinese Adolescents: A National Survey of Contributing Factors

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Purpose: There is a lack of national studies examining the relationship between insufficient sleep and depression among Chinese adolescents, and previous research has not comprehensively considered related factors. This study aimed to investigate the prevalence of depressive symptoms in adolescents with insufficient sleep and explore the role of associated factors using a nationally representative sample in China.

Patients and Methods: A pen-and-paper survey was conducted among 24147 Chinese adolescents from November 2019 to January 2020. Data on depressive symptoms, maltreatment experiences, psychological resilience, demographic information, parent–child relationships, parental marital status, and sleep duration were collected.

Results: A total of 22231 valid questionnaires were analyzed. Among the respondents, 67.7% reported insufficient sleep, while 32.3% had sufficient sleep. The prevalence of depressive symptoms was 25.3% in adolescents with insufficient sleep, compared to 8.2% in those with sufficient sleep. Insufficient sleep was identified as an independent risk factor for depressive symptoms (OR = 3.058, 95% CI: 2.753–3.396, $P < 0.001$). In adolescents with sufficient sleep, being female, emotional abuse, physical abuse, sexual abuse, and physical neglect were significant risk factors for depressive symptoms ($P < 0.05$), while higher resilience scores and a good parent–child relationship were protective factors ($P < 0.05$). Among adolescents with insufficient sleep, additional risk factors included higher body mass index (BMI), older age, parental divorce, and living with a single parent ($P < 0.05$).

Conclusion: Insufficient sleep is significantly associated with depressive symptoms in Chinese adolescents. The adolescents with insufficient sleep, particularly those who are older, have a higher BMI, or come from divorced or single-parent households, require increased attention.

Keywords: depressive symptoms, sleep duration, adolescent mental health, parent–child relationship

Introduction

Globally, depressive symptoms among adolescents are on the rise,[1] with approximately 20% experiencing depression during puberty.[2,3] In China, about 19.85% of adolescents report depressive symptoms.[4] This underscores the importance of investigating factors contributing to adolescent mental health challenges.

Research has established a correlation between mental health conditions and insufficient sleep duration.[5] The American Academy of Sleep Medicine recommends that adolescents age 13 years and older should sleep no less than 8 hours per day.[6] However, the average sleep duration among Chinese adolescents falls significantly short of this recommendation, with 66.49% not getting enough sleep.[7] Insufficient sleep has been linked to an increased risk of depression, anxiety,[8] and even suicide in adolescents.[9] For instance, a cross-sectional study involving 10185 Chinese adolescents in Sichuan Province found that depression scores were 2.614 points higher in sleep-deprived students compared to those with adequate sleep.[10] Similarly, another cross-sectional study of 7330 Chinese adolescents in Zhejiang Province revealed that longer sleep duration was associated with fewer depressive symptoms.[11] Although these studies have explored the link between insufficient sleep and depression in adolescents, they were limited by small

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sample sizes and a focus on only one province in China. This highlights the need for a nationwide survey with representative samples from different provinces.

It is known that lack of sleep impairs cognition and negatively affects brain excitability and plasticity induction,[12] both of which are related to the psychopathology of depression, which is documented in people with night shift workers.[13,14] Similarly, insufficient sleep in adolescents can also result in a decline in learning, memory, and mental health. Therefore, investigating the relationship between insufficient sleep and adolescent depression, as well as the underlying factors, is beneficial for understanding the pathogenesis.

The family environment may also influence adolescents' susceptibility to the depressive effects of insufficient sleep.[15] Poor parent–child relationships, childhood abuse, and harsh parenting styles are associated with a higher incidence of adolescent depression.[16,17] Additionally, adolescents with divorced or single parents are more likely to develop depression.[18,19] A cohort study in China suggested that better parental relationships might mitigate the risk of depressive symptoms in adolescents.[20] On the other hand, psychological resilience is a protective factor against environment-induced depression in adolescents.[21] Therefore, it is crucial to consider these factors when researching adolescent mental health.

To the best of our knowledge, it is more informative to examine the effects of psychological resilience and family environmental factors —such as maltreatment, parental marital status, and parent–child relationship— in a large sample size when investigating the relationship between insufficient sleep and depression in a national sample of Chinese adolescents.

This study is an exploratory investigation to verify the relationship between insufficient sleep and depression, and the role of maltreatment, parent-child relationship and resilience etc. We aimed to determine the prevalence of depressive symptoms among Chinese adolescents with insufficient sleep. Additionally, we examined the correlation between insufficient sleep and depression, controlling for confounding factors such as psychological resilience, maltreatment, parent–child relationship, and parental marital status. Finally, we investigated the factors influencing depression in adolescents with sufficient and insufficient sleep, respectively. Through this study, we aim to better understand the psychological impact of insufficient sleep on adolescent depression and establish a basis for developing interventions to improve adolescent mental health.

Materials and Methods

Study Design and Procedure

An onsite pen-and-paper survey using self-report questionnaire was conducted from November 2019 to January 2020 across China. A two-stage cluster sampling method was employed to select a nationally representative sample of junior high schools. In the first stage, 17 cities were randomly selected from the stratified regional framework based on the administrative divisions of China (Southwest, Northeast, Southeast, Central, North and South). In the second stage, one junior high school was randomly selected from the list provided by the education bureau in each city as the final sampling framework. Finally, the method of full sampling was used to investigate all the students aged 13–18 years old in the selected junior high school. Students under the age of 13 were not included in the study. The survey was conducted in the classroom, with experienced staff members responsible for distributing and collecting questionnaires on-site and answering questions. Each student could only fill out the questionnaire once. Invalid questionnaires were identified based on the following criteria: (1) completion rate of less than 90%, (2) confirmation by researchers that the student provided meaningless answers, and (3) missing important data, such as age and sex.

The study received approval from the Ethics Committee of the Third Affiliated Hospital of Beijing University of Chinese Medicine (No. BZYSY-2019KYKTPJ-21). Prior to the survey, informed consents were obtained from both students and their guardians. Data collection was confidential, and the survey was conducted anonymously.

Survey Response and Participants

A total of 24147 questionnaires were collected in this survey. After excluding invalid questionnaires, 22231 valid responses were retained, resulting in a validity rate of 92.1%. Among the 22231 adolescents surveyed, the average age was 14.10 years (range 13 years-18 years), with 50.3% being males.

Measurement Instruments

Data on demographic characteristics were collected using a self-designed questionnaire, which included age, body mass index (BMI), sex, boarding student or day student, parental marital status, and parent–child relationship.

Sleep duration was assessed with the question, "Over the past month, how many hours of sleep have you actually gotten per day?".[22] According to the American Academy of Sleep Medicine, adolescents aged 13–18 years old should get no less than 8 hours of sleep per day.[6] Therefore, insufficient sleep was defined as <8 hours per day, and sufficient sleep as ≥8 hours.

Depressive symptoms were assessed using the Patient Health Questionnaire for Depression (PHQ-9),[23] which has a score range of 0–27. The PHQ-9 includes a 9-item self-report depression module using a 4-point Likert scale ranging from 0 (not at all) to 3 (almost every day), which asks participants to rate their feelings over the past 2 weeks.[24] A score of 10 was set as the cut-off for having depressive symptoms.[25,26] The scale showed high reliability among Chinese adolescents (Cronbach's α = 0.854), as well as a good discrimination for depressive symptoms (sensitivity = 0.90, specificity = 0.94).[27] In this study, the Cronbach's α for the PHQ-9 was 0.911.

Childhood maltreatment was evaluated using the Childhood Trauma Questionnaire (CTQ),[28] with total scores ranging from 25 to 125. The CTQ contains 5 subscales to assess the 5 subtypes of childhood maltreatment. Each subscale consists of 5 items using a 5-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always). The cut-off scores for each subscale were as follows: 8 for physical abuse, 9 for emotional abuse, 6 for sexual abuse, 8 for physical neglect, and 10 for emotional neglect.[29] The scale has been validated with high reliability among Chinese adolescents (Cronbach's α = 0.852).[30]

Psychological resilience was measured using the Chinese version of the Connor-Davidson Resilience Scale (CD-RISC). The CD-RISC is a 25-item scale using a 5-point Likert-type response scale ranging from 0 (not true at all) to 4 (true nearly all of the time). Participants rate their feelings based on the past month.[31] The score range for the CD-RISC is 0–100, with higher scores indicating greater resilience. The Chinese version of the CD-RISC has a good internal consistency (Cronbach's α = 0.97).[32] In this study, the Cronbach's α for the CD-RISC was 0.928.

Statistical Analysis

All statistical analyses were conducted using SPSS version 25.0. Age was reported as mean ± standard deviation (SD). Non-normally distributed continuous variables, such as BMI, PHQ-9 scores, resilience, and abuse scores, were reported using median and interquartile ranges (IQRs). Statistical differences were assessed using the Student's t or Mann–Whitney *U*-test as appropriate. Count data, including sex, boarding student, parental marital status, parent–child relationship, presence of depressive symptoms, and experience of abuse were described using numbers and percentages, with statistical differences assessed using the chi-square test.

To elucidate the association between related factors and depression in all adolescents, logistic regression was performed to identify risk and protective factors for depressive symptoms. Additionally, multivariate logistic regression analysis was separately performed for adolescents with sufficient sleep and insufficient sleep to explore the differences in depression-related factors.

Results

Participant Characteristics in Adolescents with Sufficient and Insufficient Sleep

Of the 22231 participants, 7188 (32.3%) reported sufficient sleep, while 15043 (67.7%) reported insufficient sleep (Table 1).

Compared to adolescents with sufficient sleep, those with insufficient sleep were more likely to be girls (54% vs 40.8%, P <0.001) and were slightly older (14.16 years vs 13.97 years, P <0.001). Additionally, adolescents with insufficient sleep had higher BMI, a lower rate of boarding student, poorer parent–child relationships, and incomplete parental marital status (all P <0.05, Table 1).

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Table 1 Demographic Characteristics in Adolescents with Sufficient and Insufficient Sleep

Variables	Total (n=22231)	Sufficient sleep (n=7188)	Insufficient sleep (n=15043)	Z/t/χ2	p
Age (mean±SD)	14.10±0.92	13.97±0.92	14.16±0.91	−14.570	<0.001
Sex (girls, %)	11,050(49.7)	2933(40.8)	8117(54.0)	336.674	<0.001
BMI, median (IQR)	19.53(5)	19.38(6)	19.53(5)	−2.481	0.013
Boarding student (Yes,%)	5205(23.4)	1793(24.9)	3412(22.7)	13.888	<0.001
Parental marital status (N,%)				52.818	<0.001
Married	19904(89.5)	6584(91.6)	13,320(88.5)		
Divorced	1197(5.4)	287(4.0)	910(6.0)		
Remarried	785(3.5)	218(3.0)	567(3.8)		
Single-parent	345(1.6)	99(1.4)	246(1.6)		
Parent–child relationship (N, %)				209.023	<0.001
Poor	666(3.0)	147(2.0)	519(3.5)		
Average	5273(23.7)	1330(18.5)	3943(26.2)		
Good	16292(73.3)	5711(79.5)	10,581(70.3)		

Abbreviations: BMI, Body Mass Index; PHQ-9, Patient Health Questionnaire for depression.

Psychological Outcomes in Adolescents with Sufficient and Insufficient Sleep

A total of 4389 (19.7%) adolescents exhibited depressive symptoms. Adolescents with insufficient sleep had higher median PHQ-9 (IQR) scores (4 [8] vs 2 [5], P <0.001) and higher prevalence of depressive symptoms (25.3% vs 8.2%, P <0.001) compared to those with sufficient sleep. Although the prevalence of physical neglect was similar between the two groups (P =0.454), the physical neglect score was higher among adolescents with insufficient sleep (P =0.014). Rates and scores for physical abuse, sexual abuse, emotional abuse, and emotional neglect were all higher among the adolescents with insufficient sleep (all P <0.05). Conversely, resilience scores were significantly lower in the insufficient sleep group (51 [23] vs 59 [26], P <0.001, Table 2).

Relationship Between Insufficient Sleep and Depression

To identify the relationship between insufficient sleep and depression, logistic regression analysis was conducted (Table 3). Model 1 (univariate logistic regression) was unadjusted, while Model 2 (multivariate logistic regression) was adjusted for demographic characteristics including age, sex, BMI, boarding status, parental marital status, and parent–child relationship. Model 3 (multivariate logistic regression) further adjusted for psychological outcomes including resilience and abuse experiences in addition to the adjustments made in Model 2. Model 1 revealed an association between insufficient sleep and a higher likelihood of depressive symptoms (OR = 3.812, 95% CI: 3.476–4.18, P <0.001). In Model 2, adolescents with insufficient sleep continued to show a higher likelihood of depressive symptoms (OR = 3.317, 95% CI: 3.013–3.653, P < 0.001). Finally, Model 3 demonstrated that insufficient sleep remained a significant factor for depressive symptoms (OR = 3.058, 95% CI: 2.753–3.396, P < 0.001). Additionally, higher BMI, older age, being female, parental divorce, physical neglect, physical abuse, sexual abuse, and emotional abuse were all identified as risk factors for depressive symptoms (all P <0.05). In contrast, higher resilience and better parent–child relationships were protective factors against depression (all P < 0.001).

Differences in Depression-Related Factors Between Adolescents with Sufficient Sleep and Insufficient Sleep

Multivariate logistic regression analyses were performed using the significant variables (P<0.05) from Model 3 to explore depression-related factors among adolescents with sufficient sleep and insufficient sleep, respectively (Figure 1).

Table 2 Psychological Outcomes in Adolescents with Sufficient and Insufficient Sleep

Variables	Total (n=22231)	Sufficient sleep (n=7188)	Insufficient sleep (n=15043)	Z/χ2	P
PHQ-9, median (IQR)	4(7)	2(5)	4(8)	−46.465	<0.001
Depressive symptom (Yes,%)	4389(19.7)	586(8.2)	3803(25.3)	900.586	<0.001
Resilience, median (IQR)	53(25)	59(26)	51(23)	−24.771	<0.001
Emotional abuse score, median (IQR)	6(4)	6(3)	7(4)	−20.994	<0.001
Emotional abuse experience (Yes,%)	5847(26.3)	1388(19.3)	4459(29.6)	267.852	<0.001
Physical abuse score, median (IQR)	5(1)	5(1)	5(1)	−7.205	<0.001
Physical abuse experience (Yes,%)	3085(13.9)	880(12.2)	2205(14.7)	23.743	<0.001
Sex abuse score, median (IQR)	5(0)	5(0)	5(0)	−2.527	0.011
Sex abuse experience (Yes,%)	2553(11.5)	768(10.7)	1785(11.9)	6.68	0.01
Emotional neglect score, median (IQR)	10(8)	9(8)	11(8)	−10.782	<0.001
Emotional neglect experience (Yes,%)	12,114(54.5)	3543(49.3)	8571(57.0)	115.873	<0.001
Physical neglect score, median (IQR)	8(4)	8(4)	8(4)	−2.467	0.014
Physical neglect experience (Yes,%)	12,232(55.0)	3929(54.7)	8303(55.2)	0.562	0.454

Abbreviations: BMI, Body Mass Index; PHQ-9, Patient Health Questionnaire for depression.

Table 3 Logistic Regression Analysis Models of the Relationship Between Insufficient Sleep and Depression Among All Adolescents

Variable	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Insufficient sleep(1=no)	3.812(3.476–4.18)[c]	3.317(3.013–3.653)[c]	3.058(2.753–3.396)[c]
BMI		1.013(1.008–1.019)[c]	1.007(1.001–1.012)[a]
Age		1.098(1.055–1.142)[c]	1.088(1.041–1.137)[c]
Sex (1=boy)		1.75(1.625–1.884)[c]	1.536(1.412–1.67)[c]
Boarding student (1=no)		1.089(1–1.185) [a]	1.084(0.986–1.192)
Parent's marital status (1=Married)			
Divorced		1.547(1.346–1.778)[c]	1.291(1.104–1.51)[b]
Remarried		1.773(1.499–2.097) [c]	1.148(0.95–1.387)
Single-parent		1.717(1.328–2.219)[c]	1.305(0.985–1.73)
Parent–child relationship(1=poor)			
Average		0.398(0.335–0.473)[c]	0.854(0.704–1.037)
Good		0.103(0.087–0.122)[c]	0.495(0.407–0.602)[c]
Resilience			0.954(0.952–0.957)[c]
Emotional abuse experience (1=no)			4.088(3.739–4.47)[c]
Physical abuse experience (1=no)			1.415(1.27–1.577)[c]
Sex abuse experience (1=no)			1.505(1.346–1.684)[c]
Emotional neglect experience (1=no)			0.985(0.889–1.092)
Physical neglect experience (1=no)			1.151(1.048–1.265)[b]

Note: [a] P <0.05, [b] P < 0.01, [c] P < 0.001.
Abbreviation: BMI, Body Mass Index.

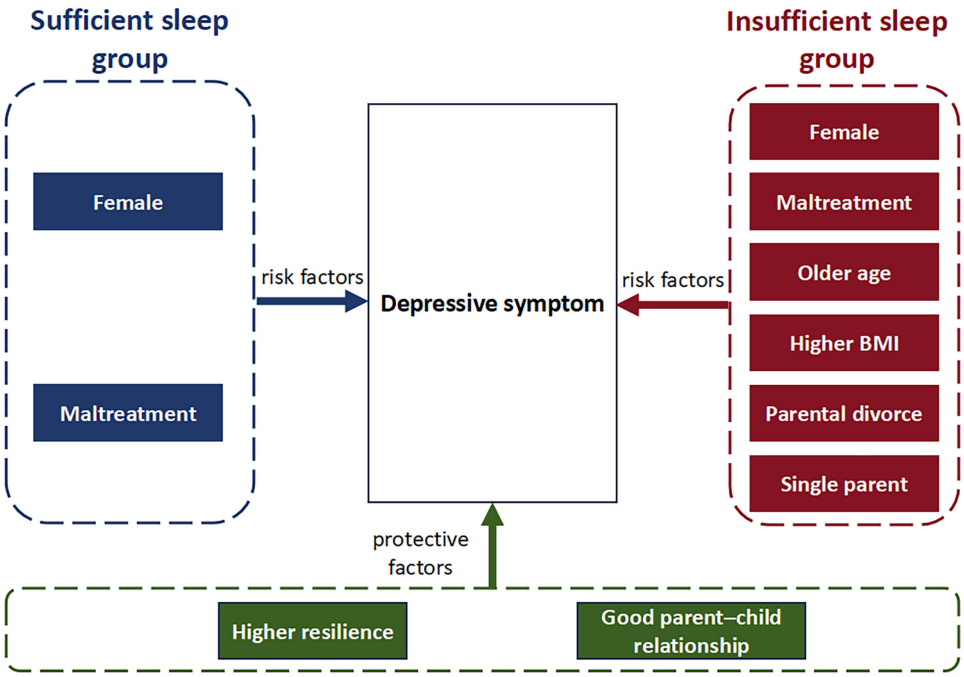

Figure 1 Depression-related factors of sufficient sleep vs insufficient sleep.
Abbreviation: BMI, Body Mass Index.

For adolescents with sufficient sleep, being female was a risk factor for depression (OR = 1.254, 95% CI: 1.042–1.51, P =0.017). Adolescents who experienced emotional abuse (OR = 3.789, 95% CI: 3.094–4.64, P < 0.001), sexual abuse (OR = 1.302, 95% CI: 1.023–1.657, P =0.032), physical abuse (OR = 1.66, 95% CI: 1.321–2.085, P < 0.001), and physical neglect (OR = 1.24, 95% CI: 1.009–1.525, P =0.041) also had higher likelihood for depressive symptoms. In contrast, higher resilience scores (OR = 0.978, 95% CI: 0.973–0.982, P < 0.001) and a good parent–child relationship (OR = 0.598, 95% CI: 0.393–0.909, P = 0.016) were protective factors against depression (Table 4).

For the adolescents with insufficient sleep, in addition to the factors mentioned above, older age (OR = 1.147, 95% CI: 1.091–1.205, P < 0.001) and higher BMI (OR = 1.007, 95% CI: 1.001–1.014, P = 0.035) increased the risk of depressive symptoms. Parental divorce (OR = 1.318, 95% CI: 1.108–1.569, P = 0.002) and living with a single parent (OR = 1.432, 95% CI: 1.04–1.972, P = 0.028) were also identified as risk factors for depressive symptoms in adolescents with insufficient sleep (Table 5).

Discussion

The aim of this study was to investigate the prevalence of depressive symptoms in Chinese adolescents with insufficient sleep and explore the role of associated factors. We also compared the differences in influencing factors of depression in adolescents with sufficient and insufficient sleep. Our study yielded several key findings: (1) Among Chinese adolescents, the prevalence of insufficient sleep was 67.7%, which significantly increased the incidence of depressive symptoms. (2) For adolescents with sufficient sleep, being female and having experiences of maltreatment were risk factors for depression, while a better parent–child relationship and psychological resilience served as protective factors. (3) For adolescents with insufficient sleep, older age, higher BMI, parental divorce, and single-parent status also increase the risk of depression.

The Prevalence of Insufficient Sleep and Its Effect on Depressive Symptoms in Adolescents

A national survey in the United States found that the prevalence of insufficient sleep was 31.2% among adolescents aged 13–17 years.[33] However, regional studies in China have reported that the prevalence of insufficient sleep ranged from

Table 4 Multivariate Logistic Regression Analysis of Depressive Symptoms Among Adolescents with Sufficient Sleep

Variable	OR	95% CI	*P*
BMI	1.005	0.993–1.017	0.451
Age	0.96	0.871–1.06	0.421
Sex (1=boy)	1.254	1.042–1.51	0.017
Parent's marital status (1=Married)			
Divorced	1.109	0.746–1.65	0.608
Remarried	0.888	0.562–1.405	0.613
Single-parent	1.042	0.529–2.053	0.906
Parent–child relationship (1=poor)			
Average	0.981	0.646–1.488	0.927
Good	0.598	0.393–0.909	0.016
Resilience	0.978	0.973–0.982	<0.001
Emotional abuse experience (1=no)	3.789	3.094–4.64	<0.001
Physical abuse experience (1=no)	1.66	1.321–2.085	<0.001
Sex abuse experience (1=no)	1.302	1.023–1.657	0.032
Physical neglect experience (1=no)	1.24	1.009–1.525	0.041

Abbreviation: BMI, Body Mass Index.

Table 5 Multivariate Logistic Regression Analysis of Depressive Symptoms Among Adolescents with Insufficient Sleep

Variable	OR	95% CI	*P*
BMI	1.007	1.001–1.014	0.035
Age	1.147	1.091–1.205	<0.001
Sex (1=boy)	1.617	1.469–1.778	<0.001
Parent's marital status (1=Married)			
Divorced	1.318	1.108–1.569	0.002
Remarried	1.209	0.976–1.498	0.082
Single-parent	1.432	1.04–1.972	0.028
Parent–child relationship (1=poor)			
Average	0.793	0.632–0.994	0.044
Good	0.465	0.37–0.583	<0.001
Resilience	0.944	0.94–0.947	<0.001
Emotional abuse experience (1=no)	4.083	3.695–4.511	<0.001
Physical abuse experience (1=no)	1.343	1.187–1.52	<0.001
Sex abuse experience (1=no)	1.585	1.393–1.802	<0.001
Physical neglect experience (1=no)	1.111	1.004–1.23	0.042

Abbreviation: BMI, Body Mass Index.

44.0% to 55.0% among middle school students,[34] which is significantly higher than that in American adolescents. In our study, 67.7% of Chinese adolescents reported insufficient sleep, suggesting that this issue is more prevalent in China. As a Confucian country, China places a particular emphasis on academic performance, which may contribute to this high prevalence of insufficient sleep. Academic pressure and a heavy burden of homework are common in China.[8] For example, 34.7% of Chinese adolescents spent more than 10 hours per day studying, and 44.2% engaged in extracurricular learning tasks.[35] Another Chinese cohort study demonstrated that 24.4–77.3% of junior high school students complete their homework after 9 p.m., increasing the risk of depression due to reduced sleep durations.[34] Therefore, insufficient sleep is a significant issue among Chinese adolescents, likely driven by academic pressure.

In our study, we found that adolescents with insufficient sleep were of an older age, which may be due to increased academic stress.[34] Additionally, a higher proportion of adolescents with insufficient sleep were females, which may stem

from the earlier changes in sleep structure and hormone levels during puberty in girls.[36] Moreover, we observed a lower prevalence of insufficient sleep among boarding students, which may be attributed to the electronic device limitations and the earlier bedtimes in schools.[37] A longitudinal study also demonstrated a positive association between parent-child relationships and adolescent sleep duration,[38] which is consistent with our findings.

Our study also found that 25.3% of adolescents with insufficient sleep exhibited depressive symptoms, compared to only 8.2% of those with sufficient sleep ($P < 0.001$). Adolescents who did not get enough sleep were at higher risk of experiencing depressive symptoms (OR=3.058) compared to those with sufficient sleep. A regional study in China revealed that the prevalence of depression among adolescents who slept ≥9 hours, 8–9 hours, 7–8 hours, and <7 hours per day was 20.49%, 27.55%, 37.80% and 52.66%, respectively.[11] Additionally, another study among Americans demonstrated that the rate of a positive depression screen was higher for those with insufficient sleep (OR =1.58).[39]

Although the exact mechanism linking insufficient sleep and depressive symptoms remains unclear, several potential explanations exist, including altered neurodevelopment,[40,41] increased limbic system activity, endocrine and immune system disorders.[42,43] Among these mechanisms, neurocognitive factors and emotional memory need a special focus.

Insufficient sleep is associated with impairments in cognitive function, including learning and executive function.[44] Sleep deprivation has been demonstrated to impair cognitive performance and induce alterations in brain excitability and plasticity.[12] There is evidence that sleep deprivation is associated with impaired synaptic plasticity in the hippocampus,[45] which can result in modifications in protein synthesis, metabolism, neuronal loss and elevated glucocorticoid levels.[46,47] Moreover, impaired plasticity is associated with the psychopathology of depression. At the neurocognitive level, impaired cognitive flexibility and prefrontal inhibition have been identified as potential contributing factors in the development of depression.[48,49] At the molecular level, neuroplasticity impairment, including neuronal atrophy and synaptic inhibition in the medial prefrontal cortex and hippocampus, represents a principal mechanism underlying the development of depression.[50,51]

Furthermore, sleep disorders may act as a risk factor for the onset of depression by impairing the processing of emotional memories. Sleep deprivation has been demonstrated to affect the regulation of cortical limbic emotional circuits, with a negative impact on emotional memory consolidation.[52] Insufficient sleep impairs the retention of positive affective memories, while the long-term negative experiences are preserved,[53] all of which are associated with the psychopathology of depression.

Factors Associated with Depressive Symptoms in the Adolescents with Sufficient Sleep

Our study found that among adolescents with sufficient sleep, being female and experiencing maltreatment were risk factors for depression, while higher resilience and parent–child relationship were protective factors.

Studies have consistently shown that depression occurs at higher rates in girls.[54,55] This sex difference may be due to several factors. First, the effect of estrogen on the regulation of the hypothalamic-pituitary-adrenal axis can result in greater sensitivity to stress in girls, while androgens in boys may play a protective role.[56] Additionally, genetic vulnerability may contribute to sex differences in depression. For example, a significant interaction between the serotonin transporter gene and stress has been identified in girls.[57] Moreover, compared to boys, girls are more likely to ruminate and have internalizing problems, making them more vulnerable to stress.[58] These factors may contribute to the greater vulnerability to depression observed in girls during adolescence.

Maltreatment has been identified as a significant risk factor for adolescent mental health problems.[59] Maltreatment may lower self-esteem and foster negative, pessimistic thinking, exacerbating the severity and duration of psychological symptoms during puberty.[60] Among the five forms of abuse, emotional abuse is most strongly linked to depression,[61] which aligns with our findings.

Resilience, the ability to positively adjust to negative conditions, is a critical factor in regulating depression.[21] A longitudinal study of Chinese adolescents showed that high resilience reduced the severity of depression induced by adverse events.[62] Therefore, enhancing psychological resilience in adolescents is crucial for preventing depressive symptoms. Our study also found that a good parent–child relationship protected adolescents from depression.

A national cohort study in China found that a better parent–child relationship provided adolescents with greater perceived social support and self-esteem.[20] Furthermore, a positive parent–child relationship can mitigate the harmful effects of parental distress on adolescents' internalizing symptoms.[63] Improving parenting styles can help alleviate internalizing problems in children, including depressive symptoms.[64]

Factors Associated with Depressive Symptoms in the Adolescents with Insufficient Sleep

Among adolescents with insufficient sleep, in addition to the factors mentioned above, older age, higher BMI, parental divorce, and single parent status also increased the risk of depression.

First, our study found that adolescents with insufficient sleep were older. Academic burden and insufficient sleep duration often increase with age,[65] and academic stress can exacerbate psychological burdens in adolescents.[66] Therefore, the combination of increasing academic stress and insufficient sleep as adolescents age is more likely to cause depression. Second, insufficient sleep can lead to adverse health outcomes, such as overweight and obesity.[8] In our study, higher BMI was associated with insufficient sleep. A meta-analysis found that the risk of being overweight or obese was 58% higher in children with a shorter sleep duration.[67] Meanwhile, the risk of depression increased by 40% among obese adolescents.[68] Insufficient sleep not only leads to decreased activity and increased food intake but also affects metabolic hormones related to hunger and appetite, such as leptin, insulin, and cortisol,[69] which play important roles in the association between obesity and depression.[70] Additionally, adolescents with higher BMI are more likely to be dissatisfied with their body image, leading to more symptoms of depression.[71] Furthermore, adolescents with a high BMI are at an increased risk of developing obstructive sleep apnea, with a prevalence of 60%.[72] Obstructive sleep apnea can exacerbate pathological processes such as cerebral small vessel disease and blood-brain barrier dysfunction through intermittent hypoxia, causing perfusion insufficiency, endothelial dysfunction, and neuroinflammation. This ultimately leads to an exacerbation of depressive symptoms.[73] Therefore, maintaining a healthy weight may help mitigate depression caused by insufficient sleep.

Our study also suggested that parental divorce or single-parent status might increase the risk of depressive symptoms among the adolescents with insufficient sleep. We found that adolescents with divorced or single parents had a higher rate of insufficient sleep ($P<0.001$). A national cross-sectional study in Lebanon showed that adolescents with divorced parents experienced more severe depression and suicidal ideation.[74] Children from single-parent families might experience more childhood stress and higher level of rumination.[75] Moreover, a study in America found that family breakdown disrupted biological rhythms of sleep, increasing the risk of adolescent depression.[76] Therefore, both parents play an integral role in the healthy upbringing of adolescents. The presence of a complete family unit is beneficial in improving adolescent mental health. These findings suggest that adolescents with insufficient sleep are more likely to suffer from academic, family, and health-related pressures, leading to an increased probability of depression. Therefore, reducing academic stress, improving the family environment, and promoting healthier lifestyles may improve the mental health of adolescents, particularly those with insufficient sleep.

Furthermore, adolescents with insufficient sleep in our study had lower resilience scores ($P< 0.001$), consistent with previous studies.[77] Insufficient sleep impairs the functioning of the prefrontal cortex, which is associated with resilience, leading to decreased ability to handle stress.[78] In fact, findings from a study in Australia suggested that sleep duration mediated depression in adolescents through psychological resilience.[79] This may also explain why adolescents with insufficient sleep are more likely to experience depression in the face of additional pressures from family, school, and health. Therefore, interventions in the family or school environment that strengthen psychological resilience and increase sleep duration may help prevent the occurrence of depression.[80]

Limitations and Strengths

There are several limitations of this study. First, this is a cross-sectional study and no causal inference can be made. The results can only be interpreted as association rather than causal relationships. Future longitudinal studies are needed to address this issue. Second, although the assessments were self-reported and may be subject to reporting bias, previous

studies have found good correlations between self-reported and device-measured sleep duration.[81] Future studies could replicate these findings using wearable device monitoring. Third, we defined insufficient sleep in adolescents as a condition characterized by less than eight hours of sleep per day, which did not consider the impact of individual differences. Subsequent studies can incorporate more indicators, such as whether daytime functions can be maintained and sleep is fragmented or not, to address this issue. Finally, some factors were not included in this study, such as economic status and use of electronic devices, which should be considered in future studies. Socioeconomic status and sleep problems have joint effects on depression, especially in those with low socioeconomic status and sleep deprivation.[82] Furthermore, prolonged mobile phone use has been linked to an elevated risk of depression in adolescents, which is partially mediated by insufficient sleep duration.[83] Thus, the results in our study should be interpreted with caution.

However, this study also has several strengths. First, we explored the relationship between sleep and mental health status based on a nationally representative sample of Chinese adolescents. Second, all evaluations were conducted through an on-site pen-and-paper survey, ensuring relatively high data quality and response rates. Moreover, we considered a range of factors related to depressive symptoms, including boarding student, resilience, parent–child relationship, parental marital status, and maltreatment.

Conclusion

In conclusion, insufficient sleep is highly prevalent among Chinese adolescents. Our study highlights the significant role of insufficient sleep in contributing to depressive symptoms among this population, providing preliminary and exploratory evidence for the correlation between sleep duration and mental health. Adolescents with insufficient sleep are more likely to experience depressive symptoms, particularly those who are older, have a higher BMI, or come from divorced or single-parent households. Promoting a healthy school and family environment, along with enhancing psychological resilience, may help reduce the incidence of depressive symptoms among adolescents.

Data Sharing Statement

The datasets used during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

The study received approval from the Ethics Committee of the Third Affiliated Hospital of Beijing University of Chinese Medicine (No. BZYSY-2019KYKTPJ-21). Informed consents were obtained from both students and their guardians. Our study adheres to the principles of the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The author(s) report no conflicts of interest in this work.

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