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# Associations of Time Spent on Study and Sleep with Anxiety and Depressive Symptoms in Junior High School Students: Report from the Large-Scale Monitoring of Basic Education Data in China

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## ABSTRACT

In the context of the COVID-19 pandemic and under the pressure of high competitiveness for higher education in China, junior high school students' mental health is facing greater challenges. Understanding the time allocation of study and sleep is necessary for developing effective prevention and treatment programs. Based on a survey of 31,057 junior high school students in 47 junior high schools in Gansu Province, mainland China, the study analyzed the associations of time spent on study and sleep with anxiety and depressive symptoms among junior high school students through chi-square test, ANOVA, logistic regression model and threshold regression model. It was found that 18.4%–21.1% of junior high school students had mild and above anxiety and depressive symptoms. Female junior high school students were more likely to have anxiety and depressive symptoms. In addition, time spent on study was significantly and positively associated with anxiety and depressive symptoms and time spent on sleep was significantly and negatively associated with anxiety and depressive symptoms. Late sleepers were more likely to suffer from anxiety and depressive tendencies. Reducing after-school study time appropriately and getting more sleep are beneficial in reducing anxiety and depression, but it is more important to ensure time of sleep. For the reduction of anxiety and depressive symptoms, the maximum time spent on study after school should not exceed 1.92 h, the minimum time spent on sleep at night should be more than 7 h and a 40-min lunch break should be guaranteed at noon.

## KEYWORDS

Time spent on study; time spent on sleep; anxiety and depressive symptoms; threshold regression

## Introduction

Adolescence is a period of high prevalence of emotional problems such as depression and anxiety. The results of previous meta-analyses indicated that the prevalence of depressive symptoms among Chinese children and adolescents was 22.2% [1]. Moreover, in recent years, adolescents have shown increasing levels of anxiety and

depressive symptoms, with Chinese adolescents' depression levels rising by 7.31 points (0.76 standard deviations) from 1989–2018 [2]. Junior high school students are in their adolescence, when their physiology and psychology are in a rapid development stage. Although junior high school students are more mature than elementary school students, their sound personality has not yet been formed so they are still prone to stressful mental health problems when facing



stressful events in daily life [3]. The unbalanced physical and mental development and the gradual awakening of their sense of independence expose them to a variety of conflicts and worries, making them prone to different degrees of negative emotions such as sadness, anxiety, loneliness and helplessness [4].

In the context of the COVID-19 pandemic, as a global public health emergency, students are more likely to lead to psychological crises such as stress disorders, anxiety and depression [5]. China's tight control strategy for the outbreak has led to school closures in areas where the novel coronavirus has emerged, with students spending long periods of time in home isolation and studying online, making it easier for junior high school students to develop anxiety or depressive symptoms [6,7]. Certainly, the frequent occurrence of mental health problems among junior high school students is related to their own academic burden and the pressure of further education [8,9]. In conclusion, the physiological traits of junior high school students, the impact of COVID-19 pandemic and the pressure to enter higher education in China are likely to make their mental health more challenging. Therefore, mental health care for junior high school students is a realistic issue that cannot be ignored.

There may be a correlation between good study and sleep time allocation and the physical and mental health of junior high school students. In terms of research on study time allocation and adolescent mental health, Gilchrist et al. pointed out that adolescents' daily time allocation was related to mental health based on a survey study of Canadian secondary school students in grades 9 to 12. Specifically, sedentary time due to excessive homework may trigger psychological problems in adolescents. Replacing 15 min of homework time with 15 min of sleep significantly reduces anxiety and depressive tendencies [10]. Yim's survey of Korean elementary school students concluded that English study time was significantly and positively related to anxiety tendencies. Though exam pressure prompted students to extend study time, learning efficacy has not been improved [11]. Study implemented by Chao & Sun in Taiwan found that students with average grades spent more time studying in after-school tutoring and would experience greater test anxiety [12]. A survey from Singapore showed that adolescents overloaded with homework more likely to have a depressed emotional state, especially those who spent more than five hours a day doing homework on weekends and lacked a sense of well-being [13]. Xiao's study of elementary school students in Wuhan, China, examined that children with dyslexia spent more time on homework and scored higher on depression compared to normal children [14]. Regarding the relationship between the study time and anxiety and depression in adolescents, some studies listed factors such as stress, crowding out of sleep and recreation time, overtime learning due to homework and exams can cause psychological pressure on adolescents. Being under too much school-related pressure can lead to poor psychological status [15]. Excessive study time and distant relationships with teachers may trigger the lack of personal academic achievement and mental exhaustion [16]. Excessive time spent on extracurricular studies also

negatively affects students' attitudes towards school and reduce the sense of belonging to the school [17]. Increased study time crowds out the time spend on leisure, exercise, extracurricular activities and sleep. In Eastern countries such as China and Singapore, adolescents spend more time on homework but less time on sleep, physical activity and recreation. So they have lower levels of well-being than their peers in most Western societies [18]. In addition, long hours of study means that adolescents need to be sedentary. A study by Zhang et al. showed that the more time children and adolescents spent sedentary, the higher the risk of suffering from psychological problems [19].

In terms of research on sleep duration and adolescent mental health, sociocultural factors and high academic competition may contribute to adolescent sleep deprivation [20]. Homework is often a barrier to adolescents getting enough sleep, although intense homework input may be positively associated with academic performance [21]. However, too much homework can take time away from students' extracurricular activities and sleep, which has a negative impact on students' physical and mental health [22,23]. At the same time, poor psychological status is associated with sleep disorders and poor sleep quality. Reduced sleep increases the risk of depression [24] and it increases the risk of sleep loss which reinforces students' anxiety and depression [25,26] even creates a vicious cycle [27]. Certainly, some teenagers are obsessed with mobile phone and other digital devices at night leading to stay up late [28,29]. Lacking of parental supervision of sleep behavior also results in late sleep and short sleep duration [17]. Adolescents who are chronically late sleepers or have sleep disorders are at higher risk for psychological and emotional distress [30]. Lam & Lam's systematic review of childhood sleep disorders on adolescent mental health suggested a positive significant and probable causal relationship between early childhood sleep disorders and the development of anxiety and depression during adolescence [31]. A study of Japanese adolescents by Kaneita et al. argued that respondents who slept less than 7 h or more than 9 h had much worse mental health than those who slept between 7 and 9 h [32]. Rahimi et al. studied that inappropriate sleep habits, such as sleep deprivation or stay up late, are accompanied by mental health problems, including depression, anxiety and psychosis [33]. In addition, sleep disorders were positively associated with suicidal and self-harming behaviors in adolescents [34]. Lack of sleep can also cause poor concentration, memory loss, behavioral problems such as irritability, emotional instability, problematic behavior, mental illness and poor academic performance in adolescents [35-37].

In regions where traditional Confucian culture is prevalent (e.g., Korea, Japan, mainland China, Hong Kong, Taiwan, and Singapore), especially in mainland China. Differences in sleep deprivation are caused by a competitive learning environment [13]. The Confucian tradition is an integrated value system that emphasizes individual effort, self-cultivation, and academic achievement [38]. In Confucianism, the virtuous person has a strong internal drive for self-improvement. If a person improves himself through continuous learning, he will be regarded as a

virtuous person. These cultural values may influence the attitudes and behaviors of East Asians related to learning performance [39]. In China, where traditional Confucianism is prevalent, a “good” student is one who is diligent, conscientious, practical, and hard-working in his or her studies. These characteristics are synonymous with “hard work” and can be referred to as “learning virtues”. Previous studies have indicated that among students in Hong Kong, Taiwan, and Korea, working hard and achieving good grades are considered primary obligations [40]. Those students who pursue high academic achievement spontaneously feel guilt toward their parents when they experience academic failure. To get rid of the feeling of guilt, students motivate to study harder to achieve academic success [41]. In such a cultural context, a high level of competition among students and students’ perceptions of responsibility are the main motivators driving students’ intense learning [42]. A high sense of competition has been agreed upon by parents at the junior high school level. Increasing the time investment to study has also become a common choice for most students and parents [13,43]. Especially influenced by the highly selective pressure to advance to higher education, junior high school students tend to trade off sleep time and other leisure in pursuit of quality high school so that teens spend less time on sleep, media use, and social activities [44,45]. The pressure to spend longer hours studying through intense homework and extracurricular tutorial input often considered necessary to achieve excellent academic performance. The fact that final test scores affect students’ future schooling and careers may be what is causing adolescents in Asian countries to sleep later and for shorter periods of time than those in Western countries [17].

It is true that a small number of studies have examined the relationship between overload learning or sleep duration and adolescent mental health. But there are no studies based on Confucian culture to verify the relationship between learning, sleep duration and anxiety and depression. Most of the existing studies use small samples to analyze this relationship. There is a lack of large-scale monitoring data to test more scientifically. In addition, to date, few studies have included both study time and sleep time to analyze the effects of both on junior high school students’ anxiety and depressive tendencies, especially in the context of the COVID-19 pandemic. There is little evidence on how junior high school students allocate study and sleep time to ensure academic progress and physical and mental health. Finally, there are also limited studies examining criteria for minimum sleep duration or maximum study duration to reduce the prevalence of anxiety and depression in adolescents. These empirical findings are important for developing and improving behavioral interventions for adolescent mental health as well as time allocation. Therefore, the purpose of this study was to examine the relationship between study and sleep duration and anxiety and depressive symptoms among Chinese junior high school students.

This study is based on Macan’s time management behaviours theoretical perspective [46]. The theory connotes

four aspects: setting task goals, mechanisms of time management behavior, preference for organization and perceived control over time. An important assumption of the model is that time management behaviors predict individual psychological states, such as personal anxiety, happiness, self-efficacy, etc. [47]. Time management behaviors affect an individual’s perception of time control, which in turn affects individual self-efficacy and psychological mood. Thus, unscientific time allocation have a negative impact on mental health. A related study analyzed the relationship between time allocation and job satisfaction and well-being of college students using time management behaviours theory [48]. In this study, adolescents’ time allocation by setting reasonable plans and goals can reduce anxiety and depression tendencies. When adolescents have excessive study time investment and do not allocate study time scientifically influenced by school and family, they cannot control time effectively and even fail to achieve the goal of improving academic performance. It leads to adolescents’ anxiety and depression tendencies.

Based on the above theoretical discussion and literature review, we proposed the following hypotheses, (1) H1: Longer homework/extracurricular tutoring time on school days or weekends would be associated with higher anxiety and depression scores. (2) H2: Lack of sleep or late sleep will be associated with higher anxiety and depression scores. (3) H3: Study and sleep duration are jointly related to anxiety and depression, and securing sleep duration is more important for reducing anxiety and depression. (4) H4: There is a maximum length of study or minimum sleep duration standard to reduce the prevalence of anxiety and depressive symptoms.

## Materials and Methods

### Sample

The data of the study were obtained from the data of the monitoring of students’ academic quality at the basic education level in China, which was conducted by the team of the Evaluation of Students’ Academic Quality in Basic Education Schools Project of East China Normal University from December 10 to 30, 2021, in 47 junior high schools in Gansu Province, mainland China. A total of 31,188 junior high school students were surveyed by the questionnaire. Owing to the very large sample size of participants, this study could maintain sufficient statistical validity precisely. In order to ensure that each questionnaire was filled out by an individual student truthfully, we arranged for the questionnaires to be distributed by school administrators at a centralized site during a uniform period of time. Sufficient time to think and recall was guaranteed. Then we eliminated 131 questionnaires that were clearly d (e.g., they filled in the same answers for most multiple choice questions or missing basic information). The final sample size of the valid questionnaires was 31,057.

In terms of research ethics, the survey was conducted anonymously and with the authorization of the Chinese government and the Faculty of Education of East China

**TABLE 1**  
**Demographic characteristics**

Variables	Number	Percentage
Gender		
Female	15046	48.4%
Male	16011	51.6%
Age		
13 years old	6313	20.3%
14 years old	15588	50.2%
15 years old	8828	28.4%
Other ages	328	1.1%
Ethnicity		
Han nationality	27764	89.4%
Ethnic minority	3293	10.6%

Normal University. All participants or their parents/guardians gave informed consent prior to participation. The demographic characteristics are shown in Table 1. In terms of gender, 16,011 (51.6%) were male and 15,046 (48.4%) were female; in terms of age, the average age of the respondents was 14 years old, of which 6,313 (20.3%) were 13-year-old children, 15,588 (50.2%) were 14-year-old children, 8,828 (28.4%) were 15-year-old children, and other 328 children of other ages, accounting for 1.1%; As for ethnic categories, 27,764 children of Han nationality, accounting for 89.4%, and 3,293 children of ethnic minorities, accounting for 10.6%.

#### Measures

**Anxiety scale.** We used the Generalized Anxiety Disorder Scale (GAD-7) to assess participants' anxiety status [49]. The Anxiety Disorder Scale (GAD-7) is a brief self-report scale designed to identify possible cases of GAD [50]. The GAD-7 scale is widely used for GAD screening in adolescents [51]. The scale has been Chineseized widely used in surveys of Chinese youth [52,53]. The Chinese version of GAD-7 has also been proven to be reliable and effective [54]. Participants were asked to respond to seven items (e.g., "I can't help worrying in daily life or learning process") on a 4-point scale (ranging from none to almost daily), with each item scoring 0–3. A total score of 0–4 for no anxiety, 5–9 for mild anxiety, 10–14 for moderate anxiety, and 15–21 for severe anxiety. The Cronbach alpha coefficient for this scale was 0.944.

**Depression Scale.** The Chinese version of the Center for Epidemiological Studies Depression 9-item scale (PHQ-9) was used to measure depressive symptoms in adolescents [55]. The PHQ-9 has been shown to have good reliability and validity [56]. The scale has nine items, each of which is scored from 0 to 3 based on the frequency of clinical depressive symptoms in the past week (from none to almost daily), with the total score being the sum of each item score. A total score of 0–4 indicates relatively healthy, 5–9 indicates mild depression, 10–14 indicates moderate depression, while

15–19 indicates moderate to severe depression and 20–27 indicates severe depression. The Cronbach alpha coefficient for the scale was 0.929.

**Time spent on study.** Since most Chinese schools are in a centralized management system, especially the junior high school belongs to the compulsory education stage, time spent on study in the school curriculum is fixed for all students in junior high school, so there is no difference in the study duration of junior high school students in school. Therefore, the measurement here is the time spent on after-school study for junior high school students. The International Student Assessment Data (PISA) showed that Chinese junior high school students spent relatively more time in extracurricular learning compared to other countries [57]. Time spent on study includes the duration of homework completion and after-school tutoring. The questionnaire measures the average daily time spent on homework completion and the participation in after-school tutoring in hours per day.

**Time spent on sleep.** Time spent on sleep included nap duration, night sleep duration and whether to sleep late. The survey respondents' average daily nap duration in the past week and average daily night sleep duration in the past week, both in hours per day. According to the sleep quality standards for junior high school students issued by the Chinese Ministry of Education, junior high school students should be in bed by 22:00 [58]. Accordingly, whether the variable sleeps late or not is distinguished by 10 pm at night.

#### Statistical analysis

In the analysis, we used STATA 16 software for statistical analysis. We first show the current status of depression and anxiety among participants, using chi-square tests to analyze the anxiety and depression symptoms among junior high school students difference in gender. Second, we use ANOVA and chi-square test to analyze the differences in time spent on study and sleep and anxiety and depressive symptoms scores of students. Third, we classify anxiety and depression into two categories: no/anxiety tendency and no/depression tendency and use binary logistic regression models to assess the relationship between time spent on study and sleep and anxiety and depressive symptoms in students then use shapley decomposition to analyze which time spent on study and sleep has the greatest association with anxiety and depressive symptoms. In this regard, the basic econometric model of the logistic regression model was set as follows:

$$\text{logit}Y_i = \ln\left(\frac{Y_i}{1 - Y_i}\right) = \beta_0 + \beta_1\text{Sleep} + \beta_2\text{Study} + \varepsilon \quad (1)$$

In Eq. (1),  $Y_i$  represents whether the student has anxiety or depressive symptoms, Sleep represents sleep duration, which includes nighttime sleep and nap duration. Study represents time spent on study, which includes the duration of homework and after-school tutoring.

Finally, the effects of both study time and sleep time on anxiety and depressive symptoms in junior high school students may not be presented in a linear fashion singularly, but rather there is an optimal duration criterion. Therefore, we measured time spent on study and sleep criteria for



TABLE 2

## Participant anxiety symptoms and gender differences

Variables	No anxiety	Mild anxiety	Moderate anxiety	Moderate to severe anxiety	Major anxiety	$X^2$	$p$
Female	11820 (78.6%)	2033 (13.5%)	478 (3.2%)	401 (2.7%)	314 (2.1%)	190.08	$p < 0.001$
Male	13536 (84.5%)	1625 (10.1%)	356 (2.2%)	278 (1.7%)	216 (1.3%)		
Total	25356 (81.6%)	3658 (11.8%)	834 (2.7%)	679 (2.2%)	530 (1.7%)	-	-

TABLE 3

## Participant depressive symptoms and gender differences

Variables	No depression	Mild depression	Moderate depression	Moderate to severe depression	Major depression	$X^2$	$p$
Female	11472 (76.2%)	2165 (14.4%)	718 (4.8%)	365 (2.4%)	326 (2.2%)	131.21	$p < 0.001$
Male	13031 (81.4%)	1903 (11.9%)	565 (3.5%)	265 (1.7%)	247 (1.5%)		
Total	24503 (78.9%)	4068 (13.1%)	1283 (4.1%)	630 (2.0%)	573 (1.8%)	-	-

reducing anxiety and depressive symptoms in junior high school students using a threshold regression model with the formula.

$$\begin{aligned}
 Y_i &= \alpha_i + \beta_{1i}X_{1i}D(q_i \leq \phi) + \beta_{2i}X_{1i}D(q_i > \phi) \\
 &\quad + \beta_{2i}X_{2i} + \varepsilon_i \\
 &= \alpha_i + \theta X_i(\phi) + \varepsilon_i
 \end{aligned}
 \tag{2}$$

In Eq. (2),  $Y_i$  is the dependent variable student anxiety and depression symptom scores.  $X_{1i}$  is the core explanatory variable influenced by the threshold.  $X_{2i}$  is the non-core explanatory variable not influenced by the threshold.  $\phi$  is the true threshold to be estimated.  $q_i$  and  $D(X)$  denote the threshold variable and the indicative function, respectively. In this study, the threshold variables  $q_i$  are study hours (total hours spent completing homework and after-school tutoring) and sleep hours, and while either threshold variable is analyzed, the other variables are considered as control variables. When  $q_i \leq \phi$ , then  $D(q_i) = 1$ , and vice versa  $D(q_i) = 0$ . If model estimation reveals that thresholds do exist, then this indicates the existence of study and sleep duration criteria that reduce students' anxiety and depressive symptoms.

## Results

### Participant anxiety and depressive symptoms and gender differences

As shown in Table 2, among the 31057 junior high school participants, 25356 (81.6%) junior high school students had no anxiety symptoms, 3658 (11.8%) junior high school students had mild anxiety symptoms and 2043 (6.6%) junior high school students had very obvious anxiety symptoms. Comparing the anxiety levels of different gender, female students were more likely to have anxiety symptoms, with 13,536 (84.5%) male students having no anxiety symptoms

and 11,820 (78.6%) female students having no anxiety symptoms, with a statistically significant difference between male and female students ( $X^2 = 190.08$ ,  $p < 0.001$ ).

Table 3 presents the depressive symptoms junior high school students. 24,503 (78.9%) students had no depressive symptoms, 4,068 (13.1%) had mild depressive symptoms and 2,486 (8.0%) had pronounced depressive symptoms. Similarly, female students were more likely to have depressive symptoms, with 13,031 (81.4%) males having no depressive symptoms and 11,472 (76.2%) females having no depressive symptoms, with a statistically significant difference between the genders ( $X^2 = 131.21$ ,  $p < 0.001$ ).

### Analysis of differences in time spent on study, sleep and students' anxiety symptoms

Table 4 below presents the results of the ANOVA for time spent on study and sleep and anxiety symptoms with statistically significant differences ( $p < 0.01$ ). Specifically, moderate and severe anxious participants spending significantly more time on homework ( $M1 = 1.44-1.45$ ,  $M2 = 1.06$ ) and extracurricular tutoring ( $M1 = 0.48-0.50$ ,  $M2 = 0.29$ ) higher than participants without anxiety disorders. Similarly, the duration of nighttime sleep ( $M1 = 6.74-6.79$ ,  $M2 = 8.03$ ) and nap time ( $M1 = 0.46-0.50$ ,  $M2 = 0.70$ ) were significantly less in participants with moderate and severe anxiety disorders than in those without anxiety disorders.

The ANOVA results for time spent on study and sleep and depressive symptoms were similar to those above. The results are shown in Table 5, where moderate and severe depressed participants had significantly more hours of homework completion and after-school tutoring and less hours of sleep than participants without depressive disorders.

As shown in Table 6, there was also a statistically significant difference ( $p < 0.01$ ) between whether or not to go to bed late and anxiety and depressive symptoms, with 30.20%–34.50% of participants who went to bed after 10 pm

TABLE 4

Analysis of variance of time spent on study, sleep and anxiety symptoms

Variables	No anxiety	Mild anxiety	Moderate anxiety	Moderate to severe anxiety	Major anxiety	F	p
Time spent on homework	1.06 ± 0.44	1.32 ± 0.47	1.39 ± 0.48	1.44 ± 0.49	1.45 ± 0.53	753.69	p < 0.01
Time spent on after-school tutoring	0.29 ± 0.39	0.41 ± 0.46	0.45 ± 0.50	0.50 ± 0.55	0.48 ± 0.57	240.06	p < 0.01
Time spent on night sleep	8.03 ± 1.13	7.28 ± 1.17	7.07 ± 1.26	6.79 ± 1.24	6.74 ± 1.43	538.43	p < 0.01
Time spent on nap	0.70 ± 0.42	0.53 ± 0.40	0.50 ± 0.37	0.46 ± 0.41	0.43 ± 0.44	146.81	p < 0.01

TABLE 5

Analysis of variance of time spent on study, sleep time and depressive symptoms

Variables	No depression	Mild depression	Moderate depression	Moderate to severe depression	Major depression	F	p
Time spent on homework	1.06 ± 0.44	1.31 ± 0.47	1.37 ± 0.49	1.42 ± 0.51	1.46 ± 0.52	547.62	p < 0.001
Time spent on after-school tutoring	0.29 ± 0.39	0.42 ± 0.47	0.46 ± 0.50	0.45 ± 0.51	0.48 ± 0.58	171.33	p < 0.001
Time spent on night sleep	8.06 ± 1.12	7.31 ± 1.17	7.09 ± 1.24	6.86 ± 1.30	6.71 ± 1.44	835.65	p < 0.001
Time spent on nap	0.71 ± 0.42	0.54 ± 0.39	0.50 ± 0.41	0.47 ± 0.40	0.43 ± 0.45	281.89	p < 0.001

TABLE 6

The relationship between time spent on study and sleep and anxiety and depressive symptoms

Items	Whether to sleep late (%)		Total	X <sup>2</sup>	p
	Sleep before 10 pm	Sleep after 10 pm			
No anxiety	15888 (90.90%)	9468 (69.80%)	25356 (81.60%)	2273.25	p < 0.001
Anxiety	1596 (9.10%)	4105 (30.20%)	5701 (18.40%)		
No depression	15612 (89.30%)	8891 (65.50%)	24503 (78.90%)	2596.97	p < 0.001
Depression	1872 (10.70%)	4682 (34.50%)	6554 (21.10%)		

suffering from depressive tendencies, while this percentage was only 9.10%–10.70% of participants who went to bed before 10 pm.

#### Logistic regression model with shapley decomposition

Binary logistic regression analysis was used, and the variables included time spent on homework, time spent on after-school tutoring, time spent on night sleep, time spent on naps, and whether or not they slept late. The results of the logistic regression model are shown in Table 7. It shows that the accuracy of the model prediction is 82.4%. Duration of homework (OR = 1.80, 95% CI = 1.67–1.93), duration of after-school tutoring (OR = 1.41, 95% CI = 1.32–1.51), and whether to sleep late (OR = 1.79, 95% CI = 1.65–1.94) were all significantly and positively correlated with anxiety symptoms. Meanwhile, duration of night sleep (OR = 0.71, 95% CI = 0.69–0.73) and duration of naps (OR = 0.51, 95% CI = 0.47–0.56) were significantly and negatively associated with anxiety symptoms.

The results of the logistic regression model for depression are shown in Table 8. The accuracy of the model prediction was 80.0%, the duration of homework (OR = 1.64, 95% CI = 1.53–1.76), duration of after-school tutoring (OR = 1.49, 95% CI = 1.39–1.59), whether to sleep late (OR = 1.89, 95% CI = 1.75–2.03) were all significantly and positively associated with depressive symptoms, and the duration of night sleep (OR = 0.713, 95% CI = 0.69–0.73), and the duration of nap (OR = 0.493, 95% CI = 0.45–0.53) were all significantly and negatively associated with depressive symptoms.

The shapley decomposition (Table 9) was used to compare the differences in the degree of influence of study and sleep duration on participants' anxiety and depressive symptoms. The comparison revealed that the correlation contribution of study duration on anxiety and depression was 27.3%–30.0%, and the correlation contribution of sleep duration on anxiety and depression was 70.0%–72.7%, and the results seemed to indicate that securing good sleep for

TABLE 7

## Logistic regression model of time spent on study and sleep and anxiety symptoms

Variables	OR	SE	z	p > z	95% CI	
Time spent on homework	1.80	0.06	15.64	0.00	1.67	1.93
Time spent on after-school tutoring	1.41	0.04	10.06	0.00	1.32	1.51
Time spent on night sleep	0.71	0.01	-20.62	0.00	0.69	0.73
Time spent on nap	0.51	0.02	-15.49	0.00	0.47	0.56
Whether to sleep late	1.79	0.07	14.47	0.00	1.65	1.94
Intercept	1.38	0.20	2.17	0.03	1.03	1.85
Index	Correct percentage prediction = 82.4%; Nagelkerke R <sup>2</sup> = 0.18					

Note: OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval.

TABLE 8

## Logistic regression model of time spent on study and sleep and depressive symptoms

Variables	OR	SE	z	p > z	95% CI	
Time spent on homework	1.64	0.05	13.89	0.00	1.53	1.76
Time spent on after-school tutoring	1.49	0.05	12.03	0.00	1.39	1.59
Time spent on night sleep	0.71	0.01	-21.49	0.00	0.69	0.73
Time spent on nap	0.49	0.02	-17.27	0.00	0.45	0.53
Whether to sleep late	1.89	0.07	16.72	0.00	1.75	2.03
Intercept	1.81	0.25	4.19	0.00	1.37	2.40
Index	Correct percentage prediction = 80.0%; Nagelkerke R <sup>2</sup> = 0.20					

Note: OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval.

TABLE 9

## A shapley analysis of time spent on study and sleep on anxiety and depression

Variables	Anxiety			Depression		
	$\beta$	Shapley (%)	Groups	$\beta$	Shapley (%)	Groups
Time spent on homework	0.02	20.0%	30.0%	0.02	18.2%	27.3%
Time spent on after-school tutoring	0.01	10.0%		0.01	9.1%	
Time spent on night sleep	0.04	40.0%	70.0%	0.04	36.4%	72.7%
Time spent on nap	0.01	10.0%		0.01	9.1%	
Whether to sleep late	0.02	20.0%		0.03	27.3%	
Total	0.10	100%		0.11	100%	

junior high school students was more helpful in reducing anxiety and depressive symptoms.

#### Estimated threshold effects of time spent on study and sleep

The threshold regression model was used to analyze whether there was a threshold effect of study and sleep duration on the reduction of anxiety and depressive symptoms. As can be seen from Table 10, the test found that there was a single threshold effect for both study and sleep duration, both of which could

help reduce depression or anxiety under certain criteria of alignment.

For study duration, the threshold value was 1.92 h, i.e., when the total number of hours of after-school study (including completion of homework and after-school tutoring hours) of junior high school students was below 1.92 h, students did not show significant anxiety symptoms ( $\beta = 0.02$ ,  $p > 0.05$ , 95% CI = [-0.01, 0.04]). But after the total number of hours of after-school study exceeded 1.92 h,

TABLE 10

## Threshold estimates for time spent on study and sleep

Variables		Coef.	Std. Err.	z	p > z	95% CI	
For anxiety							
Time spent on homework and after-school tutoring	$Q_i \leq 1.92$	0.02	0.01	2.00	0.08	-0.01	0.04
	$Q_i > 1.92$	0.20	0.02	10.00	0.00	0.16	0.24
Time spent on night sleep	$Q_i \leq 7$	0.02	0.01	2.00	0.02	0.01	0.03
	$Q_i > 7$	-0.37	0.01	-37.00	0.01	-0.40	-0.35
Time spent on nap	$Q_i \leq 0.56$	-0.53	0.03	-17.67	0.00	-0.59	-0.47
	$Q_i > 0.56$	0.04	0.02	2.00	0.01	0.01	0.08
For depression							
Time spent on homework and after-school tutoring	$Q_i \leq 1.92$	0.03	0.01	3.00	0.04	0.01	0.05
	$Q_i > 1.92$	0.21	0.02	10.50	0.01	0.17	0.25
Time spent on night sleep	$Q_i \leq 7$	-0.01	0.01	-1.00	0.26	-0.02	0.01
	$Q_i > 7$	-0.41	0.01	-41.00	0.01	-0.43	-0.38
Time spent on nap	$Q_i \leq 0.63$	-0.57	0.03	-19.00	0.01	-0.63	-0.51
	$Q_i > 0.63$	0.06	0.02	3.00	0.01	0.03	0.10
Threshold/ $\varphi$	Homework and Extra-curricular tutoring time = 1.92; Bedtime = 7; Naptime = 0.56						

students showed significant anxiety symptoms ( $\beta = 0.20$ ,  $p < 0.01$ , 95% CI = [0.16, 0.24]). The same was true for depressive symptoms, with a threshold of 1.92 h of study time for both.

For sleep duration, the threshold value was 7 h, when junior high school students slept less than or equal to 7 h at night, students showed significant anxiety symptoms ( $\beta = 0.02$ ,  $p < 0.05$ , 95% CI = [0.01, 0.03]), but when sleep duration at night was more than 7 h, junior high school students showed significantly less anxiety symptoms ( $\beta = -0.37$ ,  $p < 0.01$ , 95% CI = [0.01, 0.03]). Similarly, for depressive symptoms, the threshold for night sleep duration was 7 h. As for naps, the threshold values obtained from model estimation were 0.56 and 0.63 h, below which anxiety ( $\beta = -0.53$ ,  $p < 0.05$ , 95% CI = [-0.59, -0.47]) and depression ( $\beta = -0.57$ ,  $p < 0.01$ , 95% CI = [-0.63, -0.51]) symptoms may be exhibited, indicating that junior high school students should have a certain amount of time for naps and the duration of naps should be around 40 min.

In summary, in order to reduce anxiety and depression symptoms among junior high school students, first, time spent on after-school study should not exceed 1.92 h. Second, time spent on night sleep should be more than 7 h and a 40-min nap should be guaranteed. According to the sample distribution, among the 31057 participants, 7658 (24.6%) studied more than 1.92 h after school, 9628 (31%) slept less than or equal to 7 h at night and 15518 (49.9%) had no lunch break or less than 0.63 h.

## Discussion

Influenced by COVID-19 and the highly competitive academic pressure in China, the mental health of junior high school students is already facing greater challenges. Anxiety or

depression in adolescence not only impairs the psychological adaptive function of individuals [59], but also increases an individual's risk of severe anxiety or depression in adulthood and, even adversely affects the development of society [60]. The allocation of study and sleep time of junior high school students is undoubtedly one of the most important factors affecting mental health. Our study confirmed associations of time spent on study and sleep with anxiety and depressive symptoms with the quantitative analysis. There are some similarities and differences between our findings and previous studies, which we explain from different perspectives.

First, in general, the results of this study showed that 18.4%–21.1% of junior high school students had mild or higher anxiety and depressive symptoms. This finding is similar to the global findings that about 1 in 5 adolescents are suffering from anxiety or depressive symptoms [61]. From a gender perspective, female students reported higher levels of anxiety (21.4% > 15.5%) and depressive (23.8% > 18.6%) symptoms. It is consistent with findings from Irish adolescents [62]. Research from South Korea also concludes that female teens are more likely to suffer from depression than males [63]. There are many reasons why female students are more anxious than male students. Owing to differences in coping styles and stress responses when encountering negative life events [64], female teens are more likely than male teens to lose control of their emotions [65]. In addition, it is also related to the physiological characteristics and hormonal secretion of female adolescents [66]. Junior high school female students tend to be more psychologically sensitive than males and the probability of anxiety and depression increases significantly as females develop through puberty [67,68]. Besides, performance anxiety and parental expectations in education place a heavier psychological burden on female adolescents [69].



Second, time spent on study was significantly and positively associated with anxiety and depressive symptoms. Hypothesis 1 is supported. Specifically, there are 30.20%–34.50% of the participants who sleep late suffer from depressive tendencies. This phenomenon can be attributed to cultural and social circumstances. Junior high school students with moderate to severe anxiety tend to be accompanied by higher loads of homework and extracurricular tutoring hours and sleep less than 7 h on average. In a highly competitive society that emphasizes academic achievement, time spent on homework and after-school tutoring can be a significant barrier to adolescent sleep [13]. Especially in countries with Confucian cultures such as China, Singapore and Korea, adolescents in these regions spend more time on homework and have less time for sleep and extracurricular sports than their peers in most Western societies [70]. In addition, due to the influence of COVID-19, extracurricular tutoring and homework are now more dependent on electronic devices, but long periods of exposure to electronic screens can increase anxiety and depression in adolescents [71].

Third, time spent on sleep was significantly and negatively associated with anxiety and depressive symptoms and late sleepers were more likely to suffer from anxiety or depressive symptoms. Hypothesis 2 is supported. This is consistent with previous studies that suggest that sleep disturbance significantly predicts the depression in adolescents [72,73]. Sleep deprivation diminishes adolescents' sense of positive experience and leaves the individual with diminished physiological responsiveness to regulation in the face of the task [74]. As some studies have argued that cortisol levels were significantly higher in sleep deprived adolescents, suggesting that lack of sleep might increase physiological stress reactivity [75]. Further, it affects the adolescent's resilience to stress and leads to a greater likelihood of emotional dysregulation [76,77]. Even a study indicated that there was a two-way cause-and-effect relationship between sleep duration and anxiety and depression symptoms, with too little sleep and late sleep affecting adolescent mental health and causing anxiety and depression, while in turn causing sleep disturbances and aggravating anxiety and depression symptoms [78].

Fourth, time spent on sleep contributes much more to the correlation between anxiety and depression than time spent on study, which shows that hypothesis 3 is verified. Some studies also suggested that a high correlation between the study duration and the sleep duration [22,79]. Students tended to complete excessive homework and after-school tutoring by reducing their nighttime sleep [80], which indirectly led to psycho-emotional deterioration [81]. So we speculate that ensuring good sleep for junior high school students is significant to reduce anxiety and depressive symptoms.

Fifth, the study also measured the minimum thresholds for reducing anxiety and depression in junior high school students based on a threshold regression model. Hypothesis 4 is supported. We verified after-school study time should not exceed 1.92 h, night sleep should be at least greater than 7 h and a 40-min nap should be guaranteed at noon. Certainly, the threshold effect is defined as the minimum

threshold, not the optimal range for reducing anxiety and depression symptoms. Some studies claimed that good time management could promote adolescent mental health, reduce the risk of anxiety and depression and contribute to better performance [82]. Out of the pursuit of grades, adolescents invest more time in studying. But long hours of study do not bring good learning results, but also exacerbate anxiety and depression symptoms [83]. Accordingly, based on time management theory, educator should try to improve students' ability to manage time, for example, by teaching students to set learning goals and priorities in advance so that they can perceive and allocate their time better. Improving sleep duration for adolescents in a competitive academic environment should also target the balance of homework and extracurricular tutoring.

Finally, research has also inspected that securing a moderate amount of nap time (40 min) can be very effective in avoiding students' tendency to experience anxiety and depressive symptoms. Similarly, a study suggested that a 30-min nap opportunity was beneficial to overcome the negative effects of partial-sleep-deprivation (SDN) on emotional state and physical and cognitive performance [84]. Especially during the COVID-19 pandemic, daytime napping had a more positive effect on mood regulation [85]. However, there were 7658 (24.6%) who studied more than 1.92 h after school, 9628 (31%) who slept less than or equal to 7 h at night and 15518 (49.9%) who did not have a nap or had less than 0.63 h of nap, which indicated that at least 1/4 of junior high school students' study and sleep time allocation was unreasonable. It suggests that educators should pay more attention to students' nap time to promote their physical and mental health.

## Conclusions

Junior high school students are at greater risk for anxiety and depressive symptoms. The study analyzed the relationship between time spent on study and sleep and the anxiety and depressive symptoms obtained from a survey of 31,057 junior high school students in China. Results showed that 18.4%–21.1% of participants had mild or higher anxiety and depressive symptoms and female students were more likely to develop anxiety and depressive symptoms. Time spent on study was significantly positively associated with anxiety and depressive symptoms. Meanwhile, time spent on sleep was significantly negatively associated with anxiety and depressive symptoms and late sleepers were more likely to suffer from anxiety and depressive tendencies. Reducing after-school study time appropriately and getting more sleep are both beneficial in reducing anxiety and depression, but it is more important to ensure sleep duration. The standards for study and sleep duration to reduce anxiety and depressive symptoms are that after-school study time (including homework and after-school tutoring) should not exceed 1.92 h, night sleep should be at least 7 h, and a 40-min nap should be guaranteed at noon.

This study provides an empirical basis for the development of study and sleep schedules and mental health interventions for junior high school students. The Chinese government recognized the problem of overburdened youths

and excessive study time so that promulgated a “double reduction” policy to reduce students’ academic burdens and prohibited after-school subject tutoring, which has to some extent reduced students’ after-school study time and improved their mental health [86]. However, with the pressure of examinations, the study burden of Chinese students is heavy and the time invested in study is still too much. Parents should not only focus on their children’s academic performance and not use grades as the only criterion to evaluate whether their children are good, but also fully recognize the importance of adequate sleep and physical and mental health.

A methodological limitation of this study is that by asking adolescents to provide self-reports through recall of how much time they typically spent each day on different activities such as after-school homework and sleep over the last week, there may be some adolescents’ memory errors without providing a precise daily routine. A relatively rigorous study would have asked respondents to provide a detailed 24-h work schedule for each day of the past week and consistently recorded the respondent’s most recent daily 24-h work schedule through daily diary tracking [87]. However, due to our large-scale census, we have not been able to track each adolescent’s work schedule in detail. So for future studies, we hope to take a follow-up survey of the respondents. Another limitation is that our survey was conducted in Gansu Province, China, where there are 31 provinces and regions. We would like to expand our sample to recruit respondents from more provinces to increase the diversity of the sample in the future.

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