Research Square

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The Relationship Between Sleep Behavior, Circadian Rhythms and Symptoms of Anxiety and Depression Among Adolescents in Urumqi: A Cross-Sectional Study

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Abstract

Objective Adolescence is a critical stage during which significant changes occur in an individual's mental health. The prevalence of anxiety and depression in adolescents is high in China., which is closely related to lifestyle and behavior. However, studies on specific behavioral changes in adolescents (e.g., sleep procrastination, irregular sleep, eating patterns, and the use of electronic device) are limited. This study seeks to investigate modifiable non-genetic risk factors associated with anxiety and depression symptoms in adolescents, with an immediate aim of laying the evidence base for subsequent targeted prevention and intervention strategies.

Methods A cross sectional survey of 1,269 junior high school students was carried out in Urumqi. A structured questionnaire was designed and used to collect students' basic demographic and related information, and then symptoms of anxiety and depression were assessed by using the Generalized Anxiety Disorder-7 (GAD-7) and the Patient Health Questionnaire-9 (PHQ-9) respectively. The Adolescent Circadian Rhythm Disruption Assessment Questionnaire was used to measure sleep delay, sleep disruption, eating rhythm disturbance and electronic device usage. Differential analysis and regression analysis were performed to investigate the factors associated with anxiety and depression, as well as their relationships.

Results The GAD-7 score was 6.0 (3.0, 10.0) and the PHQ-9 score was 6.0 (3.0, 10.0) for female junior high school students in this city, which were both higher than those for male students of the same education level in this city. Concerning caregiving arrangements, adolescent girls raised by grandparents or other caregivers scored higher on GAD-7 and PHQ-9; Higher levels of maternal (than paternal) education were linked to high anxiety scores, and family economic status was not linked with GAD-7 scores. Depressive symptoms were related to family economic situation, but parental education and only child status showed no significant association with PHQ-9 score. After adjusting for sex, being a solo child, parental education and whether they lived with both parents or not, irregular sleep pattern and eating habit continued to be independently associated with anxiety (irregular sleep patterns: *OR* = 1.081, 95% CI: 1.048-1.115; irregular eating habits: *OR* = 1.059, 95% *CI*: 1.032-1.087) and depression (irregular sleep: *OR* = 1.059, 95% *CI*: 1.027-1.091; irregular eating habits: *OR* = 1.081, 95% *CI*: 1.054-1.109). Delayed bedtime was an independent risk factor for depression (*OR* = 1.115, 95% *CI*: 1.061-1.172), but showed only a marginal association with anxiety. In univariate analysis, electronic device use was associated with anxiety and depression; however, after controlling for other factors, these associations were no longer statistically significant. **Conclusions** Gender differences in anxiety and depression symptoms have been observed among junior high school students in Urumqi, with female gender being a risk factor for a higher prevalence of symptoms. The accompanying study found that while both irregular sleep schedule and disrupted eating rhythms are two important behavioral risk factors for anxiety and depression symptoms, late bedtime was more significantly associated with depressive versus anxiety symptoms. Interventions to stabilize sleep patterns, regularize mealtimes and reduce unhealthy behaviors before bed may help improve adolescents' mental health. Which might be again relevant being in other countries.

1. Background

Adolescence is a critical period of rapid physical and psychological development, accompanied by shifting social roles [1]. Epidemiological studies indicate persistently high prevalence rates of anxiety and depression among adolescents, making it a significant public health issue that affects their physical and mental well-being as well as social functioning. Mental health serves as a vital foundation for overall health and represents a state of equilibrium in physiological, cognitive, and emotional functioning, rather than merely the absence of mental illness. Sleep during adolescence is one of the core behaviors for young people, and research has confirmed that sleep is closely related to mental health [2].

Previous studies have demonstrated widespread disparities in adolescents' sleep needs and sleep quality. Chronic sleep deprivation can lead to a series of serious consequences [3] and is significantly associated with psychological issues such as anxiety and depression [4, 5]. In recent years, an increasing number of studies have further indicated that various sleep-related behaviors are closely associated with adolescent mental health [6]. Among these, poor sleep habits such as sleep procrastination and irregular sleep rhythms are not only linked to anxiety and depressive symptoms but also associated with increased risks of suicidal ideation and suicidal behavior [7]. Given adolescents' heightened sensitivity to environmental changes and the established role of adolescence as an onset period for multiple mental and behavioral disorders [8], it is crucial to thoroughly investigate the relationship between sleep behaviors and mental health within student populations.

Sleep outcomes are influenced by multiple factors, including sleep duration, regularity, and quality [9]. In recent years, the growing engagement with digital media and screen-based technologies among adolescents has been linked to poorer sleep quality, with sleep potentially mediating the relationship between device use and psychological well-being [10]. Concurrently, evidence suggests that consistent sleep schedules are strongly associated with better sleep quality, contributing to the maintenance and protection of emotional health [11].

Eating habits and mental health may influence each other in significant and complex ways. However, the evidence could indicate that changes in dietary patterns contribute to the onset of mental disorders by affecting mood. Moreover, the development of mental disorders might also lead to alterations in eating habits [12]. Given that existing research in adults has confirmed an association between dietary interventions and changes in depressive symptoms [13], the findings could demonstrate that diet represents a key modifiable factor. Research links sleep to diet. Furthermore, the significant evidence may suggest that individuals adhering to heathier dietary patterns show a lower likelihood of poor sleep quality [14]. In light of these findings, randomized controlled trial could demonstrate that Mediterranean diet interventions improve mental health outcomes in individuals with depression. Additionally, the results might indicate that large-scale prospective data from the UK Biobank support a positive association between healthy eating, good sleep, and mental health [15]. Evidence links diet, sleep, mental health.

Nevertheless, current research may suggest that investigations have primarily focused on the relationship between total sleep duration and mental health, with comparatively limited exploration of specific sleep-related behavioral patterns. Moreover, the significant evidence could indicate that existing findings also predominantly originates from adult populations, with comparatively less attention directed toward adolescent groups [16–18]. Thus, the results might demonstrate that systematic studies examining behavioral dimensions such as sleep procrastination, irregular sleep schedules, irregular eating rhythms, and electronic device usage remain particularly lacking. Notwithstanding these gaps, the evidence could suggest that previous studies have rarely included both anxiety and depression within the same sample for comparative analysis. Studies show adolescent research limited. Furthermore, the important findings may indicate that this limitation hinders a comprehensive understanding of how adolescent sleep and dietary behaviors correlate with diverse mental health outcomes. Therefore, the significant data might suggest that addressing these gaps appears critical for advancing understanding of adolescent psychological issues. Evidence shows gaps exist.

The present study may suggest that simultaneously assessing anxiety and depressive symptoms alongside four key behavioral dimensions could provide important and relevant results. However, the findings might indicate that including sleep procrastination, irregular sleep patterns, eating rhythms, and electronic device usage among secondary school students appears to offer significant analytical advantages. Given that the evidence could demonstrate that multiple scales support more comprehensive assessment, the results may suggest that this approach provides a stronger foundation for comparative analysis. Furthermore, the significant findings might indicate that comparing distinct behavioral characteristics with anxiety and depression symptoms could demonstrate important associations relevant to adolescent psychological issues. Study shows behavioral factors affect outcomes.

2. Methods

2.1 Research subjects

This study employed a stratified sampling method and conducted a questionnaire survey among junior high school students at six schools in Urumqi from March to December 2025. This study is a cross-sectional survey. Interviewers who had undergone standardized training distributed paper questionnaires in classrooms, explained the purpose of the survey and instructions for completion to the respondents, and collected the questionnaires immediately after the students had completed them independently. All questionnaires were completed anonymously.

The study included junior high school students who were physically healthy and of normal intellectual ability; had no family history of mental illness or similar psychiatric disorders; and had no history of mental or behavioral abnormalities within the past two years.

A total of 1,414 questionnaires were distributed. After excluding invalid questionnaires with significant information gaps or obvious logical errors, 1,269 valid questionnaires were ultimately included, yielding a response rate of 89.74%. Among the 1,269 valid questionnaires, a very small number had minimal missing information, which was addressed by imputing the mean (or mode) value. This study has been reviewed and approved by the Ethics Committee of Xinjiang Medical University (Approval Number: XJYKDXR20240521007).

2.2 Measurements

2.2.1 Generalized Anxiety Disorder 7-item Scale (GAD-7)

The Generalized Anxiety Disorder 7-item Scale (GAD-7) [19] may suggest that it provides a reliable measure of participants' anxiety symptoms over the past two weeks. Moreover, the scale consists of 7 items, each scored on a scale of 0 to 3, for a total score ranging from 0 to 21.

2.2.2 Patient Health Questionnaire 9 (PHQ-9)

The Patient Health Questionnaire-9 (PHQ-9) [20–21] could demonstrate that it provides a relevant measure used to assess depressive symptoms over the past two weeks. The questionnaire consists of nine items, each scored on a scale of 0 to 3, for a total score ranging from 0 to 27.

2.2.3 Self-rating Questionnaire of Biological Rhythm Disorders for Adolescents

The self-rating Questionnaire of Biological Rhythm Disorders for Adolescents (SQBRDA) [22] could demonstrate that it provides important evidence used to evaluate students' sleep and daily rhythms. Additionally, the questionnaire comprises 29 items rated on a 5-point scale (1 = completely disagree, 5 = completely agree), and the results may suggest that higher scores appear to indicate greater irregularity or severity of the corresponding behavior. Notwithstanding the original questionnaire design, the significant findings might indicate that items were grouped into four dimensions based on the objectives of this study. Thus, the key evidence could suggest that Items 1–9 total to yield the Sleep Irregularity score, Items 10–13 total to yield the Sleep Delay score, Items 14–21 total to yield the Eating Rhythm Irregularity score, and Items 22–29 total to yield the Electronic Device Use score. Dimension score sums corresponding items.

2.2.4 Other Covariates

Demographic and household information was collected via a general questionnaire, including gender (male/female), status as an only child (yes/no), daily living arrangements (with parents, with one parent, with grandparents or other relatives, etc.), household economic status (good, average, poor), and educational attainment of both parents (junior high school, senior high school, vocational/technical school/college, bachelor's degree or higher).

2.3 Statistics

Statistical analysis was performed using SPSS 29.0 software. Furthermore, for quantitative data that followed a normal distribution with homogeneity of variance, the mean ± standard deviation was used for description, if the data did not follow a normal distribution, the median (interquartile range) was used as a summary measure. Comparisons between groups were conducted using t-tests or Mann-Whitney U tests based on normality and homogeneity of variance. Qualitative data are presented as frequencies and percentages; comparisons between groups were performed using the chi-square test or Fisher's exact test. Multivariate logistic regression models were constructed, with anxiety/depression scores converted into a binary presence variable as the dependent variable, and scores on the four behavioral scales along with other covariates as independent variables. Odds ratios (*OR*) and their 95% confidence intervals (95% *CI*) were calculated. Two-tailed tests were performed, with $P < 0.05$ indicating statistical significance.

3. Results

3.1 Descriptive Statistics

This study examined that a total of 1,269 adolescents provided GAD-7 scores across different categories. However, the findings may suggest that females reported higher GAD-7 scores than males, with a statistically significant difference ($P < 0.001$). Furthermore, the significant results could indicate that caregiving patterns exhibited a clear gradient distribution, where participants raised by grandparents or other caregivers demonstrated higher GAD-7 scores than those raised by parents or solely by a mother. In light of these findings, the evidence may suggest that the overall difference between lifestyle groups appears statistically significant ($P = 0.018$). Data shows parental education links anxiety levels. Moreover, the results could indicate that although participants with higher paternal educational attainment tended to report higher GAD-7 scores, the overall association did not reach statistical significance ($Z = 6.255$, $P = 0.181$). Given that the evidence demonstrates a contrast, the findings may suggest that the mother's educational level appears significantly associated with GAD-7 scores ($Z = 10.171$, $P = 0.038$). Additionally, the key results could indicate that higher maternal educational attainment appears associated with more pronounced reported anxiety. Notwithstanding these results, the evidence may suggest that only-child status and family economic status appear not significantly associated with GAD-7 scores. (Table 1).

Table 1
Comparison of GAD-7 Scores among students with different characteristics

Variable	N (%)	GAD-7 score	*Z*-value	*P*-value
Sex			-7.226	<0.001
Male	600 (47.28)	4.00 (2.00,7.00)		
Female	669 (52.72)	6.00 (3.00,10.00)		
Only child			-0.741	0.458
No	263 (20.72)	5.00 (2.00,9.00)		
Yes	1006 (79.28)	5.00 (2.00,8.00)		
Lifestyle			10.047	0.018
Parents	1043 (82.19)	5.00 (2.00,8.00)		
Father /mother	181 (14.26)	6.00 (3.00,10.00)		
Grandparents	31 (2.44)	8.00 (4.00,13.00)		
Other	14 (1.11)	3.50 (2.00,10.25)		
Economic			5.600	0.061
Good	393 (30.97)	4.00 (2.00,8.00)		
Fair	822 (64.78)	5.00 (2.00,9.00)		
Poor	54 (4.25)	6.50 (3.00,10.25)		
Father’s educational level			6.255	0.181
Middle school	680 (53.59)	5.00 (2.00,8.00)		
High school	252 (19.86)	6.00 (2.25,9.00)		
Junior college	138 (10.87)	5.00 (2.00,9.00)		
Bachelor’s degree	170 (13.40)	6.00 (3.00,9.00)		
Postgraduate	29 (2.28)	6.00 (2.50,11.00)		
Mother’s educational level			10.171	0.038
Middle school	655 (51.62)	5.00 (2.00,8.00)		
High school	236 (18.60)	6.00 (3.00,9.00)		
Junior college	152 (11.98)	5.00 (3.00,9.00)		
Bachelor’s degree	196 (15.45)	6.00 (3.00,9.00)		
Postgraduate	30 (2.35)	8.00 (2.75,11.00)		

The results for depressive symptoms were similar to those for anxiety symptoms; female participants had significantly higher PHQ-9 scores than male participants ($P < 0.001$). Participants raised by grandparents had higher scores than those raised by both parents or a single parent, and the differences in scores between these groups were statistically significant ($P < 0.001$). Participants whose family economic status was rated as “poor” had significantly higher scores than those rated as “good” or “fair” ($P < 0.001$). However, there were no statistically significant differences in PHQ-9 scores based on parental educational level or whether the participant was an only child (Table 2).

Table 2
Comparison of PHQ-9 scores among students with different characteristics

Variable	N (%)	PHQ-9 score	Z-value	P-value
Sex			-6.939	<0.001
Male	600 (47.28)	4.0 (1.0,9.0)		
Female	669 (52.72)	6.0 (3.0,11.0)		
Only child			-0.977	0.329
No	263 (20.72)	6.0 (2.0,10.0)		
Yes	1006 (79.28)	5.0 (3.0,9.0)		
Lifestyle			19.323	<0.001
Parents	1043 (82.19)	5.0 (2.0,9.0)		
Father /mother	181 (14.26)	6.0 (3.0.11.50)		
Grandparents	31 (2.44)	10.0 (5.0.14.0)		
Other	14 (1.11)	4.0 (2.0.10.0)		
Economic			16.713	<0.001
Good	393 (30.97)	5.0 (2.0,9.0)		
Fair	822 (64.78)	6.0 (3.0,10.0)		
Poor	54 (4.25)	9.0 (3.75,14.0)		
Father’s educational level			1.906	0.753
Middle school	680 (53.59)	5.0 (2.0,10.0)		
High school	252 (19.86)	6.0 (3.0,10.0)		
Junior college	138 (10.87)	6.0 (3.0,9.0)		
Bachelor’s degree	170 (13.40)	6.0 (2.75,9.0)		
Postgraduate	29 (2.28)	7.0 (1.5,10.50)		
Mother’s educational level			5.968	0.202
Middle school	655 (51.62)	5.0 (2.0,9.0)		
High school	236 (18.60)	6.0 (3.0,10.0)		
Junior college	152 (11.98)	6.0 (3.0,9.0)		
Bachelor’s degree	196 (15.45)	6.0 (3.0,10.0)		
Postgraduate	30 (2.35)	7.0 (2.0,11.0)		

3.2 Characteristics of Student Behavior

As shown in Tables 3 and 4, students with anxiety or depression scored significantly higher than those without across all four dimensions-irregular sleep patterns, pre-sleep procrastination, irregular eating habits, and electronic device usage ($P < 0.001$).

Table 3
Comparison of behavioral scale scores between students with and without anxiety

Variable	GAD-7 score (N = 1269)		*Z* Value	*P* Value
	≤ 9 (N = 1002)	> 9 (N = 267)		
Irregular Sleep Score	24.0(20.0,28.0)	30.0(25.0,33.0)	-11.812	<0.001
Bedtime Procrastination Score	8.0(5.0,11.0)	11.0(9.0,13.0)	-9.690	<0.001
Irregular eating habits score	20.0(15.0,26.0)	26.0(22.0,32.0)	-11.298	<0.001
Electronic device use score	16.0(10.0,22.0)	22.0(13.0,28.0)	-6.654	<0.001

Table 4
Comparison of behavioral scale scores between students with and without depression

Variable	PHQ-9 score (N = 1269)		*Z* Value	*P* Value
	≤ 9 (N = 946)	> 9 (N = 323)		
Irregular Sleep Score	24.0(20.0,28.0)	30.0(25.0,33.0)	-13.022	<0.001
Bedtime Procrastination Score	8.0(5.0,10.0)	11.0(9.0,14.0)	-13.059	<0.001
Irregular eating habits score	20.0(15.0,25.0)	27.0(22.0,33.0)	-14.236	<0.001
Electronic device use score	16.0(10.0,21.0)	23.0(15.0,29.0)	-9.557	<0.001

3.3 Analysis of Risk Factors

The results of the multivariate logistic regression analysis show (Fig. 1 and Table 5), after controlling for gender, only-child status, parental education level, and living arrangements, irregular sleep scores and irregular eating habits scores continued to show a significant associated with anxiety symptoms. Each 1-point increase in irregular sleep scores was associated with an 8.1% higher risk of anxiety ($OR = 1.081$, 95% *CI*: 1.048–1.115). For each additional point in irregular eating habits scores, the risk of anxiety increased by 5.9% ($OR = 1.059$, 95% *CI*: 1.032–1.087). In contrast, after controlling for the above variables, scores for pre-sleep procrastination and electronic device usage showed no statistically significant association with anxiety risk ($P > 0.05$). Furthermore, there were no statistically significant differences in anxiety symptoms across various demographic variables ($P > 0.05$).

Table 5
Multifactorial Logistic Regression Analysis of Factors Influencing Anxiety Symptoms

Variable		***β***	***S.E.***	**waldχ2**	***P* Value**	***OR* (95% *CI*)**
Sex		0.224	0.158	2.024	0.155	1.251 (0.919–1.704)
Only child		-0.076	0.193	0.155	0.694	0.927 (0.635–1.353)
Father's educational level	High school	0.053	0.791	0.005	0.946	1.055 (0.224–4.966)
	Junior college	0.171	0.790	0.047	0.829	1.187 (0.252–5.585)
	Bachelor's degree	0.220	0.804	0.075	0.785	1.246 (0.258–6.017)
	Postgraduate	0.190	0.761	0.062	0.803	1.209 (0.272–5.374)
Mother's educational level	High school	-0.709	0.737	0.926	0.336	0.492 (0.116–2.086)
	Junior college	-0.538	0.739	0.530	0.467	0.584 (0.137–2.484)
	Bachelor's degree	-0.695	0.747	0.867	0.352	0.499 (0.115–2.156)
	Postgraduate	-0.660	0.708	0.871	0.351	0.517 (0.129–2.068)
Lifestyle	Father /mother	-0.792	0.670	1.396	0.237	0.453

Variable		*β*	*S.E.*	waldχ2	*P* Value	*OR* (95% *CI*)
						(0.122–1.685)
	Grandparents	-0.739	0.692	1.141	0.285	0.477 (0.123–1.854)
	Other	-0.316	0.791	0.159	0.690	0.729 (0.155–3.435)
Irregular Sleep Score		0.078	0.016	24.632	<0.001	1.081 (1.048–1.115)
Bedtime Procrastination Score		0.047	0.026	3.343	0.067	1.048 (0.997–1.102)
Irregular eating habits score		0.057	0.013	18.603	<0.001	1.059 (1.032–1.087)
Electronic device use score		0.001	0.010	0.003	0.958	1.001 (0.981–1.020)

As shown in Fig. 1 and Table 6, similar to the anxiety symptoms outcomes, scores for irregular sleep patterns, bedtime procrastination, and irregular eating habits were significantly associated with depression symptoms. Each 1-point increase in irregular sleep pattern scores was associated with a 5.9% higher risk of depression (*OR* = 1.059, 95% *CI*: 1.027–1.091). For each additional point in bedtime procrastination scores, the risk of depression increased by 11.5% (*OR* = 1.115, 95% *CI*: 1.061–1.172). Each additional point in irregular eating habits scores was associated with an 8.1% increase in depression risk (*OR* = 1.081, 95% *CI*: 1.054–1.109). In contrast, after controlling for the above variables, electronic device usage scores showed no statistically significant association with depression risk ($P > 0.05$). Furthermore, demographic variables demonstrated no statistically significant differences in depression symptoms ($P > 0.05$).

Table 6
Multifactorial Logistic Regression Analysis of Factors Influencing Depression Symptoms

Variable		***β***	***S.E.***	**waldχ2**	***P* Value**	***OR* (95% *CI*)**
Sex		0.155	0.154	1.012	0.314	1.168 (0.863–1.581)
Only child		0.078	0.196	0.158	0.691	1.081 (0.737–1.586)
Father's educational level	High school	1.677	0.878	3.647	0.056	5.349 (0.957–29.906)
	Junior college	1.636	0.878	3.467	0.063	5.134 (0.918–28.721)
	Bachelor's degree	1.334	0.887	2.264	0.132	3.797 (0.668–21.590)
	Postgraduate	1.097	0.844	1.693	0.193	2.996 (0.574–15.653)
Mother's educational level	High school	-1.526	0.773	3.900	0.048	0.217 (0.048–0.989)
	Junior college	-1.327	0.775	2.935	0.087	0.265 (0.058–1.211)
	Bachelor's degree	-1.653	0.782	4.467	0.035	0.191 (0.041–0.887)
	Postgraduate	-1.132	0.741	2.337	0.126	0.322 (0.075–1.376)
Lifestyle	Father /mother	-0.260	0.743	0.122	0.727	0.771

Variable		*β*	*S.E.*	waldχ2	*P* Value	*OR* (95% *CI*)
						(0.180–3.307)
	Grandparents	-0.140	0.761	0.034	0.854	0.869 (0.196–3.866)
	Other	0.761	0.856	0.792	0.374	2.141 (0.400-11.458)
Irregular Sleep Score		0.057	0.015	13.863	<0.001	1.059 (1.027–1.091)
Bedtime Procrastination Score		0.109	0.025	18.358	<0.001	1.115 (1.061–1.172)
Irregular eating habits score		0.078	0.013	35.252	<0.001	1.081 (1.054–1.109)
Electronic device use score		0.014	0.010	2.026	0.155	1.014 (0.995–1.034)

4. Discussion

This study employs a cross-sectional research design based on a questionnaire survey conducted among junior high school students in Urumqi, Xinjiang. The results showed that the mean GAD-7 score for male students in the region was 4.0 (2.0, 7.0), and the mean PHQ-9 score was 4.0 (1.0, 9.0). For female students, the mean GAD-7 score was 6.0 (3.0, 10.0), and a PHQ-9 score of 6.0 (3.0, 11.0). Female students' anxiety and depression scores were significantly higher than those of male students. Behavioral scale results indicate that students with anxiety or depression scored significantly higher than those without across four dimensions: irregular sleep patterns, sleep procrastination, irregular eating rhythms, and electronic device usage. Multivariate logistic regression analysis identified irregular sleep patterns and irregular eating rhythms as significant risk factors for both anxiety and depression. Additionally, sleep procrastination emerged as an independent risk factor for depression. Higher maternal education level was found to exert a protective effect against depression. After controlling for other behavioral factors, the association between electronic device usage and anxiety/depression was no longer significant.

According to global data, approximately 20% of children and adolescents suffer from depression or depressive symptoms [23]. Adolescent depressive symptoms have increased, with prevalence rising from 24% in 2001–2010 to 37% in 2010–2020, with female adolescents generally exhibiting higher rates of depression than males [24–25]. Research indicates that depressive symptoms increase rapidly during adolescence, with lifetime prevalence rates for major depressive disorder among adolescents reaching 14.3%–24% [26]. A Mexican study revealed a 35.8% detection rate of anxiety or depression among indigenous adolescents aged 14–20 [27]. Compared with these findings, the detection rates of anxiety and depression among Urumqi middle school students in this study were slightly below the global average. However, they likewise exhibited high prevalence rates of anxiety and depression, with females showing higher rates than males. This trend aligns with relevant domestic and international reports. This may be attributed to adolescent females being more sensitive to emotional and interpersonal factors, making them prone to emotional reactions [28–29]; higher societal and familial expectations regarding academic performance, interpersonal relationships, and physical appearance placing greater psychological pressure on girls [30–32]; and fluctuations in endocrine hormone levels during adolescence potentially increasing vulnerability to anxiety and depressive symptoms [33–34]. This study also found that students living with their parents exhibited lower rates of anxiety and depression, suggesting that family presence and emotional support play a crucial role in protecting adolescent mental health. Parents may mitigate the adverse effects of external pressures on adolescents by providing emotional support, supervising schedules, and fostering positive behavioral habits [35–37]. Family economic status is also closely linked to adolescent mental health. Students who self-reported their family economic status as “poor” exhibited significantly higher rates of depression. This suggests that lower socioeconomic status may negatively impact adolescent mental health through increased life stress, limited access to resources, and adverse family environments. These findings align with previous research indicating that socioeconomic inequality heightens the risk of emotional disorders [38–40].

The findings of this study indicate that irregular sleep patterns are closely associated with both anxiety and depression among secondary school students. For every one-point increase in irregular sleep scores, the risk of anxiety increases by approximately 8% ($OR = 1.081$, $P < 0.001$), and the risk of depression increases by approximately 6% ($OR = 1.059$, $P < 0.001$). These finding suggests that sleep schedules stability and regularity may be particularly important for adolescent mental health [41–42]. Previous studies on “social jet lag”, “total sleep duration”, and “weekend sleep recovery” indicate that significant fluctuations in sleep schedules between weekdays and weekends disrupt circadian rhythms, thereby heightening the likelihood of emotional problems, including anxiety and depression [11, 43–44]. This study further corroborates this perspective from the angle of overall sleep regularity. Regarding potential mechanisms, irregular sleep may disrupt circadian rhythms of related hormones. This interference with the balance of neurotransmitters such as serotonin and dopamine may promote the onset and progression of anxiety and depression [45–47]. Furthermore, chronic sleep rhythm disruption can cause daytime fatigue, reduced attention, and academic decline, further increasing psychological stress in adolescents. Persistent stress may then exacerbate circadian rhythm disorders, creating a

vicious cycle [48–50]. Therefore, at both the school and family levels, beyond focusing on total sleep duration, greater emphasis should be placed on maintaining consistent sleep schedules. Avoiding significant fluctuations in daily routines helps stabilize adolescents' biological rhythms, thus helping to lower the risk of anxiety and depressive symptoms.

This study revealed that sleep procrastination is significantly associated with depression among secondary school students, serving as an independent risk factor for depression (*OR* = 1.115, *P* < 0.001). However, after controlling for factors such as irregular sleep patterns, its association with anxiety was only marginally significant (*P* = 0.067). This suggests a potentially stronger link between pre-sleep procrastination and depression, while its association with anxiety may be largely explained by factors such as irregular sleep rhythms. From behavioral and psychological perspectives, bedtime procrastination typically manifests as voluntarily delaying sleep onset without external compulsion, often through “procrastinating, avoiding, or wasting time” by browsing information on multimedia devices. This pattern aligns with common depressive symptoms such as avoidance behaviors, difficulties in emotional regulation, and diminished self-control [51]. Adolescents with depression may use delayed sleep onset to temporarily escape negative emotions or real-world pressures. However, this “passive procrastination” coping strategy conversely impairs sleep quality and next-day mental functioning [52–53]. Previous research indicates that frequent sleep procrastination is associated with going to bed later and sleeping for a shorter duration, which in turn leads to next-day fatigue, decreased attention, and lower learning efficiency. This may result in academic frustration, increasing students' stress and feelings of helplessness, thereby exacerbating depressive symptoms [54–55]. The findings of this study, demonstrating a significant association between sleep procrastination and depression, align with previous research [56]. This suggests that in adolescent mental health interventions, attention should be focused on overall sleep time and sleep regularity, as well as on identifying and specifically addressing maladaptive pre-sleep behaviors, such as sleep procrastination. Such targeted interventions can help break the negative cycle perpetuated by sleep procrastination.

This study found that irregular eating patterns were significantly associated with both anxiety and depression. Irregular eating patterns emerged as an independent risk factor for anxiety (*OR* = 1.059, *P* < 0.001) and depression (*OR* = 1.081, *P* < 0.001). These findings suggest that dietary rhythms hold significant implications for adolescent health. Unlike previous studies primarily focusing on the relationship between overall dietary patterns and health in adults [57]. This research emphasizes the role of meal timing regularity in adolescents. Potential mechanisms include the regulation of metabolic rhythms by meal timing, synchronization of peripheral circadian clocks, and the influence on gut microbiota circadian rhythms, which in turn affect emotional regulation networks [58]. Despite relatively fixed schedules and meal systems for school students, this study still identified significant dietary rhythm issues among this population. This may be related to factors such as increased snacking between classes, rising frequency of late-night meals, and skipping breakfast, highlighting the necessity for interventions at both school and home levels. At the educational level, health education and curriculum-embedded interventions can promote regular eating patterns among students. At the family

level, establishing consistent bedtimes and wake-up times, along with regular breakfast intake, can help children develop stable routines for both sleep and eating [59]. Furthermore, schools and families should jointly address and mitigate factors disrupting meal regularity to enhance the effectiveness of interventions.

In univariate analyses (Tables 3 and 4), this study found that individuals with anxiety and depression had significantly higher scores for electronic device use than the control group, suggesting an association between electronic device use and psychological distress. This result is line with numerous studies that focus on screen time as a core variable, and the results also support the notion that high levels of screen exposure may be associated with emotional distress in adolescents [60–62]. However, in multivariate logistic regression analysis, after controlling for other factors, electronic device use was not a risk factor for anxiety and depression ($P > 0.05$). This suggests that it may influence mood through sleep and dietary rhythms rather than acting directly on individual emotions via an independent pathway. This indicates that electronic device use is, to some extent, a broader variable, and its impact on mood may be influenced by other mediating effects. The underlying reason may be that the use of electronic devices, particularly before bedtime or at night, may delay sleep onset, reduce sleep quality, thereby disrupt the circadian rhythm [63]. Research has confirmed that disrupted sleep rhythms are associated with mood and, consequently, increase the risk of anxiety or depression [64]. On the other hand, the use of electronic devices may be linked to multiple factors, including irregular mealtimes, increased fatigue resulting from prolonged screen exposure, and reduced attention and self-regulation abilities. These factors may lead to disrupted eating rhythms and undermine the stability of eating patterns, thereby increasing the risk of anxiety or depression [65–66].

In summary, the findings of this study suggest that certain associations between anxiety and depression in behavioral patterns share both commonalities and differences. Both are influenced by irregular sleep patterns and disrupted circadian rhythms and should therefore be addressed concurrently. At the same time, there are differences in the strength of specific effects: pre-sleep procrastination has a more significant impact on depression, while anxiety is less sensitive to pre-sleep procrastination. This may be related to characteristic manifestations of the depressed group in terms of initiative and self-directed behavior, suggesting that interventions should precisely distinguish between the behavioral differences of anxiety and depression. Public health interventions can focus on two aspects: managing pre-sleep behaviors and establishing healthy eating rhythms, with a particular emphasis on the depressed group. At the school level, interventions can be implemented through adjustments to daily schedules and health education. At the family level, parents should be encouraged to live with and accompany their children, working together to establish stable daily routines and meal schedules. In summary, the study suggests that future interventions should address both the common risk factors and the specific manifestations of these two types of emotional distress to enhance the precision and effectiveness of interventions.

5. Limitations

This study also has several limitations. First, its cross-sectional design does not allow for causal inferences. Although our findings highlight associations between sleep, diet, and mental health, longitudinal studies are needed to clarify the temporal and causal relationships among these factors. Second, the study sample was drawn mainly from urban areas of Urumqi, which may limit the external validity and generalizability of the results to other regions and populations. Future studies should therefore include participants from different geographic areas and, ideally, follow the same cohort over time to more fully examine these associations. Finally, the use of self-reported questionnaires makes the data vulnerable to recall and selection bias, so the results should be interpreted with caution. In addition, detailed information on dietary composition and meal timing was not collected, which means that some potential confounding factors could not be adequately controlled.

6. Conclusions

This cross-sectional survey of junior high school students in Urumqi, Xinjiang, Female students in Urumqi reported a consistently higher burden of anxiety and depressive symptoms, highlighting the need for targeted, gender-sensitive mental health strategies in school settings. Irregular sleep patterns and disrupted eating rhythms were both associated with symptoms of anxiety and depression, while sleep procrastination was significantly associated with depression but showed no clear association with anxiety. Although the use of electronic devices was associated with anxiety and depressive symptoms in univariate analysis, this association was no longer significant after adjusting for factors such as sleep and diet. This suggests that its influence may be primarily mediated indirectly through these behavioral pathways rather than acting as an independent risk factor. These findings emphasize the need to stabilizing daily routines, promoting regular meal times, and implementing targeted interventions to reduce unhealthy pre-sleep behaviors at both the school and family levels to support adolescents' mental health. Future longitudinal and intervention studies are needed to further elucidate causal mechanisms and develop more precise, behavior-oriented strategies for the prevention and management of anxiety and depression in adolescents.

Abbreviations

GAD-7
Generalized Anxiety Disorder – 7
OR
Odds Ratio
PHQ-9
Patient Health Questionnaire – 9
SQBRDA
Self-rating Questionnaire of Biological Rhythm Disorders for Adolescents
95%CI
95% Confidence interval

Declarations

Ethical approval and consent to participate

The study was approved by the Ethics Committee of Xinjiang Medical University (Approval No. XJYKDXR20240521007). Written informed consent was obtained from all participants. In accordance with the ethical principles outlined in the Declaration of Helsinki, all participants provided informed consent before participating in the study. The anonymity and confidentiality of the participants were guaranteed, and participation was completely voluntary.

Consent for publication

Not applicable

Availability of data materials

The corresponding author can provide the datasets used in this study upon reasonable request.

Competing Interests

The authors confirm that there is no conflict of interest.

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Author's Contributions

All authors participated in this study and made significant contributions. **Lu Liu**, **Zhen Chen**, **Xue Li**, **Rong Li** contributed to the study's design and conception; **Lu Liu** and **Tianyuan Su** participated in data analysis; **Genglin Yang**, **Zuolin Yang** and **Zhiyi Wei** participated in data collection; **Lin Tang** and **Tianyuan Su** participated in data organization and cleaning; **Lu Liu**, **Zhen Chen** and **Genglin Yang** participated in drafting the manuscript; **Xue Li, Lu Ding** and **Rong Li** participated in manuscript review, guidance, and fundraising.

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Figures

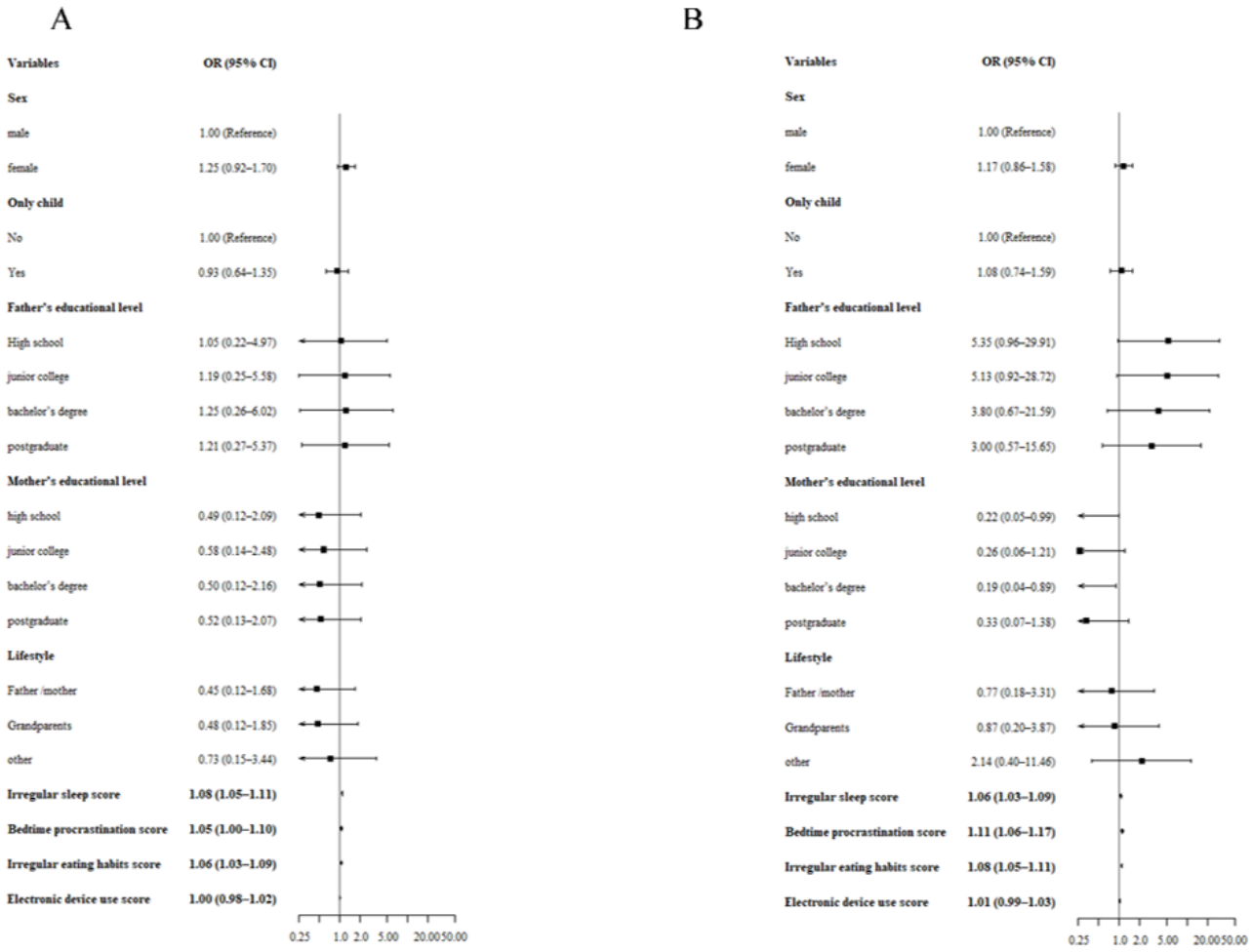


Figure 1

Forest plots of multivariable logistic regression analyses showing adjusted odds ratios and 95% CI for factors associated with depressive (A) and anxiety (B) among adolescents.