Nature and Science of Sleep

Elevate Series

Open Access Full Text Article

ORIGINAL RESEARCH

The Relationship Between Night Sleep Duration and Anxiety Among Preschool Children: A Cross-Sectional Study in China

Lili Zhang[1,*], Yanqi Hu[1,2,*], Dandan He[3,*], Xueqing Miao[1], Xinyi Tang[4], Lijun Tang[5], Yi Wang[6], Jingqiu Ma[7]

[1]Department of Pediatrics, Minhang Hospital, Fudan University, Shanghai, 201199, People's Republic of China; [2]Shanghai Minhang Medical Emergency Center, Shanghai, 201199, People's Republic of China; [3]Minhang District Center for Disease Control and Prevention (Minhang District Institute of Health Supervision), Shanghai, 201101, People's Republic of China; [4]Community Health Center of Datuan Town, Shanghai, 201311, People's Republic of China; [5]China Welfare Institute Development Research Center (Soong Ching Ling Children Development Center, China Welfare Institute Teacher Education Development Center), Shanghai, 200000, People's Republic of China; [6]Department of Neurology, Children's Hospital of Fudan University, National Children's Medical Center, Shanghai, 201102, People's Republic of China; [7]Department of Child and Adolescent Healthcare, MOE-Shanghai Key Laboratory of Children's Environmental Health, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai, 200092, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yi Wang, Department of Neurology, Children's Hospital of Fudan University, National Children's Medical Center, Shanghai, 201102, People's Republic of China, Email yiwang@shmu.edu.cn; Jingqiu Ma, Department of Child and Adolescent Healthcare, MOE-Shanghai Key Laboratory of Children's Environmental Health, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai, 200092, People's Republic of China, Email majingqiu@xinhuamed.com.cn

Objective: This study aims to examine the relationship between habitual nighttime sleep duration and anxiety symptoms in preschoolers, and to identify a potential sleep-health threshold for mental health promotion.

Methods: This cross-sectional study included 1589 participants from two public kindergartens. Parents reported habitual nighttime sleep duration using the Children's Sleep Habits Questionnaire (CSHQ) and anxiety symptoms using the Preschool Anxiety Scale (PAS). Initial non-parametric tests were supplemented with linear mixed-effects models (LMM) incorporating for fixed effects for sleep duration and covariates, with family cluster as random intercepts.

Results: Among the participants, the mean age was 4.58 ± 0.86 years, and 52.2% were male. Initial nonparametric analysis revealed significant overall differences in anxiety symptoms (PAS: H=8.503, P=0.014) and generalized anxiety (GAD: H=7.427, P=0.024) across nighttime sleep duration groups. Adjusted LMM showed preschoolers with ≤9 hours of nighttime sleep had significantly higher PAS total scores (β=3.13, 95% CI: 1.01~5.25, P=0.004) and elevated scores across multiple anxiety subdomains (physical injury fears, social phobia, and obsessive-compulsive symptoms; all P<0.05) compared to >10h sleepers. Although the overall GAD model was nonsignificant (P=0.056), these children showed elevated GAD subscale scores (β=0.60, 95% CI: 0.14~1.07, P=0.011) aligns with prior evidence. Sensitivity analyses using alternative nighttime sleep duration thresholds (8.5h, 9.5h) and weekday-specific data confirmed the robustness of these findings.

Conclusion: Our data suggests that nighttime sleep duration of 9 hours is an approximate sleep-health indicator for preschool aged children. These findings reinforce the importance of prioritizing healthy sleep habits as part of early childhood wellness initiatives, including age-appropriate nighttime sleep duration.

Keywords: nighttime sleep duration, anxiety symptoms, preschool children, cross-sectional study, linear mixed-effects models

Introduction

Anxiety disorder represents one of the most common mental health conditions in children and adolescents, characterized by excessive fear and anxiety or avoidance of perceived threats that are persistent and impairing.[1] Notably, epidemiological data from the American Academy of Child and Adolescent Psychiatry (AACAP) indicated a global point prevalence of approximately 7% in pediatric populations,[2] with half of cases emerging before age 6.[3,4] According to

https://doi.org/10.2147/NSS.S593442
Received: 3 January 2026
Accepted: 18 March 2026
Published: 21 April 2026

the Global Burden of Disease Study, the disability weight of anxiety disorder is about 0.523, higher than the other mental disorders.[5] Given their early onset and high disability burden, identifying modifiable targets like sleep duration is critical.

Existing research consistently identifies insufficient sleep duration as a key risk factor for childhood anxiety.[6–8] Mechanistically, experimental studies suggest that insufficient sleep disrupts emotional regulation through heightened amygdala reactivity,[9] dysregulated hypothalamic-pituitary-adrenal (HPA) axis activity,[10] as well as delayed prefrontal cortex maturation.[11] Critically, nighttime sleep (particularly slow-wave sleep, SWS) is thought to facilitate synaptic pruning in the amygdala-prefrontal circuit, a process essential for emotion regulation.[12] This neurobiological specificity suggests that nighttime sleep duration, independent of total sleep, may be more closely associated with emotion regulation capacities. International sleep studies demonstrated striking cultural variations in preschool sleep patterns.[13,14] Children in Pacific-Asian regions typically go to bed 2–3 hours later and obtain less nighttime sleep than Western counterparts, yet maintain similar total daily sleep duration through extended daytime naps. In China, this pattern is particularly pronounced due to mandatory kindergarten napping policies and prevalent bed-sharing practices, resulting in nighttime sleep durations of only 8.5–10.5 hours (vs. 10–12 hours in Western children).[13] These findings are concerning because daytime naps may not fully make up for lost nighttime sleep, especially SWS, which is vital for brain development. Current Western sleep recommendations inadequately address cultural variations in sleep patterns, especially the limited evidence specific to nighttime sleep in East Asian preschool populations. This gap highlights an urgent need for population-specific sleep research to develop appropriate guidelines and protect neurodevelopmental outcomes.

Therefore, this study examines the relationship between habitual nighttime sleep duration and anxiety symptoms in Chinese preschoolers, with particular attention to identifying a potential sleep-health threshold for mental health promotion. Based on the WHO sleep guidelines, we categorized nighttime sleep duration into three groups (≤9h, 9~10h, >10h) to isolate its independent association. We hypothesized that children sleeping ≤9 hours nightly will exhibit significantly higher anxiety symptoms than those sleeping >10 hours, independent of daytime napping.

Methods

Sample Size Estimation

The required sample size was calculated using the formula for cross-sectional studies with continuous outcomes:[15] $n=U^2_{1-a/2}\times S^2/d^2$, where $U_{1-a/2}=1.96$ (corresponding to a 95% confidence level with $\alpha=0.05$), the standard deviation ($S=6.9$) was estimated based on continuous CSHQ total scores from reference,[16] with the allowable error (d) set at 0.4. Considering a 15% rate of invalid questionnaires and the stability of statistical analysis, the final sample size should be greater than 1314 participants.

Participants

A cross-sectional study was conducted from April to June 2024 in two public kindergartens in Minhang District, Shanghai, China. Parents or legal guardians of eligible children received written study information and provided electronic informed consent before participation. Those who consented completed the questionnaires. To prevent coercion, kindergarten staff were blinded to individual participation status, as all electronic consent forms and questionnaires were managed exclusively by the research team. Eligible participants met the following criteria: 1) aged 3–6 years old; 2) attended the selected kindergartens; 3) had parents or legal guardians who were willing to participate. This age range was selected because preschool children exhibit heightened developmental sensitivity to sleep disturbances, with sleep loss linked to impaired cognitive performance.[17,18] Children were excluded if they had major physical or mental disorders (such as inherited neuromuscular disorders, autism spectrum disorder and schizophrenia).

Measures

Nighttime Sleep Duration

Nighttime sleep duration was derived from the CSHQ,[19] which has demonstrated acceptable validity for estimating nighttime sleep patterns in preschool-aged children within epidemiological studies.[20–22] Specifically, sleep onset times (for both weekdays and weekends) and wake-up times (for both weekdays and weekends) were used to calculate

nighttime sleep duration. The average nighttime sleep duration was computed as (weekday nighttime sleep duration×5 + weekend nighttime sleep duration×2)/7. However, as a parent-reported tool, it may overestimate sleep duration compared to actigraphy or polysomnography (PSG) due to reporting biases. While actigraphy and PSG provides more precise sleep architecture data, the CSHQ remains a practical choice for large-scale epidemiological studies like ours, balancing feasibility and reasonable accuracy. Furthermore, although the total sleep duration (including naps) is conventionally emphasized, our focus on nighttime sleep aligns with the neurobiological evidence introduced previously and accounts for cultural context. Based on the American Academy of Sleep Medicine(AASM) recommendation of 10–13 hours of total daily sleep for preschoolers,[23] and given that nighttime sleep comprises the majority of total sleep in this age group, we categorized the average nighttime sleep duration into three groups: >10 hours (reference group, likely sufficient for total sleep needs when combined with typical naps), 9–10 hours (potentially marginal for meeting total sleep recommendations), and ≤9 hours (high risk for insufficient total sleep).

Anxiety Symptoms

Anxiety symptoms were assessed using the PAS,[24] a validated 28-item parent-report questionnaire specifically designed to evaluate anxiety symptoms in preschool-aged children. The PAS is a 5-point Likert scale (0–4) with five subscales: Separation Anxiety Disorder (SAD), Physical Injury Fears (PIF), Social Phobia (SP), Obsessive-Compulsive Disorder (OCD) and Generalized Anxiety Disorder (GAD). Higher scores indicate greater symptom severity on a continuous spectrum. While a cutoff score of ≥ 48 suggests elevated anxiety symptoms, the PAS does not provide a clinical diagnosis of anxiety disorders. The Chinese version of PAS has demonstrated good reliability and validity.[25]

Data Collection

We used online surveys as methodology to collect demographic and questionnaire data via the WeChat network. Demographic data including age, sex, the only-child status, main caregiver, parental education level, and parental occupation were collected by self-administered questionnaire.

Quality Control

To ensure data integrity, a rigorous quality control protocol was implemented: 1) developing survey guidelines before the investigation. 2) the question types consisting of multiple-choice questions and fill-in-the-blank questions, where multiple-choice questions were set as mandatory responses and examples were provided for fill-in-the-blank questions. 3) for questionnaires with unclear fill-in responses, kindergarten teachers would contact parents to verify and re-complete the information. Questionnaires that do not receive a response for follow-up would be considered as incomplete information.

Statistical Analysis

STATA (Version 18.0, Stata Corp L.P.) was used for statistical analysis. Descriptive statistics were performed in total and by group. The characteristics of the study participants are presented as the means (SDs) for normally distributed variables, medians (IQRs) for skewed variables and frequencies with percentages for categorical variables. We first employed Kruskal–Wallis tests to provide initial screening of anxiety symptom differences across nighttime sleep duration groups. Given evidence that parental education and occupation jointly shape preschoolers' sleep patterns through shared socioeconomic contexts,[26] we accounted for family-level socioeconomic context by treating multiplicatively derived family clusters (parental education×occupation) as random intercepts in linear mixed-effects models (LMM), with fixed effects specified for nighttime sleep duration (categorical, using the >10h group as reference). Model assumptions were checked through residual diagnostics. No substantial violations were observed. Potential confounders, including age (z-score), gender, the only-child status, and main caregiver, were incorporated as covariates in the LMM. This approach (1) aligns with developmental theory by modeling socioeconomic status as a latent family-level construct, (2) avoids overfitting from conventional fixed-effects categories, and (3) addresses non-independence while maintaining statistical efficiency. LMMs were used to examine the statistical association between nighttime sleep duration and anxiety outcomes. To further characterize these differences and systematically evaluate sleep-anxiety associations while controlling for Type II error, we applied LMMs to all anxiety outcomes (PAS total, SAD, PIF, SP,

OCD, GAD). Given the cross-sectional design of this study, all analyses were exploratory and aimed at identifying associations between nighttime sleep duration and psychological outcomes. Based on the American Academy of Sleep Medicine guidelines, we categorized nighttime sleep duration into three groups: ≤9h, 9–10h, and >10h. To evaluate the robustness of the predefined thresholds, we conducted two complementary sensitivity analyses: (1) testing alternative thresholds (8.5h and 9.5h) to assess threshold dependency, and (2) restricting analyses to weekday-only nighttime sleep (excluding weekends) to verify consistency in structured settings. *P* values were based on two-sided tests and were considered significant at <0.05.

Ethic Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the institutional ethics committee of Minhang Hospital, Fudan University (2024–019-01K).

Results

Sample Demographic Characteristics

In total, 1633 (91.4%) CSHQ and PAS from 2 kindergartens were collected. A total of 44 (2.7%) questionnaires were not included in the final analysis due to incomplete information. Finally, 1589 questionnaires were included for further analysis. The mean age of the participants was 4.58±0.86 years, and 52.2% were male. Parents reported an average nighttime sleep duration of 9.37±0.56 hours, and the mean CSHQ total score was 47.10±6.08. Table 1 summarizes the demographic characteristics of the sample, while Supplementary Table S1 provides detailed scores for all eight CSHQ subscales. The prevalence of significant anxiety symptoms among preschoolers was 2.14%.

Table 1 Basic Characteristics of Participants

Variables	Total n=1589	Duration≤9h n=423	9<duration≤10h n=976	Duration>10h n=190
Age(years) *	4.58 (0.86)	4.68 (0.86)	4.57 (0.85)	4.44 (0.85)
The only child (yes, %)	778 (48.96)	215 (50.83)	479 (49.08)	84 (44.21)
Main caregiver (n, %)				
Parent	1,066 (67.09)	281 (66.43)	657 (67.32)	128 (67.37)
Grandparent	499 (31.40)	135 (31.91)	305 (31.25)	59 (31.05)
Other	24 (1.51)	7 (1.65)	14 (1.43)	3 (1.58)
Maternal education (n, %)				
Middle school or below	22 (1.38)	4 (0.95)	13 (1.33)	5 (2.63)
Associate degree	285 (17.94)	72 (17.02)	178 (18.24)	35 (18.42)
Bachelor's degree	923 (58.09)	239 (56.50)	559 (57.27)	125 (65.79)
Master's degree or above	359 (22.59)	108 (25.53)	226 (23.16)	25 (13.16)
Paternal education (n, %)				
Middle school or below	16 (1.01)	2 (0.47)	10 (1.02)	4 (2.11)
Associate degree	228 (14.35)	64 (15.13)	134 (13.73)	30 (15.79)
Bachelor's degree	906 (57.02)	242 (57.21)	545 (55.84)	119 (62.63)
Master's degree or above	439 (27.63)	115 (27.19)	287 (29.41)	37 (19.47)
Maternal occupation (n, %)				
Tech worker	577 (36.31)	168 (39.72)	355 (36.37)	54 (28.42)
Civil servant	233 (14.66)	66 (15.60)	136 (13.93)	31 (16.32)
Free lancer	162 (10.20)	43 (10.17)	93 (9.53)	26 (13.68)
Other	617 (38.83)	146 (34.52)	392 (40.16)	79 (41.58)

(*Continued*)

Table 1 (Continued).

Variables	Total n=1589	Duration≤9h n=423	9<duration≤10h n=976	Duration>10h n=190
Paternal occupation (n, %)				
Tech worker	728 (45.81)	203 (47.99)	454 (46.52)	71 (37.37)
Civil servant	143 (9.00)	37 (8.75)	83 (8.50)	23 (12.11)
Free lancer	229 (14.41)	65 (15.37)	135 (13.83)	29 (15.26)
Other	489 (30.77)	118 (27.90)	304 (31.15)	67 (35.26)
Average nighttime sleep duration*	9.37 (0.56)	8.71 (0.29)	9.47 (0.28)	10.35 (0.31)
Weekday nighttime sleep duration*	9.29 (0.59)	8.66 (0.34)	9.38 (0.35)	10.28 (0.38)
Weekend nighttime sleep duration*	9.58 (0.74)	8.85 (0.52)	9.71 (0.55)	10.52 (0.50)
CSHQ total scores*	47.10 (6.08)	48.34 (6.43)	46.88 (5.92)	45.47 (5.61)

Notes: *values are mean (standard deviation).
Abbreviation: CSHQ, Children's Sleep Habits Questionnaire.

Association Between Nighttime Sleep Duration and Anxiety Symptoms

Initial Kruskal–Wallis analysis showed significant overall differences in both PAS total score (H=8.503, P=0.014) and GAD score (H=7.427, P=0.024) across the three nighttime sleep duration groups, while other subscales (SAD, PIF, SP, OCD) showed non-significant trends (all P>0.05) (Table 2). Building on these findings and controlling for potential Type II error as specified in our analytical plan, LMMs adjusted for age (z-score), gender, only-child status, and primary caregiver revealed significant statistical association. Preschool aged children with nighttime sleep duration ≤9h had significantly higher anxiety scores across multiple domains compared to those sleeping >10 hours nightly. Specifically, PAS total scores were on average 3.13 points higher (β=3.13, 95% CI: 1.01~5.25, P=0.004, Cohen's d=0.25). Similar effects were observed across several subscales, including physical injury fears (PIF subscale scores, β=0.79, 95% CI: 0.12~1.46, P=0.021, Cohen's d=0.19), social phobia (SP subscale scores, β=0.71, 95% CI: 0.09~1.33, P=0.024, Cohen's d=0.19), obsessive-compulsive symptoms (OCD subscale scores, β=0.49, 95% CI: 0.14~0.84, P=0.006, Cohen's d=0.20). Notably, while the overall model for GAD was not statistically significant (Wald χ^2=29.65, P=0.056), these children showed elevated GAD subscale scores (β=0.60, 95% CI: 0.14~1.07, P=0.011, Cohen's d=0.22) aligns with prior evidence. The relatively narrow confidence intervals for most outcomes indicate reasonable precision of the estimates. However, no significant association was observed for separation anxiety (SAD subscale scores, β=0.54, 95% CI: −0.02~1.09, P=0.058) (Table 3). Model diagnostics showed that the mean of the residuals was essential to zero (−6.98e-10, t-test P=1.000), indicating no systematic bias in the model. The Q-Q plot revealed a minor deviation from normality (Supplementary Figure S1) and residual-versus-fitted plots indicated limited heteroscedasticity (Supplementary Figure S2), which is common in psychometric data and unlikely to affect the validity of the estimates given the large sample size. While parental education levels as covariables

Table 2 Comparison of Nighttime Sleep Duration and Anxiety Symptoms[a]

Variables	Total n=1,589	Duration≤9h n=423	9<duration≤10h n=976	Duration>10h n=190	*H*	*P*[b]
PAS total score	19(10, 29)	20(11, 31)	19(10, 29)	17(9, 26)	8.503	0.014
SAD	4(2, 6)	4(2, 6)	4(2, 6)	3(1, 5)	4.665	0.097
PIF	6(3, 9)	6(3, 10)	6(3, 9)	5(2, 8)	4.460	0.108
SP	4(1, 7)	5(2, 7)	4(1, 7)	3(1, 6)	5.922	0.052
OCD	2(0, 4)	2(0, 4)	2(0, 4)	2(0, 3)	4.340	0.114
GAD	3(1, 5)	3(1, 5)	3(1, 5)	2(0, 4)	7.427	0.024

Notes: [a]Values are median (p25, p75); [b]Performed by Kruskal–Wallis equality-of-populations rank test.
Abbreviations: PAS, preschool anxiety scale; SAD, separation anxiety disorder; PIF, physical injury fears; SP, social phobia; OCD, obsessive-compulsive disorder; GAD, generalized anxiety disorder.

https://doi.org/10.2147/NSS.S593442

Table 3 LMM Analysis of Nighttime Sleep Duration on Anxiety Symptoms

PAS scores	β	Univariate Analysis			β	Multivariate Analysis*		
		95% CI	z	P		95% CI	z	P
PAS total score								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	1.55	−0.24, 3.34	1.70	0.089	1.53	−0.35, 3.41	1.59	0.111
Duration≤9h (n=423)	3.14	1.09, 5.19	3.00	0.003	3.13	1.01, 5.25	2.90	0.004
SAD								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	0.29	−0.20, 0.79	1.16	0.248	0.32	−0.20, 0.83	1.21	0.225
Duration≤9h (n=423)	0.49	−0.04, 1.03	1.80	0.072	0.54	−0.20, 1.09	1.90	0.058
PIF								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	0.32	−0.20, 0.84	1.21	0.226	0.31	−0.24, 0.85	1.10	0.272
Duration≤9h (n=423)	0.81	0.19, 1.42	2.57	0.010	0.79	0.12, 1.46	2.30	0.021
SP								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	0.34	−0.19, 0.88	1.26	0.207	0.29	−0.27, 0.85	1.03	0.305
Duration≤9h (n=423)	0.77	0.16, 1.39	2.47	0.014	0.71	0.09, 1.33	2.25	0.024
OCD								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	0.23	−0.13, 0.59	1.23	0.219	0.25	−0.11, 0.61	1.35	0.176
Duration≤9h (n=423)	0.47	0.12, 0.81	2.61	0.009	0.49	0.14, 0.84	2.75	0.006
GAD								
Duration>10h (n=190)	Reference group				Reference group			
9<duration≤10h (n=976)	0.37	−0.01, 0.74	1.90	0.058	0.37	−0.01, 0.74	1.90	0.058
Duration≤9h (n=423)	0.60	0.13, 1.08	2.51	0.012	0.60	0.14, 1.07	2.53	0.011[#]

Notes: *Adjusted for age (z-score), gender, the only-child status and main caregiver. [#]Model P=0.056; coefficient p-values reported in main table.

Abbreviations: LMM, liner mixed-effects model; PAS, preschool anxiety scale; SAD, separation anxiety disorder; PIF, physical injury fears; SP, social phobia; OCD, obsessive-compulsive disorder; GAD, generalized anxiety disorder.

exhibited expected collinearity (Supplementary Table S6), this was accounted for in the model and did not alter our key findings.

Consistent with our primary analysis, sensitivity analyses using alternative thresholds (8.5h and 9.5h) did not reveal significant association between nighttime sleep duration and mental health outcomes (all P>0.05; see Supplementary Table S2 and S3).

Weekday-Specific Analysis Validates the 9-Hour Threshold in Preschoolers

To address potential confounding by weekend sleep variability, we conducted a dedicated analysis using weekday-only nighttime sleep duration data. The ≤9-hour threshold remained robustly associated with higher anxiety symptoms, with effect sizes nearly identical to the primary analysis (see Supplementary Table S4 and S5).

Discussion

In the study, 2.14% of the participants were tested positive for significant anxiety symptoms, highlighting the importance of mental health surveillance in this age group. Our data showed a significant negative correlation between nighttime sleep duration and anxiety symptoms. Specifically, average nighttime sleep duration ≤9 hours was significantly associated with higher levels of anxiety symptoms, physical injury fears, social phobia, and obsessive-compulsive symptoms compared to those sleeping >10 hours nightly. Our findings suggest that 9 hours of nighttime sleep may be a critical threshold for mental health risks in preschool-aged children, while alternative thresholds (8.5h and 9.5h) did not reach statistical significance (all $P>0.05$).

The observed prevalence of positive anxiety symptoms (2.14%) was lower than expected based on prior studies in Chinese preschoolers, such as 9.1% in Anhui[7] and 3.15% in Shenzhen,[27] though comparable to Norwegian rates.[28] This discrepancy likely reflects urban-specific reporting biases. Shanghai parents may underreport due to higher mental health literacy interpreting behaviors as normative, stigma concerns in competitive educational environments, and earlier identification through comprehensive child services.[29] While methodological consistency strengthens comparability, these findings highlight the need for regionally adjusted interpretations of parent-reported anxiety in China's socio-economically diverse contexts.

Consistent with previous research, insufficient nighttime sleep may elevate anxiety risk in early childhood through muti-level neurobiological mechanisms.[30–32] At the molecular level, sleep restriction during critical developmental windows impairs GABAergic inhibition in the amygdala,[33–35] reducing inhibitory tone and promoting hyperreactivity to threat stimuli. At the circuit level, human neuroimaging studies further suggest that reduced slow-wave sleep (SWS) compromises prefrontal cortex maturation,[36] diminishing top-down emotional regulation capacity.[37] Functionally, these alterations disrupt emotional processing, with sleep deprivation disproportionately affecting positive emotional responses,[38] potentially biasing affective systems toward threat detection. Systemically, insufficient sleep further dysregulates neurotransmitter activity,[39] HPA axis function,[40] and inflammatory pathways,[41] creating a permissive environment for anxiety development. Our findings align with this framework, showing a small but consistent association between shorter nighttime sleep duration and elevated anxiety symptoms (Cohen's d=0.22–0.25). While this association persisted after adjusting for key covariates, future longitudinal studies should explore whether optimizing sleep duration could mitigate anxiety symptoms, particularly in children with familial or environmental risk factors (eg., parental stress,[42] irregular bedtime routines[13]).

Since 2012, *Standards for Health Care Work in Nurseries and Kindergartens* issued by the National health commission of China have mandated a compulsory 2–2.5 h napping policy in kindergartens.[43] Theoretically, if daytime napping meets the recommended 2–2.5 hours, nighttime sleep duration of ≥7.5 hours should be sufficient to achieve the total daily sleep requirement (10–13h). However, our findings challenge this assumption, revealing that nighttime sleep duration exhibits an independent association with anxiety risk even in weekday analyses despite compulsory napping. This paradox may stem from circadian misalignment. Delayed bedtimes combined with early kindergarten wake times may lead to chronic sleep deprivation,[44,45] even with daytime napping. Actigraphy studies support this, showing that children with disrupted nighttime sleep have higher cortisol levels.[46,47] While US data associate ≥10 h nighttime sleep with optimal socioemotional outcomes,[48] and Japanese adolescents show gender-specific thresholds,[49] our study identifies more than 9h nighttime sleep duration is associated with lower anxiety symptoms in Chinese preschoolers. This variation likely reflects cultural modulation of sleep architecture. East Asian children exhibit higher prevalence of co-sleeping, and parental sleep scheduling practices that may alter sleep stage distribution.[50] Notably, the persistence of our findings in weekday analyses suggests that compulsory napping cannot fully compensate for insufficient nighttime sleep's impact on emotional regulation networks. Although some studies suggest a U-shaped relationship between nighttime sleep duration and anxiety risk (with both insufficient and excessive sleep associated with increased anxiety),[51] the current study could not examine the upper threshold due to limited sample size. Future studies with larger cohorts are warranted to validate these findings.

Several limitations may be noted in the current study. First, this was an exploratory analysis using cross-sectional data, which precludes causal inferences about the relationship between nighttime sleep duration and anxiety symptoms.

And unmeasured confounders (eg., genetic predisposition, sleep environment) may contribute to the observed association. Second, although we observed higher anxiety symptoms in children with ≤9h of nighttime sleep compared to >10h, our categorical analysis does not establish a strict dose-response relationship or define an upper threshold for nighttime sleep duration. Future studies with finer sleep duration categories or modeling sleep as a continuous exposure are needed to explore potential non-linear associations. Third, while the CSHQ is a cost-effective tool for large-scale studies, it lacks the precision of objective measures such as polysomnography (PSG) or actigraphy. Although parental reports included detailed sleep parameters (eg., bedtime, sleep onset time, wake-up time, and get-up time for weekdays and weekends), the derived nighttime sleep duration remains an estimate. Future studies should prioritize objective measures, particularly portable and non-invasive sleep monitoring.[52] Fourth, our focus on average nighttime sleep duration overlooks potentially critical variations between weekday and weekend sleep patterns. Fifth, the Shanghai-based sampling limits cultural extrapolation to populations with distinct socioeconomic contexts and ethnic sleep practices. Multicenter studies spanning diverse regions are warranted to enhance external validity.

In summary, our data suggests that nighttime sleep duration of 9 hours is an approximate sleep-health indicator for preschool aged children, based on cross-sectional analyses. These findings reinforce the importance of prioritizing healthy sleep habits as part of early childhood wellness initiatives, including age-appropriate nighttime sleep duration. Future research should explore whether sleep health promotion programs, particularly in high-risk populations, could enhance emotional resilience alongside broader developmental benefits.

Data Sharing Statement

The data sets generated during and analyzed during this study are available from the corresponding author on reasonable request.

Acknowledgments

The authors would like to thank all the kindergartens, children, and their parents.

Author Contributions

Lili Zhang, Yanqi Hu, and Dandan He contributed equally as joint first authors. Lili Zhang: Conceptualization, Methodology, Investigation, Writing-Original Draft. Yanqi Hu: Conceptualization, Methodology, Investigation, Writing-Original Draft. Dandan He: Conceptualization, Methodology, Investigation, Writing-Review & Editing. Xueqing Miao: Data Curation, Validation. Xinyi Tang: Formal Analysis. Lijun Tang: Resources, Formal Analysis, Supervision, Writing-Review & Editing. Yi Wang (Corresponding Author): Conceptualization, Supervision, Project Administration, Writing-Review & Editing. Jingqiu Ma (Corresponding Author): Conceptualization, Data Curation, Supervision, Project Administration, Writing-Review & Editing. All authors 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 agreed to be accountable for all aspects of the work.

Funding

This study was supported by the Cooperation Program of Fudan-Minhang Health Union (2024FM03) and the national fitness program, Shanghai Municipal Administration of Sports (25Q002).

Disclosure

The authors declare no conflict of interest.

References

1. Penninx BW, Pine DS, Holmes EA, Reif A. Anxiety disorders. *Lancet*. 2021;397:914–927. doi:10.1016/S0140-6736(21)00359-7
2. Walter HJ, Bukstein OG, Abright AR, Keable H, Ramtekkar U, Ripperger-Suhler J. Clinical practice guideline for the assessment and treatment of children and adolescents with anxiety disorders. *J Am Acad Child Adolesc Psychiatry*. 2020;59:1107–1124. doi:10.1016/j.jaac.2020.05.005

3. Zacharek SJ, Kribakaran S, Kitt ER, Gee DG. Leveraging big data to map neurodevelopmental trajectories in pediatric anxiety. *Dev Cogn Neurosci*. 2021;50:100974. doi:10.1016/j.dcn.2021.100974
4. Grieshaber A, Silver J, Bufferd SJ, Dougherty L, Carlson G, Klein DN. Early childhood anxiety disorders: continuity and predictors in adolescence. *Eur Child Adolesc Psych*. 2024;33:1817–1825. doi:10.1007/s00787-023-02287-5
5. Kieling C, Buchweitz C, Caye A, Silvani J, Ameis SH, Brunoni AR. Worldwide prevalence and disability from mental disorders across childhood and adolescence: evidence from the global burden of disease study. *JAMA Psychiatry*. 2024;81:347–356. doi:10.1001/jamapsychiatry.2023.5051
6. Hoyniak CP, Vogel AC, Puricelli A, Luby JL, Whalen DJ. Day-to-day bidirectional associations between sleep and emotion states in early childhood: importance of end-of-day mood for sleep quality. *Sleep Health*. 2024;10:264–271. doi:10.1016/j.sleh.2023.12.007
7. Ding X, Wang J, Li N, Su W, Wang H, Song Q. Individual, prenatal, perinatal, and family factors for anxiety symptoms among preschool children. *Front Psychiatry*. 2021;12:778291. doi:10.3389/fpsyt.2021.778291
8. Crowe K, Spiro-Levitt C. Sleep-Related problems and pediatric anxiety disorders. *Psychiatr Clin North Amer*. 2024;47:213–228. doi:10.1016/j.psc.2023.06.014
9. National Health Commission of the People's Republic of China. 2012. Health and hygiene regulations for nursery and kindergarten institutions Available from: https://www.nhc.gov.cn/wjw/c100175/201205/e3000d6d39f44e8c8446916e5249308c.shtml. Accessed April 08, 2026.
10. Schüle C, Baghai T, Zwanzger P, Minov C, Padberg F, Rupprecht R. Sleep deprivation and hypothalamic-pituitary-adrenal (HPA) axis activity in depressed patients. *J Psychiatr Res*. 2001;35:239–247. doi:10.1016/s0022-3956(01)00027-9
11. Dang-Vu TT, Schabus M, Desseilles M, Sterpenich V, Bonjean M, Maquet P. Functional neuroimaging insights into the physiology of human sleep. *Sleep*. 2010;33:1589–1603. doi:10.1093/sleep/33.12.1589
12. Tomaso CC, Johnson AB, Nelson TD. The effect of sleep deprivation and restriction on mood, emotion, and emotion regulation: three meta-analyses in one. *Sleep*. 2021;44:zsaa289. doi:10.1093/sleep/zsaa289
13. Mindell JA, Sadeh A, Kwon R, Goh DYT. Cross-cultural differences in the sleep of preschool children. *Sleep Med*. 2013;14:1283–1289. doi:10.1016/j.sleep.2013.09.002
14. Takahashi M, Wang G, Adachi M, Jiang F, Jiang Y, Saito M. Differences in sleep problems between Japanese and Chinese preschoolers: a cross-cultural comparison within the Asian region. *Sleep Med*. 2018;48:42–48. doi:10.1016/j.sleep.2017.11.1145
15. Ritz C, Olsen MF, Grenov B, Friis H. Sample size calculations for continuous outcomes in clinical nutrition. *Eur J Clin Nutr*. 2022;76:1682–1689. doi:10.1038/s41430-022-01169-4
16. Liu Z, Wang G, Geng L, Luo J, Li N, Owens J. Sleep patterns, sleep disturbances, and associated factors among Chinese urban kindergarten children. *Behav Sleep Med*. 2016;14:100–117. doi:10.1080/15402002.2014.963581
17. Zhou J, Zhu L, Teng Y, Tong J, Gao G, Yan S. Early sleep duration trajectories and children's cognitive development: a prospective cohort study. *Eur J Pediatr*. 2023;182:5353–5365. doi:10.1007/s00431-023-05195-7
18. Lokhandwala S, Spencer RMC. Relations between sleep patterns early in life and brain development: a review. *Dev Cogn Neurosci*. 2022;56:101130. doi:10.1016/j.dcn.2022.101130
19. Owens JA, Spirito A, Mcguinn M. The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep*. 2000;23:1043–1051.
20. Rong T, Sun X, Deng Y, Liu J, Lin Q, Zhu Q. Sleep and prosocial behaviors among young preschoolers: the mediating role of cognitive empathy. *Sleep Med*. 2025;131:106512. doi:10.1016/j.sleep.2025.106512
21. Touchette E, Rousseau M, Simard V, St-Amand A. Portrait of sleep in preschoolers involved with child protective services and from the community. *Sleep Med*. 2023;110:166–171. doi:10.1016/j.sleep.2023.08.008
22. Werner H, Molinari L, Guyer C, Jenni OG. Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Arch pediatr adolesc med*. 2008;162:350–358. doi:10.1001/archpedi.162.4.350
23. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, Doncarlos L. National sleep foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health*. 2015;1:40–43. doi:10.1016/j.sleh.2014.12.010
24. Spence SH, Rapee R, Mcdonald C, Ingram M. The structure of anxiety symptoms among preschoolers. *Behav Res Ther*. 2001;39:1293–1316. doi:10.1016/s0005-7967(00)00098-x
25. Wang M, Zhao J. Anxiety disorder symptoms in Chinese preschool children. *Child Psychiatry Hum Dev*. 2015;46:158–166. doi:10.1007/s10578-014-0461-7
26. Lan QY, Chan KC, Au CT, Chan PH, Chan NY, Wing YK. Secular trends of sleep-wake patterns in Hong Kong preschoolers. *Sleep Med*. 2023;104:73–82. doi:10.1016/j.sleep.2023.02.018
27. Wu J, Zhang Y, Yang Y, Qiu S, Zhou Q, Li J. Association between early childhood outdoor activity and anxiety symptoms in preschoolers. *BMC Psychiatry*. 2025;25:388. doi:10.1186/s12888-025-06831-2
28. Steinsbekk S, Ranum B, Wichstr ML. Prevalence and course of anxiety disorders and symptoms from preschool to adolescence: a 6-wave community study. *J Child Psychol Psychiat Allied Discipline*. 2022;63:527–534. doi:10.1111/jcpp.13487
29. Qian J, Zhang H, Guo A, Fu Q, Shi J, Jin H. Distribution characteristics of mental disorders in community health service center: based on outpatient data from 2014-2022 in Shanghai, China. *BMC Psychiatry*. 2025;25:216. doi:10.1186/s12888-025-06656-z
30. Zheng M, Rangan A, Olsen NJ, Heitmann BL. Longitudinal association of nighttime sleep duration with emotional and behavioral problems in early childhood: results from the Danish Healthy Start Study. *Sleep*. 2021;44. doi:10.1093/sleep/zsaa138
31. Liu H, Ma S, Feng L, Gao J, Wu B, Xia W. Longitudinal association of nighttime sleep duration with emotional and behavioral problems among rural preschool children. *Eur Child Adolesc Psych*. 2024;33:267–277. doi:10.1007/s00787-023-02153-4
32. Ko AJ, Kim J, Park EC. Association of sleep and generalized anxiety disorder in Korean adolescents. *BMC Public Health*. 2024;24:2045. doi:10.1186/s12889-024-19524-4
33. Ding X, Ma S, Liu H, Wang H, Li N, Song Q. The relationships between sleep disturbances, resilience and anxiety among preschool children: a three-wave longitudinal study. *J Psychosom Res*. 2023;168:111203. doi:10.1016/j.jpsychores.2023.111203
34. Deng Y, Zhang Z, Gui Y, Li W, Rong T, Jiang Y. Sleep disturbances and emotional and behavioral difficulties among preschool-aged children. *JAMA Network Open*. 2023;6:e2347623. doi:10.1001/jamanetworkopen.2023.47623
35. Kostev K, Kaur N, Vetter C, Konrad M. Sleep disorders are associated with subsequent depression and anxiety disorders in children and adolescents in Germany-a retrospective cohort study. *J Psychiatr Res*. 2025;187:299–303. doi:10.1016/j.jpsychires.2025.05.030

36. Seo J, Pace-Schott EF, Milad MR, Song H, Germain A. Partial and total sleep deprivation interferes with neural correlates of consolidation of fear extinction memory. *Biol Psychiat Cogn Neurosci Neuroimag*. 2021;6:299–309. doi:10.1016/j.bpsc.2020.09.013
37. Chellappa SL, Aeschbach D. Sleep and anxiety: from mechanisms to interventions. *Sleep Med Rev*. 2022;61:101583. doi:10.1016/j.smrv.2021.101583
38. Alfano CA, Bower JL, Harvey AG, Beidel DC, Sharp C, Palmer CA. Sleep restriction alters children's positive emotional responses, but effects are moderated by anxiety. *J Child Psychol Psychiatr*. 2020;61:1150–1159. doi:10.1111/jcpp.13287
39. Bruni O, Breda M, Mammarella V, Mogavero MP, Ferri R. Sleep and circadian disturbances in children with neurodevelopmental disorders. *Nat Rev Neurol*. 2025;21:103–120. doi:10.1038/s41582-024-01052-9
40. Meerlo P, Sgoifo A, Suchecki D. Restricted and disrupted sleep: effects on autonomic function, neuroendocrine stress systems and stress responsivity. *Sleep Med Rev*. 2008;12:197–210. doi:10.1016/j.smrv.2007.07.007
41. Patel SR, Zhu X, Storfer-Isser A, Mehra R, Jenny NS, Tracy R. Sleep duration and biomarkers of inflammation. *Sleep*. 2009;32:200–204. doi:10.1093/sleep/32.2.200
42. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Hafer A, Carskadon MA. Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. *Sleep*. 2005;28:1568–1577. doi:10.1093/sleep/28.12.1568
43. National Health Commission of the People's Republic of China. 2012. Standards for health care work in nurseries and kindergartens Available from: https://www.nhc.gov.cn/fys/c100078/201205/556cd5d040b24bc19fad2f80b98a7d99.shtml. Accessed April 08, 2026.
44. Doi Y, Ishihara K, Uchiyama M. Epidemiological study on chronotype among preschool children in Japan: prevalence, sleep-wake patterns, and associated factors. *Chronobiol Int*. 2016;33:1340–1350. doi:10.1080/07420528.2016.1217231
45. Kohyama J, Shiiki T, Hasegawa T. Sleep duration of young children is affected by nocturnal sleep onset time. *Pediatrics Int*. 2000;42:589–591. doi:10.1046/j.1442-200x.2000.01304.x
46. Guo K, Zhao X, Luo J, Ren Y, Liu Y, Yang J. Relationship of sleep with diurnal cortisol rhythm considering sleep measurement and cortisol sampling schemes. *Psychoneuroendocrinology*. 2024;162:106952. doi:10.1016/j.psyneuen.2023.106952
47. Rocha S, Almeida DM, Chiang JJ, Cole SW, Irwin MR, Seeman T. The relationship between family socioeconomic status and adolescent sleep and diurnal cortisol. *Psychosom Med*. 2022;84:848–855. doi:10.1097/PSY.0000000000001104
48. Teti DM, Whitesell CJ, Mogle JA, Crosby B, Buxton OM, Bierman KL. Sleep duration and kindergarten adjustment. *Pediatrics*. 2022;150. doi:10.1542/peds.2021-054362
49. Ojio Y, Nishida A, Shimodera S, Togo F, Sasaki T. Sleep duration associated with the lowest risk of depression/anxiety in adolescents. *Sleep*. 2016;39:1555–1562. doi:10.5665/sleep.6020
50. Chen X, Qiang Y, Liu X, Yang Q, Zhu Q, Li B. The prevalence of insufficient sleep and bedtime delay among kindergarten children aged 3 to 6 years in a rural area of Shanghai: a cross-sectional study. *Front Pediatr*. 2021;9:759318. doi:10.3389/fped.2021.759318
51. Zhou L, Zhang H, Luo Z, Liu X, Yang L, Hu H. Abnormal night sleep duration and inappropriate sleep initiation time are associated with elevated anxiety symptoms in Chinese rural adults: the henan rural cohort. *Psychiatry Res*. 2020;291:113232. doi:10.1016/j.psychres.2020.113232
52. Cid-Verdejo R, Domínguez Gordillo AA, Sánchez-Romero EA, Ardizone García I, Martínez Orozco FJ. Diagnostic accuracy of a portable electromyography and electrocardiography device to measure sleep bruxism in a sleep apnea population: a comparative study. *Clocks Sleep*. 2023;5:717–733. doi:10.3390/clockssleep5040047