

Children's Sleep May Depend on Maternal Sleep Duration During Pregnancy: A Retrospective Study

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Background: Animal studies suggested that maternal sleep during pregnancy was associated with sleep pattern in offspring; however, it has not been clear in human populations.

Aim: Our study discusses the relationships of maternal sleep duration with sleep characteristics in their offspring through an epidemiological study.

Methods: A retrospective cross-sectional study including 6236 mother-child dyads was conducted in 31 preschools in May 2019, in Shanghai, China. Information regarding maternal sleep duration in three trimesters of pregnancy was collected retrospectively. Children's current sleep characteristics were evaluated through the Children's Sleep Habits Questionnaire (CSHQ). Linear regressions and logistic regression models were applied to estimate β and adjusted odds ratios with 95% confidence intervals (95% CI).

Results: Maternal sleep duration was positively associated with childhood sleep duration, which was shown in the first ($\beta=0.113$), second ($\beta=0.131$), and third trimesters ($\beta=0.088$). Meanwhile, insufficient maternal sleep duration could increase the risk of children's short sleep duration (first trimester: AOR=1.25; second trimester: AOR=1.33; third trimester: AOR=1.33). Maternal sleep duration was also associated with childhood CSHQ score: $\beta=-0.308$, -0.392 , and -0.300 for the first, second, and third trimesters, respectively. Similarly, insufficient maternal sleep duration could predict childhood sleep disturbance as AOR=1.28 in the second trimester and AOR=1.26 in the third trimester.

Conclusion: Our findings established a relationship between maternal sleep during pregnancy and their children's sleep pattern through a population-based epidemiology study. Poor childhood sleep was found when their mother experienced less sleep duration during pregnancy, especially in the second and third trimesters.

Keywords: Children's Sleep Habit Questionnaire, pregnant women, preschooler, sleep duration

Introduction

It is reported that sleep problems have influenced almost the half of all children around the world.¹ Sufficient high-quality sleep duration has benefits for children's health, growth, and development.²⁻⁵ It has been confirmed by accumulating studies that short sleep duration and sleep disturbance have negative impacts upon a range of aspects including metabolic balance, neurobehavioral function, and mental health.²⁻⁷

To date, a large number of factors have been reported affect children's sleep. However, almost all studies focused on children's own environmental exposure, lifestyle factors, and health condition, such as family members' interaction, sleep environment, physical activity, obesity, etc.⁸⁻¹² Data from the ALSPAC cohort in the UK indicated that maternal mood disturbance in pregnancy has persisting

effects on sleep problems in their children.¹³ A very recent study in Finland also suggested that maternal depressive symptoms during pregnancy are associated with an increased risk of children's sleep deficiency and sleep disorders.¹⁴ It seemed that there should be a link between maternal condition during pregnancy and their offspring's sleep.^{13,14}

According to developmental origins of health and disease theory, environmental exposure during pregnancy could affect the development and programming of the embryo.^{15,16} It has been proposed that an individual's circadian rhythm begins in the embryo.^{17,18} Melatonin, a circadian rhythm messenger linking mother and fetus, has essential functions not only in fetal maturation but also in children's sleep patterns.^{18–24} Because it has been confirmed that sleep disturbance during pregnancy could interfere with the rhythm and amplitude of melatonin secretion,^{16,25} we strongly hypothesized that maternal sleep was associated with their offspring's sleep. Two animal studies provided evidence for our hypothesis.^{26,27} They found that if female rats experienced sleep restriction in the third trimester, their pups had higher active sleep and lower quiet sleep as well as wakefulness.²⁶ More impressively, if sleep deprivation took place in the rapid eye movement sleep phase at the third trimester, the development and maturation of their pups' sleep-wake neural networks would be delayed.²⁷ To the best of our knowledge, the relationship of maternal sleep with childhood sleep in humans has been discussed in only two studies since 1998.^{28,29} The first was a retrospective case-control study in 97 mother-child dyads, in which it was found that those mothers experienced a higher level of maternal sleep distress when their children had sleep problems.²⁸ The other study, based on a prospective cohort containing 111 mother-child dyads, found that maternal exposure to daytime sleepiness could predict childhood sleep problems.²⁹

Based on the previous studies, we explored two questions: (1) if there were associations between maternal sleep duration during pregnancy and childhood sleep duration and sleep disturbance; and (2) if the strength of the association of sleep duration with childhood sleep duration and sleep disturbance were different between different trimesters.

Materials and Methods

Study Design and Participants

This study was based on a cross-sectional study conducted in 31 preschools in Shanghai, China during May, 2019.

The institutional review board of the Shanghai Municipal Education Commission approved this study.

After the permissions were obtained from these schools, children who were eligible to participate in this study were invited to bring a questionnaire to their parents, with a letter explaining the objectives of the project and instructions on how to complete the questionnaire. Parents were told that participation was voluntary and written informed consent should be signed to confirm. Among 6389 children recruited to the study, 6236 (response rate 97.62%) returned the qualified questionnaires. Our final sample consisted of 6236 mother-child dyads with children aged 3–7 years.

Children with any of the following conditions were excluded from the study: (1) death of the mother; (2) parents were illiterate; (3) inability to locate the parents to complete the questionnaire; (4) children take certain drugs (such as aspirin, Ritalin, amphetamine, caffeine, diazepam, phenobarbital, etc.) for a long time or recently (within one week).

Measures

Demographic Characteristics

All the demographic characteristics were reported through the questionnaire by mothers. Maternal characteristics were listed as follows: maternal age at delivery was grouped into <25, 25–34, and ≥35 years; maternal educational level was categorized into less than high school, high school, and college and above; family structure was grouped into single-parent family, nuclear family, and large family; overweight/obesity before pregnancy was defined as body mass index (BMI) >24.0 kg/m² (yes vs no) according to modified the standard by group of China obesity;³⁰ family income (RMB (yuan)/month/person) was categorized into <3999, 4000–7999, and >8000; smoking during pregnancy (yes vs no); alcohol use during pregnancy (yes vs no); maternal physical activity was categorized into <2 h/day vs ≥2 h/day; maternal stressful life event (including financial problems, divorce, husband violence, lost job, illness/injury of someone close, death of someone close, relationship difficulties, accident/natural disaster) exposure (yes vs no); family history of sleep disorders (yes vs no). Childhood characteristics included age, gender, obesity/overweight (calculated by age and sex-specific BMI reference³¹); allergic disease (including allergic rhinitis, eczema, and asthma); attention deficit hyperactivity disorder (ADHD) (yes vs no); childhood physical activity was categorized into ≥1 h/day vs <1 h/day according to previous study;³² and screen exposure

was categorized into ≥ 1 h/day vs < 1 h/day according to previous study.³³

Sleep Duration and Sleep Disturbance

Maternal sleep duration around pregnancy was retrospectively collected through a set of questions at the time of the child sleep assessment, including: “How long did you actually sleep per day on average during the first trimester?” “How long did you actually sleep per day on average during the second trimester?” “How long did you actually sleep per day on average during the third trimester?” Short sleep duration was defined as less than 8 h/night as recommended by the American Academy of Sleep Medicine.³⁴

The Children’s Sleep Habits Questionnaire (CSHQ)³⁵ was used to assess children’s sleep habits and sleep problems and sleep duration. CSHQ was a 36-item parent-reported questionnaire, which was designed and developed to assess sleep behaviors of preschool and school-aged children.³⁵ Respondents were asked to indicate how often the sleep behaviors occurred over a “typical” recent week using a three-point scale: “usually” if it occurred 5–7 times per week, “sometimes” for 2–4 times per week, and “rarely” for 0–1 time per week. The 33 sleep problems were conceptually grouped into eight subscales: bedtime resistance, sleep onset delay, sleep duration disorder, sleep anxiety, night awakening, parasomnias, sleep-disordered breathing, and daytime sleepiness. In the CSHQ, sleep duration was examined by the question: “What time does your child actually sleep during weekdays and on weekends (including daytime nap)?” In our study, childhood sleep duration was the average of sleep duration during weekdays and on weekends (calculated as: childhood sleep duration = $5/7 \times$ Sleep duration during weekdays + $2/7 \times$ Sleep duration on weekends). CSHQ score was calculated by the sum of 33 question (higher is worse).³⁵ Short sleep duration was defined as less than 10 h/night as recommended by the American Academy of Sleep Medicine.³⁴ Sleep disturbance was defined as total CSHQ score > 41 .³⁵

Statistical Analysis

The description was made by use of the mean and SD (standard deviation) for continuous variables, and number and percentage for categorical variables.

Independent *t*-test and chi-squared test were used to compare differences between two groups. Pearson correlation coefficient was used to analyze the correlation of maternal sleep duration in three trimesters. RM-ANOVA (repeated measurement analysis of variance) was used to

compare the differences of maternal sleep duration in three trimesters. Penalized splines in generalized additive models were used to examine the linearity of relationships between maternal sleep duration during pregnancy with childhood sleep duration and childhood CSHQ score. Generalized cross-validation was used to automatically select the degree of smoothing for splines.

Multiple linear regressions were further applied to assess the associations of maternal sleep duration with sleep duration and CSHQ score in offsprings. Logistic regression analyses were then applied to examine the risk of short maternal sleep duration on short sleep duration and sleep disturbance in their offspring. Adjusted models were controlled for maternal age at delivery, maternal education level, overweight/obesity before pregnancy, family structure, family income, smoking during pregnancy, alcohol use during pregnancy, physical activity during pregnancy, maternal stressful life events, family history of sleep disorder, children’s age, gender, obesity/overweight, allergic disease, ADHD, childhood physical activity, and screen exposure.

A statistical significance level was set at $p < 0.05$ (two-tailed). All analyses were performed with the Statistical Package for the Social Sciences (SPSS) (IBM-SPSS Statistics v24.0, Inc., Chicago, IL) and R version 3.5.3 (The R Foundation for Statistical Computer, www.r-project.org).

Results

Sample Demographic Characteristics

A total of 6236 children were enrolled in this study. Among the 6236 children, 2150 children (34.5%) reported short sleep duration and 5874 children (94.19%) reported sleep disturbance. Sample characteristics are shown in Table 1.

Comparisons of Maternal Sleep Duration with Childhood Sleep Duration and Sleep Disturbance

As shown in Table 2, maternal sleep duration among three trimesters was correlated and showed a slightly decreased trend through the first trimester to the third trimester. Correspondingly, the prevalence of short sleep duration increased with the progress of the pregnancy. As shown in Table 3, children with short sleep duration reported less maternal sleep duration and higher prevalence of insufficient maternal sleep duration in all three trimesters (all $p < 0.05$). Similarly, children with sleep disturbance also showed the trend in all three trimesters.

Table 1 Maternal and Childhood Characteristics by Childhood Total Sleep Duration and Sleep Disturbance (n, %)

Variables	Total		Childhood Sleep Duration (9.37±1.30)				Childhood Sleep Disturbance (52.49±7.88)				p value	
	n	%	≥10 h	<10 h	χ^2/t		CSHQ≤41	CSHQ>41	χ^2/t			
			N=2150	N=4086	65.50%		N=362	N=5874	94.19%			
Maternal Characteristics												
Maternal age at delivery												
<25	933	15.18%	323	610	15.14%	0.502	63	17.55%	870	15.03%	7.034	0.03
25–34	4699	76.43%	1612	3087	76.64%		255	71.03%	4444	76.77%		
≥35	516	8.39%	185	331	8.22%		41	11.42%	475	8.21%		
Maternal education level												
Less than high school	588	9.43%	184	404	9.89%	4.127	38	10.50%	550	9.36%	3.678	0.159
High school	963	15.44%	350	613	15.00%		67	18.51%	896	15.25%		
College and above	4685	75.13%	1616	3069	75.11%		257	70.99%	4428	75.38%		
Overweight/obesity before pregnancy												
Yes	595	9.56%	190	405	9.93%	1.865	40	11.08%	555	9.47%	1.025	0.311
No	5629	90.44%	1955	3674	90.07%		321	88.92%	5308	90.53%		
Family structure												
Nuclear family	3561	57.10%	1268	2293	56.12%	4.816	241	66.57%	3320	56.52%	14.269	0.001
Single-parent family	170	2.73%	54	116	2.84%		9	2.49%	161	2.74%		
Large family	2505	40.17%	828	1677	41.04%		112	30.94%	2393	40.74%		
Family income (RMB (yuan)/month/person)												
<3999	667	10.70%	220	447	10.94%	6.961	48	13.26%	619	10.54%	2.711	0.258
4000–7999	2345	37.60%	769	1576	38.57%		130	35.91%	2215	37.71%		
>8000	3224	51.70%	1161	2063	50.49%		184	50.83%	3040	51.75%		
Smoking during pregnancy												
Yes	134	2.15%	49	85	2.08%	0.265	6	1.66%	128	2.18%	0.441	0.507
No	6102	97.85%	2101	4001	97.92%		356	98.34%	5746	97.82%		
Alcohol use during pregnancy												
Yes	153	2.45%	53	100	2.45%	0.002	7	1.88%	136	2.32%	0.434	0.51
No	6083	97.55%	2097	3986	97.55%		365	98.12%	5728	97.68%		
Physical activity during pregnancy												
≥2 h	2373	38.05%	846	1527	37.37%	2.337	614	13.31%	265	16.32%	8.955	0.003
<2 h	3863	61.95%	1304	2559	62.63%		3998	86.69%	1359	83.68%		

Stressful life event	Yes	266	4.30%	90		4.20%	176	4.30%	0.051	0.822	13	3.60%	253	4.30%	0.428	0.513
	No	5970	95.70%	2060		95.80%	4086	95.70%			349	96.40%	5621	95.70%		
Family history of sleep disorders	Yes	1637	26.25%	549		25.53%	1088	26.63%	0.869	0.351	48	13.26%	1589	27.05%	33.502	<0.001
	No	4599	73.75%	1601		74.47%	2998	73.37%			314	86.74%	4285	72.95%		
Childhood Characteristics																
Age (mean, SD)		5.16	0.88	4.9943		0.87	5.2446	0.87	10.733	<0.001	5.39	0.89	5.14	0.88	-5.271	<0.001
Gender	Boys	3289	52.74%	1102		51.26%	2187	53.52%	2.908	0.088	207	57.18%	3082	52.47%	3.04	0.081
	Girls	2947	47.26%	1048		48.74%	1899	46.48%			155	42.82%	2792	47.53%		
Obesity/overweight	Yes	1135	18.28%	348		16.26%	787	19.35%	8.93	0.003	75	20.83%	1060	18.13%	1.664	0.197
	No	5073	81.72%	1792		83.74%	3281	80.65%			285	79.17%	4788	81.87%		
Allergic disease	Yes	3485	55.89%	1195		55.58%	2290	56.05%	0.123	0.726	122	33.70%	3363	57.25%	76.712	<0.001
	No	2751	44.11%	955		44.42%	1796	43.95%			240	66.30%	2511	42.75%		
ADHD	Yes	99	1.59%	36		1.67%	63	1.54%	0.158	0.691	1	0.28%	98	1.67%	3.386	0.66
	No	6137	98.41%	2114		98.33%	4023	98.46%			361	99.72%	5776	98.33%		
Physical activity	≥1 h	2675	42.90%	1025		47.67%	1650	40.38%	30.585	<0.001	207	57.18%	2468	42.02%	32.021	<0.001
	<1 h	3561	57.10%	1125		52.33%	2436	59.62%			155	42.82%	3406	57.98%		
Screen exposure	≥1 h	2273	36.45%	754		35.07%	1519	37.18%	2.697	0.101	105	29.01%	2168	36.91%	9.194	0.002
	<1 h	3963	63.55%	1396		64.93%	2567	62.82%			257	70.99%	3706	63.09%		

Note: Bold values indicate statistical significance.
 Abbreviations: ADHD, attention deficit hyperactivity disorder; CSHQ, children's sleep habits questionnaire; SD, standard deviation.

Table 2 Correlation and Longitude Analysis of Maternal Sleep Duration in Three Trimesters

Correlation and Longitudinal Differences of Maternal Sleep Duration During Pregnancy		
Correlation coefficient		p value
First trimester vs Second trimester	0.727	<0.001
Second trimester vs Third trimester	0.713	<0.001
First trimester vs Third trimester	0.572	<0.001
RM-ANOVA (Mean Difference)		
First trimester vs Second trimester	0.038	0.006
Second trimester vs Third trimester	0.351	<0.001
First trimester vs Third trimester	0.389	<0.001

Note: Bold values indicate statistical significance.

Abbreviation: RM-ANOVA, repeated measurement analysis of variance.

Association of Maternal Sleep Duration with Childhood Sleep Duration and Sleep Disturbance

As shown in generalized additive models by using a penalized spline of maternal sleep duration, a linear association between maternal sleep duration with childhood sleep duration was observed (Figure 1). Similarly, a linear association of maternal sleep duration with childhood CSHQ score were also observed (Figure 2).

Less maternal sleep duration was observed in all three trimesters when their children had either shorter sleep duration ($\beta=0.113$, $\beta=0.131$, and $\beta=0.088$ for the first, second, and third trimesters, respectively, all $p<0.01$) or sleep disturbance ($\beta=-0.308$, $\beta=-0.392$, and $\beta=-0.300$ for the first, second, and third trimesters, respectively, all $p<0.01$). After controlling for possible confounders, the associations were still kept (Tables 3 and 4).

Correspondingly, maternal short sleep duration, no matter in which trimester, could predict both short sleep duration (OR=1.24, OR=0.133, and OR=1.30 for the first, second, and third trimesters, respectively, all $p<0.01$) and sleep disturbance (OR=1.28, OR=1.41, and OR=1.34 for the first, second, and third trimesters, respectively, all $p<0.01$) in their children. After controlling for possible confounders, the associations were also kept, especially in the second and third trimesters (Tables 3 and 5).

Based on these results in linear and logistic regressions, the associations between maternal sleep duration and childhood sleep duration and childhood sleep disturbance have been preliminarily established, especially in the second and the third trimesters.

Discussion

To our knowledge, only a few studies have indicated that maternal sleep could be involved in the offspring's childhood sleep characteristics.^{26–29} Our study provides more detailed sleep parameters from humans on the basis of a population-based epidemiological study. It is also worth noting that maternal sleep from middle to late gestation, especially in the second trimester, was more important to their children's sleep pattern. The findings enriched our understanding with sleep health and the origins of childhood sleep pattern.

In the present study, we applied data analysis taking sleep duration and sleep disturbance not only as continuous variables but also cutting them into categorical variables. The very similar results confirmed the findings and enforced the evidence. In addition, demographic characteristics and a number of lifestyle factors were taken into account when examining the associations. Also, as suggested by previous studies, maternal mood during pregnancy was a predictor of childhood sleep quality and sleep disorders.^{13,14} In this study, we used maternal exposure to stressful life events as an indicator of mood and stress³⁶ and took it as a confounding factor when discussing the association of maternal sleep with childhood sleep. Therefore, maternal sleep could be independently related to childhood sleep pattern.

Genetic imprinting between mother and offspring in their behavioral connections have been confirmed by accumulating animal studies.^{26,27,37} At least two studies in rats found sleep restriction and sleep duration during pregnancy have negative impact on offspring's sleep-wake network development.^{26,27} In addition, two studies provided evidence to support the relationship between maternal sleep and childhood sleep in humans.^{28,29} The data from a retrospective case-control study found that sleep problems during pregnancy were more prevalent among those mothers when their children were exposed to poor sleep quality compared to the control.²⁸ A longitudinal study also found that maternal daytime sleepiness during pregnancy could predict childhood sleep problems.²⁹ Our study further provided enriched information to discuss the association between maternal sleep and childhood sleep based on a large-sample epidemiology study.

Our finding also extended the understanding that there should be a key period for the development of sleep patterns. Our results suggested that middle to late gestation may be more crucial for offspring's sleep pattern.

Table 3 Maternal Sleep Duration During Pregnancy by Children's Total Sleep Duration and Sleep Disturbance

	Total	Childhood Sleep Duration (9.37±1.30)						Childhood Sleep Disturbance (52.49±7.88)						
		≥10 h		<10 h		χ^2/t	p value	CSHQ≤41		CSHQ>41		χ^2/t	p value	
		N=2150	34.50%	N=4086	65.50%			N=362	5.80%	N=5874	94.19%			
First Trimester														
Sleep duration In continue (means, SD)	8.46	1.38	8.64	1.44	8.36	1.33	-7.51	<0.001	8.60	1.36	8.45	1.38	-1.99	0.046
In category														
>8h	3142	50.56%	1163	54.19%	1979	48.65%	17.29	<0.001	204	56.51%	2938	50.20%	5.42	0.020
≤8h	3072	49.44%	983	45.81%	2089	51.35%			157	43.49%	2915	49.80%		
Second Trimester														
Sleep duration In continue (means, SD)	8.41	1.40	8.62	1.45	8.29	1.35	-8.90	<0.001	8.59	1.43	8.39	1.39	-2.62	0.009
In category														
>8h	3041	48.84%	1150	53.51%	1891	46.37%	28.73	<0.001	206	56.91%	2835	48.34%	10.02	0.002
≤8h	3186	51.16%	999	46.49%	2187	53.63%			156	43.09%	3030	51.66%		
Third Trimester														
Sleep duration In continue (means, SD)	8.06	1.59	8.27	1.61	7.95	1.58	-7.46	<0.001	8.25	1.58	8.05	1.59	-2.27	0.023
In category														
>8h	2479	39.81%	947	44.05%	1532	37.58%	24.59	<0.001	169	46.69%	2310	39.39%	7.58	0.006
≤8h	3748	60.19%	1203	55.95%	2545	62.42%			193	53.31%	3555	60.61%		

Note: Bold values indicate statistical significance.
Abbreviations: CSHQ, children's sleep habits questionnaire; SD, standard deviation.

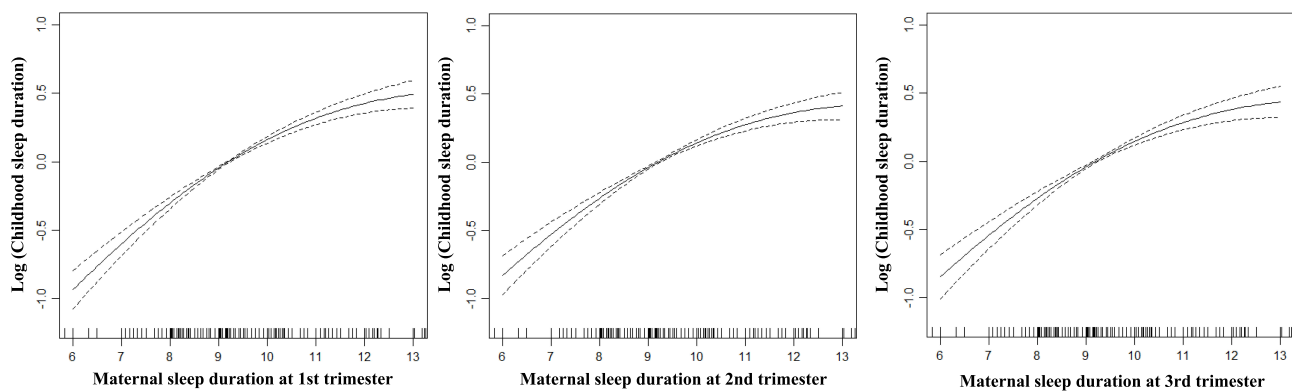


Figure 1 The associations between maternal sleep duration during pregnancy with childhood sleep duration.

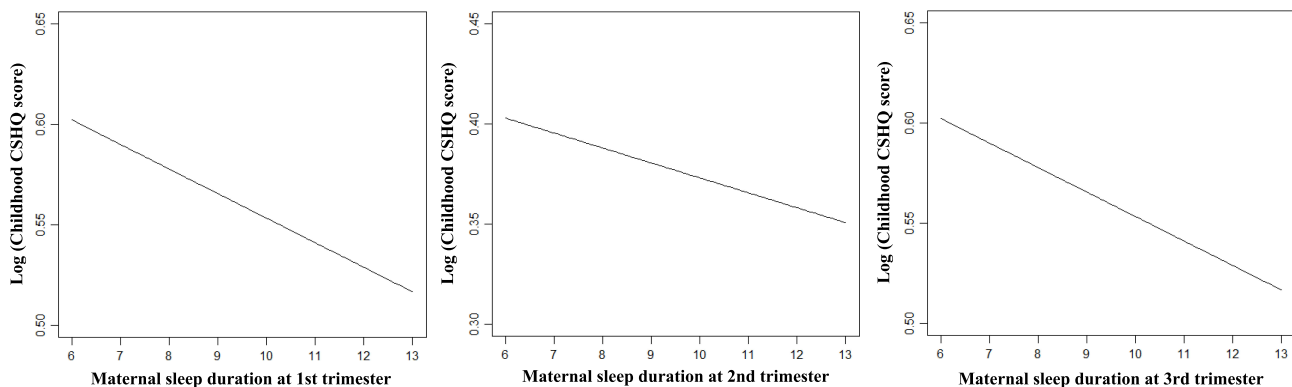


Figure 2 The associations between maternal sleep duration during pregnancy with childhood CSHQ score.

Compared with the first trimester, the impact of maternal sleep became stronger in the second and third trimesters. As demonstrated by previous studies, fetal circadian rhythms were developed in the second trimester and matured in the third trimester.^{17,38} We speculate that the second trimester could be a “window period” for the establishment of sleep patterns in the fetus due to the start of circadian rhythms. It has been reported that circadian rhythms became mature and could be influenced by the outside environment, such as light.²³ The fetus has the ability to sense changes in the maternal sleep–wake cycle during the third trimester.²³

Although few studies discussed the relationship between maternal sleep and childhood sleep, some potential biological mechanisms have been proposed in theory to support the relationship. Previous studies have put forward an explanation that disturbed sleep during pregnancy could interfere with the rhythm and amplitude of melatonin secretion.^{16,25} Melatonin plays a role of circadian rhythm messenger between mother and fetus, which should be involved in the form of normal fetal sleep

patterns and circadian rhythms.^{18,19} We speculated that the melatonin regulated the circadian rhythms and brought about the associations between maternal sleep and childhood sleep. There has been evidence to support the association of maternal melatonin with children’s sleep by longitudinal observation.²²

The biggest strength of our study was the big sample size to explore the relationship between maternal sleep and childhood sleep pattern in population. Second, maternal sleep covered three trimesters. Third, our study was conducted with a large sample. Other strengths included the proper questionnaire (CSHQ) and confounding factor controls.

However, there were also some limitations in interpreting the data. Based on a retrospective cross-sectional study, recall bias of maternal sleep duration cannot be ignored. However, as a special period, mothers always pay close attention to their health during pregnancy, so recall bias may be limited to a certain extent. Meanwhile, in data analysis, sleep duration and sleep disturbance were brought into the regression model as

Table 4 Associations of Maternal Sleep Duration During Pregnancy with Childhood Sleep Duration and CSHQ Score in Their Offsprings

Maternal Sleep Duration	Childhood Sleep Duration (9.37±1.30)			Childhood CSHQ Score (52.49±7.88)		
	β	SE	p value	β	SE	p value
First Trimester Sleep duration	0.113	0.012	<0.001	-0.308	0.072	<0.001
Second Trimester Sleep duration	0.131	0.012	<0.001	-0.392	0.071	<0.001
Third Trimester Sleep duration	0.088	0.10	<0.001	-0.300	0.061	<0.001

Notes: Bold values indicate statistical significance. Adjusted for maternal age at delivery, maternal education level, overweight/obesity before pregnancy, family structure, family income, smoking during pregnancy, alcohol use during pregnancy, physical activity during pregnancy, maternal stressful life events, family history of sleep disorder, children's age, gender, obesity/overweight, allergic disease, ADHD, childhood physical activity, and screen exposure.

Abbreviations: CSHQ, children's sleep habits questionnaire; SE, standard error.

Table 5 The Association of Maternal Short Sleep Duration with Childhood Short Sleep Duration and Sleep Disturbance in Their Offsprings

Maternal Sleep Duration	Childhood Short Sleep Duration (Less Than 10 h/day)		Childhood Sleep Disturbance (CSHQ > 41*)	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
First Trimester				
Sleep duration >8 h	Reference	Reference	Reference	Reference
≤8 h	1.24 (1.12, 1.38)[#]	1.25 (1.12, 1.39)[#]	1.28 (1.04, 1.59)[#]	1.13 (0.90, 1.42)
Second Trimester				
Sleep duration >8 h	Reference	Reference	Reference	Reference
≤8 h	1.33 (1.199, 1.47)[#]	1.33 (1.19, 1.49)[#]	1.41 (1.13, 1.74)[#]	1.28 (1.02, 1.54)[*]
Third Trimester				
Sleep duration >8 h	Reference	Reference	Reference	Reference
≤8 h	1.30 (1.17, 1.45)[#]	1.33 (1.19, 1.48)[#]	1.34 (1.08, 1.66)[#]	1.26 (1.01, 1.45)[*]

Notes: Bold values indicate statistical significance. Adjusted for maternal age at delivery, maternal education level, overweight/obesity before pregnancy, family structure, family income, smoking during pregnancy, alcohol use during pregnancy, physical activity during pregnancy, maternal stressful life events, family history of sleep disorder, children's age, gender, obesity/overweight, allergic disease, ADHD, childhood physical activity, and screen exposure. * $p < 0.05$; [#] $p < 0.01$.

Abbreviations: CSHQ, children's sleep habits questionnaire; CI, coefficient interval; OR, odds ratio.

continuous variables or cutting them into categorical variables, respectively. The very similar results could enforce the evidence. This study did not collect maternal sleep at the time of child sleep assessment, however, which should be taken into account when exploring the relationship of maternal sleep during pregnancy with childhood sleep. Children's sleep was reported by their parents rather than objective recording. This made it possible that there are biases in children's sleep variables because of reporting bias. We made a preliminary research on maternal sleep during pregnancy and childhood sleep; other maternal

sleep parameters, such as sleep problems and sleep disturbance, were unavailable in the present study.

Conclusion

This study, for the first time, established the associations of maternal sleep duration through the whole pregnancy with childhood sleep duration and sleep disturbance. However, middle to late gestation was more important to the associations. Insufficient maternal sleep duration was associated with childhood short sleep duration and sleep disturbance. The findings provided new evidence to

support the relationship between maternal sleep during pregnancy and childhood sleep, which has been discussed by only two studies so far.^{28,29} Due to the retrospective design of our study, prospective longitudinal studies are needed to provide further and enriched evidence.

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Disclosure

The authors report no conflicts of interest in this work.

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