HHS Public Access

Author manuscript

Psychiatry Res. Author manuscript; available in PMC 2017 August 30.

Published in final edited form as:

Psychiatry Res. 2016 August 30; 242: 218–225. doi:10.1016/j.psychres.2016.05.017.

Sleep Disordered Breathing Symptoms and Daytime Sleepiness are Associated with Emotional Problems and Poor School Performance in Children

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Abstract

This study examined the prevalence of sleep disordered breathing (SDB) symptoms and their associations with daytime sleepiness, emotional problems, and school performance in Chinese children. Participants included 3,979 children (10.99 ± 0.99 years old) from four elementary schools in Jintan City, Jiangsu Province, China. Children completed a self-administered questionnaire on sleep behavior and emotional problems, while parents completed the Child Sleep Habit Questionnaire (CSHQ). SDB symptoms included 3 items: loud snoring, stopped breathing, and snorting/ gasping during sleep. Teachers rated the children's school performance. The prevalence rates of parent- and self-reported SDB symptoms were 17.2% and 10.1% for "sometimes" and 8.9% and 5.6% for "usually". SDB symptoms, more prevalent in boys than in girls, increased the risks for depression, loneliness, and poor school performance. Daytime sleepiness mediated the relationship between SDB symptoms and depression, loneliness, and poor school performance. This study suggests the importance of early screening and intervention of SDB and daytime sleepiness in child behavioral and cognitive development.

Keywords

Sleep disordered breathing; daytime sleepiness; emotional problems; behavior outcomes; school performance; Chinese children

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Financial Disclosure

The authors have no financial relationships relevant to this article to disclose.

Conflict of Interest

None of the authors declare any conflicts of interests and there has been no off-label or investigational use.

1. Introduction

Sleep-disordered breathing (SDB), with symptoms like frequent loud snoring, snorting, gasping, or obstructive sleep apnea (OSA), is prevalent in children. Anywhere from 4% to 20% of children are estimated to have SDB symptoms (Bonuck et al., 2011; Li et al., 2015). SDB in children has been associated with increased risk for mental health problems, such as depression, anxiety, inattention, and hyperactivity (Rosen et al., 2004; Aronen et al., 2009). In addition to increased risk for emotional and behavioral outcomes, data from epidemiological and clinical studies suggest that SDB symptoms in children are associated with cognitive deficits, including dysfunctions in memory, executive functioning, general intelligence, and academic functioning (Bourke et al., 2011; Van Dongen & Kerkhof, 2011; Bucks et al., 2013; Lande et al., 2014). For example, snoring and poor oxygen intake can lead to excessive daytime sleepiness, which is associated with negative mood and poor cognitive functioning (McLaughlin Crabtree et al., 2004), as well as impaired processing speed (Calhoun et al., 2012). Finally, an intervention study in children also demonstrated that positive airway pressure therapy, which is used to treat OSA in children, is associated with significant improvements in attention deficits, sleepiness, and behavior (Marcus et al., 2012).

Although researchers have reported the impact of SDB on academic performance in children, the findings were thus far inconsistent. For example, both Gozal (1998) and Brockmann et al. (2012b), reported an association between SDB and poor academic performance using objective measures.However, Mayes et al. (2008) reported that among children ages 6-12 years, none of the sleep-disordered breathing indices, including lowest oxygen saturation percentage, were significantly related to reading and math achievement. Similarly, using objective measures, Ting et al. (2011) failed to detect any differences in academic performance among varying severities of SDB or between children with and without SDB. More recently, Jackman and colleagues (2012) found significantly greater executive functioning impairments and behavioral problems, but not cognitive impairments, among preschool children with SDB than in non-snoring preschool children. The inconsistent findings in previous studies may be due to confounding variables, such as socioeconomic status (Chervin et al., 2003) or mental health problems, which in turn may interfere with learning (Beebe et al., 2010).

Whereas most studies of SDB and associated emotional and cognitive outcomes have been conducted on Western children, little is known about the impact of SDB on emotion and school performance in a Chinese context, where school children may experience more academic pressure. Additionally, children's sleeping behavior is not only influenced by biological (i.e. anatomical variation) and psychological factors, but also by cultural, social, and familial factors (Liu et al., 2005). For example, anatomically, craniofacial features, such as an elongated soft palate and shortened cranial base, may differentially affect Asian populations (Li et al., 2000). Furthermore, several studies (Liu et al., 2005) have observed differences in sleep practices, sleep patterns, and SDB between Chinese children and the US children. Consequently, findings from other countries and cultures may not be applicable to Chinese children.

We previously reported in this sample that sleep problems and fatigue were associated with poor cognitive performance in kindergarten children (Liu et al, 2012b). However, the specific sleep problem of SDB in relation to school children's emotions and school performance is unclear. Furthermore, although daytime sleepiness has been linked to both SDB and poor emotional status and school performance, few studies have specifically tested the mediating role of daytime sleepiness in the complex interplays among these factors. The aim of this study is three-fold: 1) to assess the prevalence rate of SDB symptoms as measured by both parent- and self-reports in a large community sample of Chinese school-aged children; 2) to test how SDB symptoms are associated with school academic performance and emotional problems (including depression and loneliness); and 3) to examine whether daytime sleepiness mediates the relationship between SDB and emotional and academic outcomes. We hypothesize that 1) sleep disordered breathing symptoms are associated with increased emotional and behavioral problems and poor school performance; 2) daytime sleepiness is significantly associated with SDB symptoms and increased emotional and behavioral problems and poor school performance; and 3) the predictive effect of SDB symptoms on emotional and behavioral problems as well as school performance will decrease or disappear when daytime sleepiness is adjusted for in the regression models.

2. Methods

2.1. Subjects

A sample of 3,979 fourth through sixth graders from four elementary schools in Jintan City, Jiangsu Province participated in a sleep and health survey. The samples were extended from the original China Jintan Preschool Cohort study established in 2004. Using multi-stage sampling methods, the initial cohort study selected 1656 preschoolers from Jintan (as of June 1, 2015, Jintan City became the Jintan District of Changzhou City, Jiangsu Province, China), located in the southeastern coastal region of China with a population of 600,000 people. This longitudinal preschool cohort aimed to study the impact of early health factors on children's and adolescents' long-term behavioral outcomes. We first set up a stratified sampling process to select four schools in terms of their location: rural, suburban, and urban area. Within selected schools, we used a cluster sampling strategy that included every student in each school. The present study includes both the original cohort participants and their current classmates in elementary schools, thus totaling to 3,979 participants. The sociodemographic profile and additional details of this location are reported elsewhere (Liu et al., 2010, 2015; Liu et al., 2011).

2.2. Procedures

Multiple informants were used to collect data on children's sleeping behavior, behavioral/emotional problems, and school performance. From 2011-2013, school children in Jintan were asked to complete a questionnaire adapted from the Adolescent Health Questionnaire (AHQ) that surveyed demographics, sleeping behavior, and emotional problems (Liu et al., 2008). Questionnaires were distributed to the children in their school classroom and completed under the supervision of a research assistant.

Parents completed the Child Sleep Habit Questionnaire (CSHQ) (Owens et al., 2000). Research assistants asked children to bring the questionnaires home to their parents to complete and return within 3 days. The head teacher of each class was asked to report the children's school performance on 3 major subjects (Chinese, Math, and English). Written consent from parents and written assent from children were obtained prior to the initiation of the study. Institutional Review Board approval was obtained from both the University of Pennsylvania and the Ethical Committee for Research at Jintan Hospital in China.

2.3. Measures

2.3.1. Sleep problems

2.3.1.1. Self-reported Sleep and Health Questionnaire: Children completed the self-reported sleep and health questionnaire, which included 3 items on sleep disordered breathing symptoms (loud snoring, stopped breathing, and snorting/gasping) and 7 items on daytime sleepiness (wakes up with negative mood, hard time getting out of bed, takes a long time to be alert, seems tired, sleepiness while watching TV, and sleepiness while riding in a car) (Liu et al., 2008). Children were asked to rate each item on a 3-point scale: “usually” if the sleep behavior occurred 5-7times/week (score = 3); “sometimes” for 2-4 times/ week (score = 2); and “rarely” for 0-1 time/week (score = 1) in the past month. From the samples with complete data of all 3 SDB items, we computed a new variable, called “any of the SDB symptoms,” as a proxy to the general SDB status. This self-reported sleep questionnaire showed acceptable psychometric properties. The internal consistency (Cronbach) was 0.71 for sleep-related breathing items in previously reported Chinese samples (Liu et al., 2008).

2.3.1.2. Parents report: Parents completed a Chinese version of CSHQ, which consists of 33 sleep-disturbance items that were conceptually grouped into 8 subscales: bedtime resistance, sleep-onset delay, sleep duration, sleep anxiety, night waking, parasomnia, sleep-disordered breathing, and daytime sleepiness. Parents were asked to rate each item on a 3-point scale: “usually” if the sleep behavior occurred 5-7 times/week; “sometimes” for 2-4 times/week; and “rarely” for 0-1 time/week in a typical week in the past month. For the purpose of the current study, we focused on sleep-disordered breathing and daytime sleepiness. The internal consistency of the entire CSHQ was 0.68 for the community sample and 0.78 for the clinical sample. The alpha coefficient was 0.58 on the Sleep-Disordered Breathing subscale (Owens, 2000). The CSHQ has been widely used with satisfactory psychometric properties in the assessment of sleep problems in Chinese children (Li et al., 2007) and has been shown to have reliability and content and construct validity (Liu et al., 2005; Liu et al., 2008).

2.3.2. Loneliness—Children's loneliness and social dissatisfaction were assessed by a self-report measure that was adapted from Asher et al. (1984). Children responded to self-statements (e.g., “I have nobody to talk to,” “I feel lonely”, “I don't have anybody to play with at school”) using a 5-point scale (1 = not at all true; 5 = always true). The average score of the responses was calculated, with higher scores indicating greater degrees of loneliness. The measure has been used and proved reliable and valid in previous studies in Chinese children (Chen et al., 2004). The Cronbach alpha was 0.893 in the present study.

2.3.3. Depression—Children's depression was measured by administering a Chinese version of the Childhood Depression Inventory (CDI) (Kovacs, 2004). Items were centered on thoughts, feelings, or behaviors associated with depression, including self-deprecation, reduced social interest, anhedonia, self-hate, self-blame, fatigue, somatic concerns, and reduced appetite. The items were scored 0, 1, or 2, with higher scores indicative of greater degrees of depression. The measure has been proved reliable and valid in Chinese children (Dong et al., 1994; Chen & Li, 2000; Kovacs, 2004). Following the procedure outlined by Kovacs (2004), the average score of the responses was computed. The Cronbach alpha was 0.838 in the present study.

2.3.4. School performance—All the schools in the Jintan school district have a system to record all the students' final grades which are based on their quizzes, midterms, and final exams of each semester. We asked the teacher to rate each child's academic performance based on their last semester's school performance on 3 major subjects (Chinese, Math, and English**)** on a 5-point scale: 1 = very poor (F), 2 = poor (D), 3 = fair (C), 4 = good (B), and 5 = very good (A). We then recoded 4 and 5 points as "good" and 1-3 points as "not good".

2.4. Statistical Analysis

Characteristics of the study sample were summarized by descriptive statistics such as mean, standard deviation (SD), and percentage. A Chi-square test was used to examine the differences in parent- and self-reported SDB between boys and girls. Pearson's product-moment correlation coefficients were calculated to estimate the strength of the linear relationship among SDB symptoms, daytime sleepiness, emotional problems, and school performance. The differences in school performance by SDB symptoms were tested by analysis of variance (ANOVA).

A series of logistic regression analyses were performed to examine the association of SDB symptoms and daytime sleepiness with clinical emotional problems and poor school performance. The 90^{th} percentile of the loneliness or depression scale was used as the cutoff to define clinical levels of loneliness or depression (Liu et al., 1999). Odds ratio (OR) and a 95% Confidence Interval (CI) were used to estimate the strength of the association. In Model 1, we examined the unadjusted association. In Model 2, we adjusted for age, sex, school, father's education, and mother's education. These variables were adjusted based on literature reports of the association of these factors with children's sleeping behavior, behavioral/emotional problems, or school performance (Gaina et al., 2007; Buckhalt et al., 2009). In Models 1 and 2, the factors SDB and daytime sleepiness were entered in the regression models separately. In Model 3, we adjusted for variables in Model 2, in addition to self-reported daytime sleepiness. The statistical mediation of daytime sleepiness was determined based on changes in coefficients of SDB from Model 2 and 3 (Baron and Kenny, 1986; MacKinnon and Dwyer, 1993). All of the analyses were performed using SPSS, Version 20 (Chicago, IL).

3. Results

3.1. Sample characteristics

Of the 3,979 students who were asked to participate in the study and whose parents were asked to complete a parent questionnaire, 3,914 (98.3%) returned the sleep and health questionnaire, and 3,389 (85.2%) had parent-reported sleep data. Of the 3,914 participated students, 52.2% were boys, and the mean age was 10.99 years (SD=0.99). The distribution of fourth, fifth, and sixth grade students was approximately equal (i.e. 1/3 for each grade). More than 60% of parents had high school education or above. Detailed sample characteristics are presented in Table 1.

3.2. Prevalence of SDB symptoms

The prevalence rates of parent- and self-reported SDB were 17.2% and 10.1% for “sometimes” and 8.9% and 5.6% for “usually.” The prevalence rates of individual SDB problems by gender and informant (parent and self) can be found in Table 2. All SDB problems were more prevalent in boys than in girls. For both boys and girls, parents reported more SDB problems than children reported. The agreement between parent- and self-reported SDB was low. The Kappa values were 0.112 for loud snoring, 0.049 for stopped breathing, 0.095 for snorting/gasping, and 0.144 for any SDB problems.

3.3. Bivariate correlations and ANOVA

The bivariate correlations between parent- and self-reported SDB and child daytime sleepiness, emotional problems and school performance are shown in Table 3. Both parent- and self-reported SDB were significantly positively related to child daytime sleepiness, depression, and loneliness and negatively related to school performance on Chinese, Math, and English. Daytime sleepiness was positively related to depression and loneliness and negatively related to school performance on the 3 subjects. Furthermore, the ANOVA results on the differences in school performance by SDB symptoms are presented in Table 4. It represents the distribution of the academic grades among frequency of SDB symptoms, as categorized by no/rarely, sometimes, and usually. The results showed that children who “usually” or “sometimes” experienced SDB symptoms, as reported by both parent and self-report, had lower academic grades.

3.4. Logistic regression

Raw and adjusted odds ratios (OR) of SDB and daytime sleepiness on clinical levels of depression and loneliness are shown in Table 5. Self-reported SDB and daytime sleepiness were associated with increased risks for depression and loneliness independent of age, gender, school district, and parental education. After adjustment for daytime sleepiness in Model 3, the associations between self-reported SDB and depression and loneliness were reduced, especially for the category of “usually” having SDB symptoms, and the association between “usually” having SDB symptoms and depression was no longer significant. As shown in Model 1, parent-reported SDB was also associated with depression and anxiety. However, the associations were not as strong as self-reported SDB and were more likely to be influenced by demographic variables.

The associations between SDB, daytime sleepiness and poor school performance in Chinese, Math, and English are shown in Table 6. In Model 1, both parent- and self-reported SDB and daytime sleepiness were associated with increased odds of poor school performance in all 3 subjects. After adjustment for demographic factors in Model 2, daytime sleepiness remained significant for all 3 subjects and their odds ratios had no marked changes. Self-reported SDB was still significantly associated with poor school performance in the 3 subjects, but their odds ratios had marked decline in Model 2, whereas parent-reported SDB was only significantly associated with poor performance on English. After further adjustment for daytime sleepiness in Model 3, both parent- and self-reported SDB were no longer associated with poor school performance.

4. Discussion

To our knowledge, this is one of the first and largest epidemiological studies on SDB in this community sample of Chinese young children, utilizing both parent- and self-reports. We found that SDB symptoms were more prevalent in boys than in girls. SD symptoms from both parent- and self-reports were significantly associated with daytime sleepiness and increased risk for depression, loneliness, and poor school performance. Finally, in terms of the coefficient changes, our findings indicated that daytime sleepiness partially mediated the relationship between SDB and emotion, and completely mediated the relationship between SDB and school performance. Our findings are similar to those reported by a study done on Taiwanese children (Ting et al., 2011). However, we further extended the study by examining the mediation effect of daytime sleepiness.

The prevalence of SDB symptoms was relatively lower in this sample (approximately 6-9% for children who “usually” displayed symptoms) than rates reported in Western children (Marcus, 2001; Bonuck et al., 2011; Calhoun et al., 2011). Similarly, Li et al. (2010) reported a lower prevalence of habitual snoring (7%) in a large sample of school-aged children in Hong Kong. Western children are cited as having greater rates of obesity and higher body mass index than many Eastern pediatric populations (Wu, 2006), which may in turn contribute to a higher prevalence of SDB symptoms. Additionally, there was an increased prevalence of SDB with age and male gender in our sample, which is consistent with the results in Western samples (Goldstein et al., 2011; Silva et al., 2011) and other Asian samples (Li et al., 2010; Ramli & Samsinah, 2012). Similarly, Setterneri et al. (2012) found a relationship between sadness and daytime sleepiness, but it was stronger in girls than in boys. It's also interesting to note that parents reported more problems than children did, possibly due to children's unawareness of having sleeping problems, such as snoring.

Children with SDB in this study displayed greater likelihood of having emotional problems (including depression and loneliness), which is consistent with findings from previous studies. For example, samples of children have similarly demonstrated a link between SDB and internalizing conditions, such as depression (McLaughlin Crabtree et al., 2004). However, our findings differ from those of O'Brien et al. (O'Brien et al., 2004), whose study found no differences in Child Behavior Checklist (CBCL) scores for both internalizing and externalizing problems, such as depression, social problems, and aggression between children with and without SDB symptoms. While the present study used a large community

sample of children, the comparatively small number of subjects studied in O'Brien et al.'s study may have reduced the power for detecting emotional and behavioral differences (Beebe, 2006).

In this study, SDB symptoms reported by both parent- and self-report are related to poor school performance across all three subjects, including Math, Chinese, and English. These findings have been reported by others. Brockmann et al. (2012a) found that Chilean children aged 7-17 years with habitual snoring had significantly lower school grades in Spanish language and general average school grades. In another study, children with SDB at 5-years-old who received treatment for sleep-associated gas exchange abnormalities showed significant improvements in academic performance after a 12-month intervention relative to the untreated group (Gozal, 1998). However, findings on the correlation between SDB symptoms and cognition in current literature are, thus far, inconsistent. For example, using the mid-term examination scores as a measure of school performance, SDB was not found to be closely associated with poor school performance among Korean elementary students at 9-years-old (Kim et al., 2011). Similar results were reported in a cohort of school-aged children in Australia (Biggs et al., 2014). This study observed a predictive effect of the improvement in obstructive apnea hypopnea index (OAHI), an indicator of SDB severity, on Performance IQ, but not on Verbal IQ or academic ability assessed by Wide Range Achievement Test-3 (WRAT) (Biggs et al., 2014). Our study, on the contrary, used the teacher-proxy measure for school performance in 3 major subjects (Chinese, Math, and English) and found significant correlations. The inconsistency in obtaining statistically significant associations between SDB and school performance in the literature may be due to differences in evaluation measures. Future study with sensitive measure is warranted to confirm our findings.

Our findings also suggested a mediating role of daytime sleepiness between SDB symptoms and outcomes of emotional problems and school performance. Both SDB and daytime sleepiness were significantly predictive of emotional and performance outcomes; meanwhile, the absolute effect size of SDB decreased or disappeared after the mediator daytime sleepiness was taken into account. The findings above indicated that unrestful nocturnal sleep in children with SDB may cause excessive daytime sleepiness, and in turn, affect behavior and emotion regulation as well as school performance. Although the evidence regarding the mediation of daytime sleepiness has been limited in prior research, our findings are in agreement with previous studies that have examined the association of daytime sleepiness with SDB, emotion and academic performance separately. For example, O'Brien et al. (2004) assessed sleep pressure using polysomnography (PSG) and found that children with SDB had more sleep propensity than children in the control groups. Meanwhile, daytime sleepiness was also found to be a significant predictor of mood and affective states (Lau et al., 2013), as well as school performance (Dewald et al., 2010).

The mechanism underlying the complex relationships between SDB, daytime sleepiness, and emotional and academic outcomes have yet to be established. It could be that children with SDB, such as obstructive sleep apnea, have reduced slow wave stability (Kheirandish-Gozal et al., 2007) and impaired slow wave activity dissipation over the course of the night (Biggs et al., 2012), thus affecting the recovery function of sleep and daytime alertness.

Additionally, intermittent hypoxia, which can occur in OSA, can induce hippocampal damage, oxidative stress, and neuronal damage – all of which may be associated with depression, as well as neurocognitive impairment (Urschitz et al., 2004; Feng et al., 2012).

There are a few limitations in this study. First, the present study is cross-sectional, making it impossible to extrapolate long-term outcomes or make any inferences about causal directions. Second, SDB was derived from subjective reports. Given that studies have shown poor correlations between subjective and objective sleep data (Baker et al., 1999), future research with clinical diagnosis from PSG is warranted to confirm our findings. Furthermore, possible confounding factors, such as BMI, sleep duration (Liu et al., 2012a), and low cognition unrelated to sleepiness or SDB, were not included in the study. Despite these limitations, our study used a large sample size and incorporated self-reports from both children and parents. These findings, to our knowledge, are the first to be reported on SDB, emotional functioning, and academic performance among young children in Mainland China.

In conclusion, the current study demonstrated that sleep disordered breathing and daytime sleepiness are associated with emotional problems and poor school performance in a large sample of Chinese children. Findings from this study may have implications for early detection and treatment of SDB and daytime sleepiness to improve children's mental health and academic performance in children. Sleep and affective functioning are intertwined, and improvement in one may reciprocally improve the other. Adequate sleep has been suggested as a protective factor against mental health problems in children and adolescents (Silk et al., 2007), and it may improve mood disturbance. Studies, such as the present one, that provide evidence of a relationship between specific sleep dysfunction and affective outcomes may contribute to a better understanding of the underlying pathophysiology by which sleep is associated with emotional wellbeing.

Acknowledgements

Thanks are extended to the participating children and their families from Jintan City and to the Jintan Cohort Study Group.

Funding Source

All phases of this study were supported by an NIH grant from the National Institute of Environment Health Sciences (NIH/NIEHS, R01-ES018858; K02-ES019878-01), USA.

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Highlights

- SDB symptoms were correlated increased risk for depression and loneliness independent of daytime sleepiness.
- SDB symptoms were associated with poor school performance but not after daytime sleepiness was adjusted.
- This study suggests the importance of early screening and intervention of SDB in child behavioral and cognitive development.

Table 1

Sample characteristics of the children involved in the current study

	N‡	%
Sex	3768	
Male	1966	52.2
Female	1802	47.8
Age, Mean (SD)	3818	10.99 (0.90)
School	3915	
1	1330	34.0
2	1236	31.6
3	906	23.1
4	443	11.3
Grade	3914	
4^{th}	1319	33.7
5^{th}	1261	32.2
6^{th}	1334	34.1
Father's education	3440	
Primary school	182	5.3
Middle school	887	25.8
High school	1211	35.2
College or above	1160	33.7
Mother's education	3434	
Primary school	289	8.4
Middle school	1046	30.5
High school	1159	33.8
College or above	940	27.4

‡Number of students differed across sample characteristics due to missing values.

Table 2

Frequency of Sleep Disordered Breathing in Children by Sex from Parent- and Self-Report

	Boys (%)				Girls (%)				Statistics
	N‡	No/rarely	Sometimes	Usually	N‡	No/rarely	Sometimes	Usually	X^2
Parent report									
Loud snoring	1363	75.3	16.7	8.1	1362	84.3	9.7	6.0	36.07**
Stopped breathing	1268	87.8	5.8	6.4	1300	91.8	3.3	4.9	12.59*
Snorting/gasping	1307	79.3	13.4	7.3	1317	84.1	9.6	6.4	10.90*
Any	1203	68.5	21.9	9.6	1242	79.1	12.6	8.2	41.03**
Self report									
Loud snoring	1737	86.1	8.5	5.4	1615	94.3	4.5	1.2	70.20**
Stopped breathing	1702	92.3	4.3	3.4	1600	95.8	2.8	1.4	19.13**
Snorting/gasping	1714	90.6	5.3	4.1	1627	91.3	6.0	2.7	5.82
Any	1660	80.1	12.7	7.2	1529	88.9	7.3	3.8	46.43**

Any: any of the SDB symptoms in samples with complete data of three SDB items, a proxy to the general SDB status.

*****P value of correlation is < 0.001.**

‡Number of students differed across sample characteristics due to missing values.

***P value of correlation is < 0.05.**

****P value of correlation is < 0.01.**

Table 3

Correlations between SDB, daytime sleepiness, depression, loneliness, and school performance

	N‡	Mean (SD)	PSDB	SSDB	DS	Depression	Loneliness	Chinese	Math
Parent-reported SDB (PSDB) **(any)** [a]	2556	3.66 (1.42)							
Self-reported SDB (SSDB) **(any)** [a]	3395	3.33 (0.91)	0.119***						
Daytime sleepiness(DS)	3374	10.01 (12.38)	0.087***	0.310***					
Depression	3833	18.17 (4.23)	0.110***	0.241***	0.308***				
Loneliness	3857	28.45 (11.26)	0.092***	0.211***	0.248***	0.652***			
Chinese	3616	3.62 (1.03)	−0.052*	−0.127***	−0.067***	−0.272***	−0.272***		
Math	3615	3.65 (1.09)	−0.056**	−0.110***	−0.072***	−0.271***	−0.264***	0.807***	
English	3617	3.68 (1.12)	−0.032	−0.128***	−0.083***	−0.283	−0.275***	0.822***	0.795***

SDB was positively related to child daytime sleepiness, depression, and loneliness and negatively related to grades on Chinese, Math, and English. Daytime sleepiness was positively related to depression and loneliness, and negatively related to grades on the 3 subjects.

‡Number of students differed across sample characteristics due to missing values.

[a]**SDB (any): any of the SDB symptoms in samples with complete data of three SDB items, a proxy to the general SDB status.**

*__P value of correlation is < 0.05.__

**__P value of correlation is < 0.01.__

***__P value of correlation is < 0.001.__

Table 4

School performance by sleep disordered breathing reported by parents and self in Chinese children

	Parent-reported SDB (any) Mean (SD)					Self-reported SDB (any) Mean (SD)				
	No/rarely	**Sometimes**	**Usually**	**F**	**p**	**No/rarely**	**Sometimes**	**Usually**	**F**	**p**
Chinese	3.77±0.98	3.68±1.03	3.56±1.04	6.36	0.002**	3.73±1.00	3.54±1.06	3.32±1.01	19.99	0.00***
Math	3.80±1.05	3.74±1.08	3.56±1.12	7.56	0.001**	3.76±1.06	3.54±1.06	3.32±1.01	17.51	0.00***
English	3.85±1.05	3.74±1.11	3.67±1.14	4.64	0.01*	3.79±1.08	3.58±1.09	3.36±1.09	22.26	0.00***

a. SDB (any): any of the SDB symptoms in samples with complete data of three SDB items; SD, standard deviation;

b. *P value of correlation is < 0.05. **P value of correlation is < 0.01. ***P value of correlation is < 0.001;

c. Academic grades were lower in children who usually or sometimes had self- or parent-report SDB symptoms;

Table 5

Associations of SDB and daytime sleepiness (both parent- and self-report) with depression and loneliness (OR, 95%CI)

	Depression			Loneliness		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Parent-reported SDB **(any)**						
No/rarely	Ref	Ref	Ref	Ref	Ref	Ref
Sometimes	2.10 (1.54-2.85)***	1.72 (1.20-2.47)**	1.63 (1.09-2.43)*	1.59 (1.14-2.21)**	1.54 (1.05-2.24)*	1.45 (0.96-2.21)
Usually	2.03 (1.35-3.05)**	1.74 (0.99-3.05)	1.31 (0.67-2.57)	1.28 (0.80-2.05)	0.98 (0.51-1.88)	1.03 (0.52-2.04)
Daytime sleepiness	1.19 (1.15-1.23)***	1.19 (1.15-1.23)***	1.18 (1.13-1.24)***	1.15 (1.12-1.19)***	1.16 (1.12-1.20)***	1.17 (1.11-1.22)***
Self-reported SDB **(any)**						
No/rarely	Ref	Ref	Ref	Ref	Ref	Ref
Sometimes	2.83 (2.11-3.79)***	2.41 (1.71-3.41)***	1.93 (1.31-2.83)**	1.99 (1.44-2.76)***	1.89 (1.30-2.74)***	1.63 (1.08-2.43)*
Usually	4.27 (3.03-6.01)***	3.27 (2.15-4.98)***	1.47 (0.88-2.46)	4.16 (2.94-5.87)***	3.09 (2.01-4.75)***	1.66 (1.00-2.76)*
Daytime sleepiness#	1.19 (1.15-1.23)***	1.19 (1.15-1.23)***	1.17 (1.13-1.22)***	1.15 (1.12-1.19)***	1.16 (1.12-1.20)***	1.15 (1.10-1.20)***

Model 1 Unadjusted. Model 2 adjusted for age, sex, school, father's education, mother's education. Model 3 adjusted for variables in Model 2 and daytime sleepiness.

SDB: sleep disordered breathing; OR: odds ratio.

Both self- and parent-reported SDB as well as daytime sleepiness were associated with depression and anxiety. In adjusted models, the magnitudes and statistical significance of the associations changed, parent-reported SDB in particular.

#Daytime sleepiness and SDB entered Model 1 and 2 separately.

*P value of correlation is < 0.05.

**P value of correlation is < 0.01.

***P value of correlation is < 0.001.

Table 6

Adjusted associations of SDB and daytime sleepiness by both parent- and self-report with school performance (OR, 95%CI)

	Chinese			Math			
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**
Parent-reported SDB **(any)**							
No/rarely	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Sometimes	1.45 (1.05-2.02) *	1.32 (0.89-1.98)	1.42 (0.91-2.20)	1.32 (0.97-1.80)	1.26 (0.87-1.83)	1.31 (0.86-1.98)	1.73 (1.28-2.33)
Usually	1.62 (1.07-2.43) *	1.24 (0.67-2.30)	1.32 (0.66-2.63)	1.79 (1.24-2.60) **	1.16 (0.67-2.00)	1.31 (0.72-2.40)	1.50 (1.01-2.23)
Daytime sleepiness	1.05 (1.02-1.09) **	1.06 (1.02-1.10) **	1.04 (0.99-1.10)	1.04 (1.01-1.07) *	1.04 (1.00-1.08) *	1.01 (0.96-1.06)	1.07 (1.04-1.10)
Self-reported SDB**(any)**							
No/rarely	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Sometimes	2.03 (1.50-2.75) ***	1.48 (1.01-2.17) *	1.47 (0.97-2.23)	1.60 (1.18-2.17) **	1.24 (0.85-1.82)	1.14 (0.75-1.75)	2.04 (1.53-2.72)
Usually	2.23 (1.52-3.27) ***	1.44 (0.88-2.37)	1.03 (0.57-1.86)	2.14 (1.48-3.08) ***	1.69 (1.08-2.66) *	1.57 (0.94-2.64)	2.31 (1.61-3.31)
Daytime sleepiness#	1.05 (1.02-1.09) **	1.06 (1.02-1.10) **	1.05 (1.00-1.10) *	1.04 (1.01-1.07) *	1.04 (1.00-1.08) *	1.02 (0.98-1.06)	1.07 (1.04-1.10)

Model 1 Unadjusted. Parent- and self-reported SDB as well as daytime sleepiness were associated with poor performance on 3 subjects.

Model 2 adjusted for age, sex, school, father's education, mother's education. Self-reported SDB and daytime sleepiness were associated with poor performance on 3 subjects. Parent-reported SDB was associated with poor performance on English.

Model 3 adjusted for variables in Model 2 and daytime sleepiness. Both parent- and self-reported SDB were no longer associated with school performance.

SDB (any): any of the SDB symptoms in samples with complete data of three SDB items, a proxy to the general SDB status; OR: odds ratio.

#Daytime sleepiness and SDB entered Model 1 and 2 separately.

*P value of correlation is < 0.05.

**P value of correlation is < 0.01.

***P value of correlation is < 0.001.