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Prevalence of sleep problems and their association with inattention/hyperactivity among children aged 6–15 in Taiwan

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SUMMARY This study investigated the 6-month prevalence rates of sleep-related problems and their association with daytime inadvertent napping, inattention, hyperactivity/impulsivity, and oppositional symptoms in children and adolescents. A representative school-based sample of 2463 first to ninth graders was recruited using a multistage sampling method. The instruments included the Sleep Habits Questionnaire (including dyssomnia, parasomnia, sleep schedules, and sleep-disordered breathing), the Chinese Health Questionnaire, and the Chinese versions of the Conners' Parent and Teacher Rating Scales-Revised: Short forms. The informants were mothers and teachers. The linear and nonlinear mixed models were used for statistical analyses and sex and age were controlled in the model. Results showed that the rates of middle insomnia, disturbed circadian rhythm, mouth breathing, and daytime inadvertent napping increased with age; whereas those of bedwetting, bruxism, sleep terrors decreased with age. Dyssomnia, sleep-disordered breathing problems, daytime inadvertent napping, and sleep schedules were related to attention-deficit/hyperactivity disorder (ADHD)-related symptoms as assessed by mothers' and teachers' ratings. Parasomnia was associated with ADHD-related symptoms as assessed by mothers' ratings. Our findings suggest an age trend of sleep problems similar to those found in the literature and the association of daytime inadvertent napping, inattention, hyperactivity/impulsivity, and oppositional symptoms with sleep-related problems.

KEYWORDS children and adolescents, inattention, hyperactivity/impulsivity, prevalence, sleep-related problems

INTRODUCTION

Children's sleep problems, and daytime inattention, hyperactivity, and oppositional/conduct behaviors are parents' major concerns. The prevalence and manifestation of sleep problems and daytime sleepiness may vary with gender (e.g., Gottlieb *et al.*, 2003; Liu *et al.*, 2000; Shang and Gau, 2006; Stein *et al.*, 2001) and developmental stage across the childhood to adolescence (e.g., Gau and Soong, 2003; Kales *et al.*, 1987; Liu *et al.*, 2000; Stein *et al.*, 2001). Despite its importance, much fewer studies have examined the rates, clinical significance, patterns, and behavioral comorbidity of sleep problems from childhood to adolescence (Gau and Soong, 1999; Stein *et al.*, 2001) when compared with adult populations.

Community-based studies have demonstrated that sleep-disorder breathing (SDB) (e.g., Chervin *et al.*, 2002a), snoring (e.g., Gottlieb *et al.*, 2003), and periodic leg movements (PLM) during sleep (Chervin *et al.*, 2002b) at childhood are associated with daytime sleepiness (e.g., Gottlieb *et al.*, 2003), inattention (e.g., Chervin *et al.*, 2002a), hyperactivity (e.g., O'Brien *et al.*, 2003a), academic problems (e.g., Gozal and Pope, 2001; Weissbluth *et al.*, 1983), and aggressive/conduct behaviors (e.g., Ali *et al.*, 1993; Chervin *et al.*, 2003). Clinic-based studies on the relationship between attention-deficit/hyperactivity disorder (ADHD) and sleep-related problems have revealed controversial findings (e.g., Corkum *et al.*, 1998; Crabtree *et al.*, 2003). The most confirmative findings are that PLM are related to the diagnoses of ADHD (e.g., Crabtree *et al.*, 2003), ADHD-related symptoms (e.g., Chervin *et al.*, 2002b),

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particularly hyperactivity (Chervin and Archbold, 2001), or oppositional/conduct symptoms (Chervin *et al*., 2003), which gains strong support from studies using subjective measures (Chervin *et al*., 1997, 2002b) and objective measures (Corkum *et al*., 1998; Crabtree *et al*., 2003; Picchietti *et al*., 1998). Several studies have also demonstrated that children with ADHD or ADHD-related symptoms are more likely to have a longer sleep onset latency at night (e.g., O'Brien *et al*., 2003a; Ring *et al*., 1998), more nocturnal and early morning awakenings (e.g., Crabtree *et al*., 2003), longer (Corkum *et al*., 1999, 2001) or shorter (Day and Abmayr, 1998) average sleep duration, shorter sleep onset latency during daytime (Konofal *et al*., 2001), increased daytime sleepiness (e.g., Crabtree *et al*., 2003), and more frequent episodes of enuresis, bruxism, sleep talking, sleep apnea, and snoring (e.g., Chervin *et al*., 1997, 2002a; Marcotte *et al*., 1998) than those of normally developing children. However, these findings are not supported by some others (e.g., Chervin and Archbold, 2001; Corkum *et al*., 1999; O'Brien *et al*., 2003b).

Although SDB may not be related to hyperactivities during daytime, they have been reported to be an effect modifier of the association between hyperactivity and PLM (Chervin and Archbold, 2001). Moreover, although mild inattention and hyperactivity are associated with snoring and sleep apnea, children with significant ADHD symptoms (O'Brien *et al*., 2003a) or with the diagnosis of ADHD (O'Brien *et al*., 2003b) did not display higher rates of SDB. Therefore, O'Brien *et al*. (2003a) concluded that snoring and sleep apnea may cause mild inattention and hyperactivity during the daytime, but may not be associated with an ADHD diagnosis (O'Brien *et al*., 2003b). The relationship between ADHD and dyssomnias has been considered to be confounded by comorbid oppositional defiant disorder and stimulant medication (Corkum *et al*., 1999; O'Brien *et al*., 2003b). There is no enough evidence to support the association between ADHD-related symptoms and parasomnia (e.g., Corkum *et al*., 1999) except more frequent episodes of enuresis (O'Brien *et al*., 2003a,b).

Studies on childhood and adolescent sleep problems have used either subjective (e.g., Chervin *et al*., 2002a,b; Gottlieb *et al*., 2003) or objective measures (e.g., Konofal *et al*., 2001), or both (Corkum *et al*., 2001; Crabtree *et al*., 2003). Although subjective measures, mainly parent-reported questionnaires (Day and Abmayr, 1998), provided strong evidence supporting an association between ADHD-related symptoms and sleep problems (e.g., Chervin *et al*., 2002a,b, 2003), most of them were not supported by studies using objective measures (Corkum *et al*., 1998, 2001; Crabtree *et al*., 2003; Konofal *et al*., 2001; O'Brien *et al*., 2003a,b). Explanations for this discrepancy include parental report bias, retrospective and prospective assessments, or durations of measures covering a period of time, and one-time measures with regards to subjective and objective measures, respectively (Corkum *et al*., 2001).

Daytime sleepiness, related to inattention and probably hyperactivity, is assumed to be the consequence of sleep restriction (Carskadon *et al*., 1998; Fallone *et al*., 2001), a delayed sleep pattern (e.g., Gau and Soong, 1995, 2003), a short sleep (e.g., Wolfson and Carskadon, 1998), and sleep disruption by SDB (e.g., Ali *et al*., 1993) and dyssomnia (Ferber, 1990). Inattention and hyperactivity may be explained by the sleepy children's attempt to maintain their alertness by attention-shifting and body movement (Fallone *et al*., 2001).

The majority of previous studies are limited by their inclusion of restricted items of sleep problems (e.g., Chervin and Archbold, 2001; Picchietti *et al*., 1998) and the narrow age range (e.g., Gottlieb *et al*., 2003; O'Brien *et al*., 2003a). Moreover, the relationship between ADHD-related symptoms and sleep problems has not been well studied, particularly in non-Western population. In view of this, we conducted a large-scale epidemiological study of sleep problems and their relationship to ADHD-related symptoms using a representative sample from childhood to adolescence.

The objectives of this study were to answer the following three main research questions: (1) Is there an age trend in sleep schedules and the rates of sleep problems across a wide range of ages (6–16)? (2) Is there a gender difference in sleep schedules and the rates of sleep problems? and (3) Are sleep problems and schedules related to daytime inadvertent napping, inattention, hyperactivity/impulsivity, or oppositional symptoms?

METHODS AND SUBJECTS

Participants and procedures

We targeted a representative school-based sample of 2584 grade 1 to grade 9 students in northern Taiwan. There are 204 primary and junior high schools in a total of 12 districts in Taipei city and county. In September 2003, we sent letters to the principals of the Taipei primary and junior high schools, which had at least six classes in each grade, to explain the purpose and procedure of this study. Of the 12 districts, four districts were randomly selected, and the schools targeted. Within each selected district, we randomly selected one primary school (grades 1–6) and one junior high school (grades 7–9). Three classes from each grade level (grade 1–9) were randomly selected. The sample included all the students of the selected 108 classes, with a total of 2584 participants: 1354 (52.4%) boys and 1230 (47.6%) girls, in total.

The Institute Review Board of the Department of Health, Taiwan, approved the ethics of this study prior to multistage sampling. Written informed consent was obtained from each of the study participants, their parents, and their teachers after an explanation of the purpose and procedure of the study, the lack of an obligation to participate in the study, and a reassurance of confidentiality. In February 2004, at the beginning of the spring semester, mothers and teachers completed their versions of the questionnaire at home and at school, respectively. Of 2584 selected subjects, mothers of 2463 student subjects (participation rate = 95.3%) and teachers of all the student participants (participation rate = 100%) consented to this study and completed the questionnaires.

The data of the 2463 subjects with complete assessments by their mothers and teachers were used for data analysis. Any ambiguous response or no response was treated as missing. There was no gender difference between those students whose mothers completed and did not complete the questionnaires ($P = 0.157$). The distributions of the participants were: 275 [male (M): 142; female (F): 133], 265 (M: 135; F: 130), 257 (M: 139; F: 118), 254 (M: 136; F: 118), 286 (M: 147; F: 139), 252 (M: 130; F: 122), 291 (M: 149; F: 142), 297 (M: 155; F: 142), and 286 (M: 150; F: 136) from the first to ninth grades. There was no significant difference in gender distribution across the nine school grade levels. The participants' ages ranged from 6 to 16 years old, with a mean age of 11.6 [standard deviation (SD) = 2.6].

Instruments

Mothers reported on participants' sleep schedules and sleep-related problems on the Chinese version of the Conners' Parent Rating Scale-Revised: Short Form (CPRS-R:S), and the Chinese Health Questionnaire (CHQ). Teachers only reported participants' behaviors on the Chinese version of the Conners' Teacher Rating Scale-Revised: Short Form (CTRS-R:S).

Sleep schedule and sleep-related problems

Items regarding sleep habits and problems were modified from the Sleep Habit Questionnaire (SHQ) used in our previous studies in preschool, kindergarten, elementary and junior high school students (Gau, 2000; Gau and Soong, 2003; Gau *et al.*, 2004; Shang and Gau, 2006) with operational definitions of each sleep problem in accordance with the DSM-IV 'Sleep Disorders', if relevant. The SHQ was designed to survey children's current (past 6 months) sleep-related problems based on maternal reports. These sleep-related problems, which lasted for at least 1 month for the past 6 months, included early insomnia (sleep latency more than half an hour at least three times a week for 1 month), middle insomnia (waking up more than half an hour, at least once per sleep, three times a week for 1 month), disturbed circadian rhythm (different sleep–wake pattern from conventional schedules, i.e., sleep while others awake, and awake while others sleep), PLM, sleep apnea, snoring, noisy snoring, mouth breathing, nightmares, betwetting, sleep talking, bruxism, sleepwalking (DSM-IV criteria), and sleep terrors (DSM-IV criteria). A past history of tonsillectomy or adenoidectomy was also inquired. Binary response (yes, no) was used for reporting on the sleep-related problems and frequent daytime inadvertent napping. Daytime function included daytime inadvertent napping more frequent than that of peers, and the measures of inattention, hyperactivity and oppositional symptoms by the CPRS-R:S and CTRS-R:S.

Chinese versions of the Conners' Parent Rating Scale-Revised: Short Form and the Conners' Teacher Rating Scale-Revised: Short Form

The CPRS-R:S, a 27-item parent-reported rating scale, and the CTRS-R:S, a 28-item teacher-reported rating scale, for the assessment of behavioral symptoms, consist of four subscales: the Oppositional (6 and 5 items), Inattention/Cognitive Problems (6 and 5 items), Hyperactivity/Impulsivity (6 and 7 items), and ADHD-index (12 and 12 items) subscales, respectively (Conners, 1997). Each item is rated on a 4-point Likert scale – 0 for not true at all (never, seldom), 1 for just a little true (occasionally), 2 for pretty much true (often, quite a bit), and 3 for very much true (very often, very frequent).

Prior psychometric studies on both Conners' rating scales have shown that the Chinese versions of CPRS-R:S and CTRS-R:S demonstrated similar factor structures as the English versions with the eigenvalues ranging from 3.02 to 6.24 and 3.84 to 7.49, respectively (Gau *et al.*, 2006) . The Cronbach α for internal consistency ranged from 0.84 to 0.95, and Pearson correlations for test–retest reliability ranged from 0.75 to 0.79 for the Chinese CPRS-R:S (Gau *et al.*, 2006). The Cronbach α for internal consistency ranged from 0.91 to 0.94, and Pearson correlations for test–retest reliability ranged from 0.81 to 0.96 for the Chinese CTRS-R:S (Gau *et al.*, 2006). The Pearson correlation coefficients for parent and teacher agreement on the Conners' rating scales were 0.43 for the Inattention/Cognitive Problems, 0.36 for the Hyperactivity/Impulsivity, 0.18 for the Oppositional subscale, and 0.42 for the ADHD-index (Gau *et al.*, 2006). The tests of the Chinese CPRS-R:S and CTRS-R:S for each subject were purchased from the Multi-Health Systems.

Chinese Health Questionnaire

The CHQ, a 12-item self-administered questionnaire, was modified from the General Health Questionnaire (Goldberg and Williams, 1988). The CHQ measures the domains of anxiety/depression, sleep disturbance, somatic concerns, and interpersonal difficulties. The sum scores of the CHQ range from 0 to 12. This instrument has been widely used to identify those who have minor psychiatric disorders in primary care as well as in community settings (Cheng and Williams, 1986; Chong and Wilkinson, 1989). The Cronbach α for internal consistency of the CHQ was 0.80 in this study. The CHQ score was controlled in the statistical model to minimize any bias derived from maternal reports on the child's behavioral symptoms and sleep-related problems.

Data analysis

The SAS 9.1 was used to conduct the statistical analysis (SAS Institute Inc., Cary, NC, USA). We employed chi-square tests for the contingency tables, with discrete demographic variables and one-way analyses of variance for continuous measures to assess the demographic homogeneity between the two comparison groups as a t-score of the ADHD-index >60 versus a t-score ≤ 60 for the Chinese CPRS-R:S and CTRS-R:S. The t-score is defined as multiplying the z-score by 10 and adding 50 with a mean of 50 and a standard deviation of 10 (t-score = z-score*10 + 50). The mean score of each subscale in this study by sex and school grade levels was used to calculate the t-score.

Because of the possible inflated type I error caused by multiple tests of 16 sleep-related problems assessed in this study, factor analysis was conducted for data reduction. The orthogonal varimax rotation following the principle-axis factor analysis was performed to generate four factors (eigenvalue): (1) parasomnia (2.06) including nightmares, bed-wetting, sleep talking, bruxism, sleepwalking, and sleep terrors; (2) dyssomnia (1.44) including early insomnia, middle insomnia, disturbed circadian rhythm, and PLM; (3) SDB (1.27) including snoring, noise snore, mouth breathing, and sleep apnea; and (4) adenotonsillectomy (1.34) including a past history of tonsillectomy and/or adenoidectomy. The four groups of sleep-related problems were used for data analysis.

The linear and nonlinear mixed models were employed to control for the lack of independence within the same class and school derived from a school-based sample (Singer, 1998). The linear trend for school grade level was tested for each sleep-related problem and the subscales of the two Conners' rating scales as well after departure from the linear trend was rejected using the goodness-of-fit test, by comparing the model treating the school grade level (age) as a categorical variable to the model treating school grade level as a continuous variable. Goodness-of-fit statistics (ΔG) were equal to a -2 logarithm of likelihood for the model, with the variable of interest treated as a linear or ordinal variable minus a -2 logarithm of likelihood for the model, with the variable of interest treated as a categorical variable. ΔG was distributed as a chi-square distribution with 7 degrees of freedom.

The nonlinear mixed model was employed first to examine the association between sleep-related problems and the behavioral syndrome and to test the random intercept effect. If the P value of the t-statistic of the random intercept effect was less than 0.05, indicating that the random intercept was not equal to zero, we used the nonlinear mixed model to obtain the odds ratios (OR) and 95% confidence intervals (CI) for the OR. The student participant's age, gender, and mother's educational levels and psychological distress measured by the CHQ were controlled in the statistical model to decrease potential confounding effects from these variables. The modifying effect from the student participant's age and sex on the association between sleep-related problems and behavioral symptoms was tested first. If there was a significant interaction, the parameter estimate and statistics of the interaction term were presented in the tables and results. Otherwise, the student participant's age and sex were controlled in the models.

RESULTS

Demographic characteristics

Table 1 presents the demographic data of the subjects with either a t-score of the ADHD-index of the CPRS-R:S or that of the CTRS-R:S greater and less than 60. Boys were more prevalent in the group with high t-score. Mothers of the subjects with high t-scores were less educated than their counterparts. There were no differences between the comparison groups defined by the t-score of the two Conners' rating scales in terms of age, birth order, and child rearing history before 3 years old.

The results of gender and age differences in the ADHD-related symptoms in this study has been described explicitly

Table 1 Demographic characteristics by the CPRS-R:S and CTRS-R:S grouping

	ADHD-Index of the CPRS-R:S, t-score, n (%)			*ADHD-Index of the CTRS-R:S, t-score, n (%)*		
	T ≤ *60*; n = *2049*	T > *60*; n = *414*	*Group differences*	T ≤ *60*; n = *2145*	T > *60*; n = *318*	*Group differences*
Gender						
Male	998 (48.7)	285 (68.8)	$\chi^2_1 = 55.61$; $P < 0.0001$	1030 (48.0)	253 (79.6)	$\chi^2_1 = 110.40$; $P < 0.0001$
Female	1051 (51.3)	129 (31.2)		1115 (52.0)	65 (20.4)	
Age (years)						
Mean ± SD	10.8 ± 2.6	10.7 ± 2.7	$F = 0.44$; $P = 0.507$	10.8 ± 2.6	10.6 ± 2.7	$F = 0.26$; $P = 0.609$
Mother's education						
≥College	657 (33.0)	107 (27.0)	$\chi^2_2 = 11.73$; $P = 0.003$	661 (31.7)	103 (33.9)	$\chi^2_2 = 9.38$; $P = 0.009$
Senior high	882 (44.3)	169 (42.7)		941 (45.1)	111 (36.5)	
≤Junior high	453 (22.7)	120 (30.3)		484 (23.2)	90 (29.6)	
Raising experience						
Full time by parents	1134 (58.6)	217 (55.8)	$\chi^2_1 = 1.08$; $P = 0.298$	1186 (58.5)	166 (55.7)	$\chi^2_1 = 0.84$; $P = 0.359$
Other	800 (41.4)	172 (44.2)		841 (41.2)	132 (44.3)	
Birth order						
First child	711 (35.5)	139 (35.0)	$\chi^2_3 = 5.38$; $P = 0.146$	749 (35.7)	102 (33.1)	$\chi^2_3 = 7.79$; $P = 0.051$
Single child	179 (8.9)	50 (12.6)		190 (9.1)	39 (12.7)	
Youngest child	835 (41.6)	157 (39.5)		857 (40.9)	135 (43.8)	
Middle child	281 (14.0)	51 (12.9)		301 (14.3)	32 (10.4)	

CPRS-R:S, Conners' Parent Rating Scale-Revised: Short Form; CTRS-R:S, Conners' Teacher Rating Scale-Revised: Short Form; ADHD, attention-deficit/hyperactivity disorder; T, t-score.

elsewhere (Gau *et al*., 2006). Simply put, compared with the girls, boys scored significantly higher in all the subscales of the two scales except the Oppositional subscale of the CPRS-R:S, in which there was no gender difference at grades 7–9. There was no interaction between gender and the nine school grade levels, with the exception that the linear trend on the Inattention subscale of the CTRS-R:S varied between boys and girls ($P = 0.015$). The linear trend for school grade level in parent-reported hyperactivity decreased over school grade levels for both genders ($P < 0.0001$), but this was not apparent in the teachers' reports ($P > 0.05$). Parent-reported oppositional behaviors increased over school grade levels for girls ($P = 0.007$) rather than for boys ($P > 0.05$). Teacher-reported inattention problems increased over school grade levels only for boys ($P = 0.005$).

Sleep schedules

Regarding sleep schedule, interaction between sex and age, and ADHD-related symptoms were tested first. Results showed that based on the CPRS-R:S, children with high *t*-scores went to bed later on weekends and had greater difference in bed times between weekends and schooldays. The magnitude of these relationships was greater in boys than in girls, and significantly decreased with age (Table 2). There was no other interaction of sex (P values ranging from 0.435 to 0.863) or age (P values ranging from 0.081 to 0.967).

Based on the CTRS-R:S, children with *t*-scores >60 got up later and had a longer nocturnal sleep duration during school days, a shorter nocturnal sleep duration on weekends, and a greater difference in bedtime, less difference in rising time, and less difference in nocturnal sleep between the weekends and schooldays (Table 2). The magnitude of later bedtime on weekend and greater difference in bedtime between weekends and schooldays in children with high *t*-scores was greater in boys than in girls, and significantly decreased with age. The magnitude of shorter nocturnal sleep on weekends in children with high *t*-scores was significantly greater in girls than in boys. The magnitude of less difference in nocturnal sleep duration between weekends and school-days in children with high *t*-scores was greater in girls than in boys, and significantly increased with age. There was no other interaction of sex (P values ranging from 0.310 to 0.764) or age (P values ranging from 0.076 to 0.962). The results of the sleep schedules and number of sleep problems between the two comparison groups based on the *t*-scores of the other three subscales of the two Conners' rating scales were similar to those based on the ADHD-index (data not shown).

Table 2 also summarizes the parameter estimates and P values of sex and age as covariates in the models. Results showed that girls tended to go to bed later on schooldays and weekends and to sleep less on schooldays. In terms of age effect, compared with younger children, older children tended to go to bed later on schooldays and weekends, rise earlier on schooldays and later on weekends, had shorter nocturnal sleep on schooldays, greater difference in rise time and nocturnal sleep between weekends and schooldays.

Age and gender effect on sleep problems and schedules

Table 3 presents the 6-month prevalence rates of sleep problems. A total of 44.5% of subjects suffered from at least one of the sleep problems (sleep talking excluded) assessed in this study. There were linearly increased rates of middle insomnia, disturbed circadian rhythm, mouth breathing, and daytime inadvertent napping from first-graders through ninth-graders. In contrast, the rates of bedwetting, bruxism, and sleep terrors decreased linearly across the nine school grade levels.

Regarding the sleep schedule, we found that student participants tended to go to bed later on schooldays [$F(1, 2448) = 218.57$, $P < 0.001$] and weekends [$F(1, 2448) = 40.57$, $P < 0.001$], have shorter daily sleep hours [$F(1, 2448) = 353.38$, $P < 0.001$], and get up earlier on schooldays [$F(1, 2448) = 13.12$, $P < 0.001$] but later on weekends [$F(1, 2448) = 13.70$, $P < 0.001$] linearly with the increased school grade levels.

There were no gender differences in terms of sleep problems, sleep schedules, and daytime napping, with the exceptions that 5th ($P = 0.014$) and 7th grade boys ($P = 0.007$) were more likely than girls to snore during sleep, and 9th grade girls were more likely than boys to have nightmares ($P = 0.001$). Moreover, girls went to bed later than boys during school days [$F(1, 2448) = 10.66$, $P = 0.004$]. There was no modification effect from gender or age except that an increased rate of middle insomnia with age was more apparent in boys than in girls (Table 3).

Sleep problems and schedules, and daytime sleepiness

Based on univariate analyses, all the individual sleep problems measured in this study significantly increased the risk for daytime inadvertent napping (all $P_s < 0.05$). Regarding sleep schedules, shorter sleep hours, later bedtime, and earlier rising time during schooldays significantly increased the risk for daytime inadvertent napping (all $P_s < 0.05$). We further conducted a backward model selection with four groups of sleep-related problems and sleep schedules as the independent variables, and daytime sleepiness presented by daytime inadvertent napping as the dependent variable. The final model revealed that dyssomnia, parasomnia, SDB, a past history of adenotonsillectomy, shorter sleep duration, later bedtime on schooldays, and increased age significantly increased the risk for daytime sleepiness (Table 4).

To determine any association between sleep duration and sleep problems, we further defined those who slept less than 6 h as short sleepers ($n = 84$) and those who slept longer than 10 h as long sleepers ($n = 92$). There was no difference in the rates of sleep problems between the two sleepers (all $P_s > 0.05$), except that the short sleepers had higher risks for daytime inadvertent napping (OR: 5.9, 95% CI: 1.6–21.5).

Table 2 Sleep schedules by the CPRS-R:S and CTRS-R:S grouping

	ADHD-Index of CPRS-R:S, mean (SD)		*Covariate, β (P value)*		*ADHD-Index of CTRS-R:S, mean (SD)*		*Covariate, β (P value)*	
Variables	T ≤ *60* (*n* = *2047*)	T > *60* (n = *414*)	*Sex*	*Age*	T ≤ *60* (n = *2145*)	T > *60* (n = *318*)	*Sex*	*Age*
School days								
Bed time	12:18 hours (52)	22:15 hours (57)	−6.5 (<0.001)	9.2 (<0.001)	22:18 hours (53)	22:11 hours (54)	−5.6 (0.002)	9.2 (<0.001)
Rise time	06:40 hours (91)	06:40 hours (26)	5.9 (0.084)	−2.8 (<0.001)	06:38 hours (24)	06:52 hours (225)[d]	4.1 (0.232)	−2.7 (<0.001)
Nocturnal sleep	8 h 22 min (106)	8 h 25 min (63)	12.6 (0.001)	−12.3 (<0.001)	8 h 20 min (59)	8 h 41 min (232)[e]	10.0 (0.010)	−12.1 (<0.001)
Weekends								
Bed time*	23:05 hours (53)	23:28 hours (352)[a]	−14.5 (0.018)	8.8 (<0.001)	23:07 hours (54)	23:20 hours (401)	−14.3 (0.021)	8.8 (<0.001)
Rise time	08:52 hours (160)	09:09 hours (398)	−16.0 (0.075)	6.2 (<0.001)	08:58 hours (232)	08:38 hours (81)	−11.8 (0.194)	6.0 (<0.001)
Nocturnal sleep†	9 h 47 min (157)	9 h 41 min (517)	−1.0 (0.927)	−2.6 (0.206)	9 h 50 min (228)	9 h 17 min (395)[f]	3.0 (0.775)	−2.7 (0.173)
Differences between school days and weekends (min)								
Bed time‡	48 (45)	73 (348)[b]	−7.9 (0.190)	−0.9 (0.503)	49 (46)	69 (397)[g]	−8.4 (0.168)	−0.8 (0.563)
Rise time	133 (184)	149 (399)	−21.9 (0.022)	8.9 (<0.001)	140 (232)	106 (240)	−16.0 (0.098)	8.7 (<0.001)
Nocturnal sleep§	85 (185)	76 (521)	−13.6 (0.223)	9.8 (<0.001)	90 (233)	35 (454)[h]	−7.2 (0.521)	9.6 (<0.001)
Number of sleep problems	1.20 (1.50)	2.14 (2.04)[c]	−0.1 (0.198)	0.01 (0.540)	1.30 (1.57)	1.75 (2.07)[i]	−0.05 (0.499)	0.01 (0.557)

CPRS-R:S, Conners' Parent Rating Scale-Revised: Short Form; CTRS-R:S, Conners' Teacher Rating Scale-Revised: Short Form; ADHD, attention-deficit/hyperactivity disorder; *T*, *t*-score.
[a]$F_{(1,2422)} = 9.72$, $P = 0.002$; [b]$F_{(1,2421)} = 10.68$, $P = 0.001$; [c]$F_{(1,2456)} = 118.78$, $P < 0.0001$; [d]$F_{(1,2434)} = 5.21$, $P = 0.023$; [e]$F_{(1,2434)} = 6.95$, $P = 0.008$; [f]$F_{(1,2411)} = 4.58$, $P = 0.002$; [g]$F_{(1,2423)} = 5.74$, $P = 0.017$; [h]$F_{(1,2409)} = 8.85$, $P = 0.003$; [i]$F_{(1,2458)} = 21.52$, $P < 0.0001$.
*Interaction of age for ADHD-Index of CPRS-R:S, $\beta = -7.67$, $F = 6.15$, $P = 0.013$; interaction of sex for ADHD-Index of CPRS-R:S, $\beta = 49.94$, $F = 8.36$, $P = 0.004$; interaction of age for ADHD-Index of CTRS-R:S, $\beta = -11.37$, $F = 10.35$, $P = 0.001$; interaction of sex for ADHD-Index of CTRS-R:S, $\beta = 104.48$, $F = 23.01$, $P < 0.0001$.
†Interaction of sex for ADHD-Index of CPRS-R:S, $\beta = -69.16$, $F = 5.46$, $P = 0.020$; interaction of sex for ADHD-Index of CTRS-R:S, $\beta = -93.75$, $F = 23.01$, $P < 0.0001$.
‡Interaction of age for ADHD-Index of CPRS-R:S, $\beta = -8.99$, $F = 8.67$, $P = 0.003$; interaction of sex for ADHD-Index of CPRS-R:S, $\beta = 46.92$, $F = 7.56$, $P = 0.006$; interaction of age for ADHD-Index of CTRS-R:S, $\beta = -13.13$, $F = 14.10$, $P = 0.0002$; interaction of sex for ADHD-Index of CTRS-R:S, $\beta = 109.97$, $F = 26.22$, $P < 0.0001$.
§Interaction of sex for ADHD-Index of CPRS-R:S, $\beta = -70.00$, $F = 4.99$, $P = 0.026$; interaction of age for ADHD-Index of CTRS-R:S, $\beta = 12.88$, $F = 4.06$, $P = 0.044$; interaction of sex for ADHD-Index of CTRS-R:S, $\beta = -86.42$, $F = 4.73$, $P = 0.030$.

Table 3 Six-month prevalence rates of sleep-related problems across grades 1–9

	Percentage										*Statistics for linear trend*		
Grade	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Total*			
No. of subjects	*275*	*265*	*257*	*254*	*286*	*252*	*291*	*297*	*286*	*2463*	β	χ^2	P *value*
Early insomnia	4.0	2.6	5.1	3.9	5.6	4.4	5.1	6.4	3.9	4.6	–	–	–
Middle insomnia*	0.4	0.4	0.8	2.0	2.1	0.4	1.4	3.4	1.8	1.4	0.18	6.56	0.010
Disturbed circadian rhythm	0.4	0.4	0.0	1.2	2.1	1.2	3.8	4.4	3.2	1.9	0.32	20.91	< 0.0001
Periodic leg movements	7.6	6.8	7.4	6.7	9.4	6.8	11.3	7.7	9.8	8.2	–	–	–
Sleep talking	24.0	26.4	24.1	22.8	22.0	24.2	27.8	21.6	24.5	24.2	–	–	–
Sleep walking	3.3	3.8	5.1	3.9	5.9	4.4	4.5	5.4	4.9	4.6	–	–	–
Sleep terror	8.4	9.1	7.4	5.1	7.7	6.4	3.4	6.1	5.6	6.5	−0.07	5.39	0.020
Nightmare	16.0	18.1	14.8	16.9	17.8	14.7	10.6	15.2	15.7	15.5	–	–	–
Bedwetting	10.2	8.3	3.5	5.5	4.9	2.8	0.7	0.7	0.0	4.0	−0.36	54.15	< 0.0001
Bruxism	25.1	23.8	16.0	17.7	17.1	14.7	14.8	13.5	12.9	17.2	−0.10	23.20	< 0.0001
Mouth breathe	2.6	2.6	2.3	2.8	3.5	4.8	4.5	5.7	4.2	3.7	0.11	6.24	0.013
Snore	7.3	7.6	9.0	7.9	8.4	11.5	7.9	7.1	9.4	8.4	–	–	–
Noisy snore	0.7	1.1	2.0	2.0	1.1	2.4	2.1	1.0	2.8	1.7	–	–	–
Sleep apnea	0.7	0.0	0.4	0.0	0.7	0.0	0.0	0.0	0.4	0.2	–	–	–
Daytime nap	1.8	1.5	1.6	4.7	3.2	3.6	8.3	7.7	10.5	4.9	0.26	40.10	< 0.0001
Tonsillectomy	0.0	0.4	0.0	0.4	0.4	1.6	0.7	1.0	0.0	0.5	–	–	–
Adenoidectomy	0.0	0.4	0.0	0.0	0.4	1.2	0.7	0.0	0.4	0.3	–	–	–

*Interaction between age and sex, $\beta = 0.32$, $\chi^2 = 4.35$, $P = 0.037$.

Table 4 Effects of sleep-related problems and sleep schedules on daytime inadvertent napping

	Daytime inadvertent nap		
Sleep problems	*Yes*	*No*	*OR (95% CI)*
Dyssomnia			
Yes	46/310	264/310	2.9 (1.9–4.6)[c]
No	74/2153	2079/2153	
Parasomnia			
Yes	79/1135	1056/1135	1.9 (1.2–2.9)[b]
No	41/1328	1287/1328	
Sleep-disordered breathing			
Yes	32/284	252/284	2.1 (1.3–3.4)[b]
No	88/2179	2091/2179	
Adenotonsillectomy			
Yes	3/16	13/16	6.4 (1.6–25.4)[b]
No	117/2447	2330/2447	
Sleep duration			0.7 (0.6–0.9)[a]
Bedtime on schooldays			1.5 (1.1–2.0)[b]
Age			1.1 (1.0–1.3)[a]

OR, odds ratio; CI, confidence interval. [a]$P < 0.05$; [b]$P < 0.01$; [c]$P < 0.0001$.

Sleep-related problems and maternal reports on the CPRS-R:S

Table 2 shows that children with either higher scores on the CTRS-R:S or the CPRS-R:S had a higher number of sleep-related problems, which was not influenced by sex or age. Table 5 summarizes the ORs of having a *t*-score > 60 on the four subscales of the CPRS-R:S for the four dimensions of sleep-related problems and daytime inadvertent napping. We found that dyssomina, parasomnia, and SDB increased the degree of inattention, hyperactivity/impulsivity, oppositional symptoms, and ADHD symptoms. Moreover, PLM was significantly associated with all the ADHD-related symptoms (OR ranging from 2.4 to 3.2, all $P_s < 0.0001$). Daytime inadvertent napping was associated with all the ADHD-related symptoms. A past history of adenotonsillectomy did not reveal an association with any of the behavioral syndromes identified by the CPRS-R:S. The magnitude of relationship between dyssomnia and oppositional symptoms was greater in boys than in girls. The magnitudes of associations between daytime inadvertent napping and hyperactivity–impulsivity, oppositional symptoms, and scores of the ADHD-index were greater in boys than in girls and significantly increased with age.

We further tested whether subjects with a *t*-score on the ADHD-index > 70 (extreme ADHD symptoms) had higher rates of sleep problems and different sleep schedules compared with those whose *t*-score ranged between 60 and 70 (mild ADHD symptoms). Results showed that subjects with extreme ADHD symptoms were more likely than subjects with mild ADHD symptoms to have SDB (OR: 1.9, 95% CI: 1.2–3.2), PLM (OR: 2.0, 95% CI: 1.2–3.4), and daytime inadvertent napping (OR: 5.0, 95% CI, 2.7–9.5). Sleep schedules and the other sleep problems were not different between subjects with extreme and mild ADHD symptoms.

Sleep-related problems and teacher's reports on the CTRS-R:S

Table 6 summarizes the ORs of having a *t*-score > 60 on the four subscales of the CTRS-R:S for the four dimensions of sleep-related problems and daytime inadvertent napping. Dyssomnia, SRB, and daytime inadvertent napping were associated with increased scores of all the subscales of the CTRS-R:S. Moreover, PLM were significantly associated with hyperactivity/impulsivity (OR: 1.7, 95% CI: 1.1–2.6), oppositional symptoms (OR: 1.6, 95% CI: 1.1–2.4), and ADHD symptoms (OR: 1.8, 95% CI: 1.2–2.6). The magnitude of

Table 5 Sleep-related problems by the grouping based on the *t*-score of the four subscales of the Chinese CPRS-R:S

CPRS-R:S Sleep-related variables	*Inattention* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*Hy-Im* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*Oppositional* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*ADHD-Index* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*
Dyssomnia*	2.8 (2.0–3.8)[d]	a	a	2.6 (1.9–3.6)[d]	b	c	3.0 (2.3–4.0)[d]	NS	a	3.0 (2.3–4.0)[d]	b	b
Parasomnia	1.6 (1.2–2.1)[c]	NS	d	1.9 (1.5–2.4)[d]	NS	c	1.8 (1.4–2.3)[d]	NS	d	1.7 (1.4–2.1)[d]	NS	d
Sleep-disordered breathing	2.4 (1.7–3.2)[d]	b	NS	2.0 (1.4–2.7)[d]	b	a	2.0 (1.5–2.7)[d]	c	NS	1.8 (1.4–2.5)[d]	b	NS
Adenotonsillectomy	0.9 (0.2–4.3)	NS	NS	1.6 (0.4–6.1)	NS	NS	1.1 (0.3–4.2)	NS	NS	0.7 (0.1–3.2)	NS	NS
Daytime inadvertent nap†	4.1 (2.6–6.3)[d]	NS	d	3.1 (1.9–4.9)[d]	NS	d	2.8 (1.8–4.2)[d]	NS	d	3.2 (2.1–4.9)[d]	NS	d

CPRS-R:S, Conners' Parent Rating Scale-Revised: Short Form; *T*, *t*-score; Hy-Im, hyperactivity/impulsivity; ADHD, attention-deficit/hyperactivity disorder; OR, odds ratio; CI, confidence interval; NS, not significant.

[a]$p < 0.05$; [b]$p < 0.01$; [c]$p < 0.001$; [d]$p < 0.0001$.

*Interaction of sex for Oppositional, $\beta = 0.54$, $\chi^2 = 3.95$, $P = 0.047$.

†Interaction of age for Hy-Im, $\beta = 0.09$, $\chi^2 = 23.87$, $P < 0.0001$; interaction of age for Oppositional, $\beta = 0.09$, $\chi^2 = 23.79$, $P < 0.0001$; interaction of age for ADHD-Index, $\beta = 0.08$, $\chi^2 = 10.11$, $P = 0.002$; interaction of sex for Hy-Im, $\beta = 1.01$, $\chi^2 = 11.07$, $P = 0.0009$; interaction of sex for Oppositional, $\beta = 1.06$, $\chi^2 = 13.32$, $P = 0.0003$; interaction of sex for ADHD-Index, $\beta = 0.69$, $\chi^2 = 4.29$, $P = 0.038$.

Table 6 Sleep-related problems by the grouping based on the *t*-score of the four subscales of the Chinese CTRS-R:S

CTRS-R:S *Sleep-related variables*	*Inattention* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*Hy-Im* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*Oppositional* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*	*ADHD-Index* (T > *60*), *OR (95% CI)*	*Covariate* P *value* *Sex*	*Age*
Dyssomnia	1.4 (1.0–1.9)[a]	NS	a	1.7 (1.2–2.5)[b]	a	b	1.7 (1.2–2.4)[b]	NS	a	1.8 (1.3–2.5)[c]	a	b
Parasomnia*	1.1 (0.9–1.4)	NS	d	1.1 (0.9–1.5)	NS	d	1.1 (0.8–1.4)	NS	d	1.1 (0.8–1.3)	NS	d
Sleep-disordered breathing	1.4 (1.0–1.9)[a]	b	NS	1.5 (1.0–2.1)[a]	b	NS	1.5 (1.1–2.1)[a]	b	NS	1.4 (1.0–2.1)[a]	b	NS
Adenotonsillectomy	0.7 (0.2–3.3)	NS	NS	1.3 (0.3–5.9)	NS	NS	0.5 (0.1–3.5)	NS	NS	0.4 (0.1–3.3)	NS	NS
Daytime inadvertent nap†	2.9 (1.9–4.3)[d]	NS	d	3.2 (2.0–5.4)[d]	NS	d	1.9 (1.1–3.0)[a]	NS	d	3.8 (2.4–5.9)[d]	NS	d

CTRS-R:S, Conners' Teacher Rating Scale-Revised: Short Form; *T*, *t*-score; Hy-Im, hyperactivity/impulsivity; ADHD, attention-deficit/hyperactivity disorder; OR, odds ratio; CI, confidence interval; NS, not significant.

[a]$p < 0.05$; [b]$p < 0.01$; [c]$p < 0.001$; [d]$p < 0.0001$.

*Interaction of sex for Oppositional, $\beta = -0.69$, $\chi^2 = 5.65$, $P = 0.017$.

†Interaction of age for Hy-Im, $\beta = 0.06$, $\chi^2 = 11.94$, $P = 0.0005$; interaction of age for Oppositional, $\beta = 0.08$, $\chi^2 = 18.80$, $P < 0.0001$; interaction of age for ADHD-Index, $\beta = 0.04$, $\chi^2 = 4.70$, $P = 0.030$; interaction of sex for Oppositional, $\beta = 0.62$, $\chi^2 = 4.77$, $P = 0.029$.

relationship between parasomnia and oppositional symptoms was greater in girls than in boys. The magnitudes of associations between daytime inadvertent napping and hyperactivity–impulsivity, oppositional symptoms, and scores of the ADHD-index significantly increased with age. The magnitude of associations between daytime inadvertent napping and oppositional symptoms was greater in boys than in girls.

Similar to the analysis on the CPRS-R:S, we further tested whether subjects with extreme ADHD symptoms had higher rates of sleep problems and different sleep schedules compared to subjects with mild ADHD symptoms based on the *t*-score of the ADHD-index of the CTRS-R:S. Results showed that subjects with extreme ADHD symptoms were more likely than subjects with mild ADHD symptoms to rise later ($P < 0.007$) and sleep longer on schooldays ($P < 0.018$). Neither sleep problems nor daytime sleepiness were found to be different between subjects with extreme and mild ADHD symptoms (all $P_s > 0.05$).

Tables 5 and 6 also summarize the significance of sex and age as covariates in the models using the CPRS-R:S and CTRS-R:S, respectively. Simply put, dyssomina and daytime inadvertent napping increased and parasomnia decreased with ages. SDB was more prevalent in boys than girls.

DISCUSSION

Researchers in pediatric sleep and behavioral medicine have long investigated the relationship between ADHD-related symptoms and sleep-related problems, yielding inconsistent findings as the ADHD-related symptoms associated with some sleep problems (Ali *et al*., 1996; Corkum *et al*., 1998; O'Brien *et al*., 2003a) but not with some other sleep problems (Chervin and Archbold, 2001; Corkum *et al*., 1998, 1999; O'Brien *et al*., 2003b). Besides, there has been little information regarding the age trend of sleep problems in one study using a sample with a wide age range and covering a variety of sleep problems. This study attempted to replicate such studies in a non-Western population by using a large-scale representative sample and valid instruments to answer the research questions proposed herein. The major findings of this study are that rates of bedwetting, bruxism, and sleep terrors decreased with age; whereas those of middle insomnia, disturbed circadian rhythm, mouth breathing, and daytime inadvertent napping increased with age. Sleep problems, delayed sleep schedules, and short sleep were related to daytime inadvertent napping. Dyssomnia, SDB, and daytime sleepiness were related to mother's and teacher's reports on child's symptoms of inattention, and hyperactivity/impulsivity. However, parasomnia was only related to mother's reports on ADHD-related symptoms.

The prevalence of childhood sleep problems in Taiwan differs from that of several similar prevalence studies. Similar to Simonds and Parraga's (1982) study, this study covers a wide range of age groups but other studies cover a narrower age range among the children (e.g., Blader *et al*., 1997; Paavonen *et al*., 2000; Stein *et al*., 2001). Contradictory to the finding of lower rates of sleep problems in Chinese school children than in Western children (Liu *et al*., 2000), the 6-month prevalence rates of sleep problems in Taiwan are higher than those in most Western studies. Moreover, this study demonstrates rates of difficulties going to sleep ('early insomnia' in this study) similar to Fisher *et al*.'s (1989) studies but lower than others (e.g., Blader *et al*., 1997; Paavonen *et al*., 2000; Stein *et al*., 2001); and rates of snoring similar to Simonds and Parraga's (1982) study but lower than others (O'Brien *et al*., 2003a; Smedje *et al*., 1999). This study displays similar rates of nightmares (Kahn *et al*., 1989), sleep terrors (Stein *et al*., 2001), and sleepwalking (Kahn *et al*., 1989; Paavonen *et al*., 2000), but higher rates of nightmares (e.g., Fisher *et al*., 1989; Stein *et al*., 2001), sleep talking (e.g., Kahn *et al*., 1989), bruxism (e.g., Smedje *et al*., 1999), sleep terrors (e.g., Blader *et al*., 1997; Paavonen *et al*., 2000; Smedje *et al*., 1999), and sleepwalking (e.g., Smedje *et al*., 1999; Stein *et al*., 2001) than those of other studies. The rate of enuresis is similar to some studies (e.g., Fisher *et al*., 1989), but lower than two studies (Paavonen *et al*., 2000; Stein *et al*., 2001), and higher than others (e.g., Blader *et al*., 1997). The rate of daytime sleepiness measured by daytime inadvertent napping is lower than that of Stein *et al*.'s (2001) study, but higher than others (Simonds and Parraga, 1982; Smedje *et al*., 1999). Discrepancy in findings may be due to different criteria and definitions of sleep problems, different sources and age distribution of subjects, and cultural-ethnic differences. The rate of DSM-IV-defined middle insomnia in this study is much lower than that of waking at night found in others (e.g., Fisher *et al*., 1989; Paavonen *et al*., 2000; Stein *et al*., 2001), simply because of the stricter criteria used in this study. This explanation can also be applied to the lower rate of early insomnia in this study. Shorter nocturnal sleep among children and adolescents in Taiwan (Gau and Soong, 1995) than Western Countries may be attributable for increased daytime sleepiness found in this study. As it is common that children sleep in the same room with their parents in Taiwan, it is likely that parents observe their children's bruxism, sleep talking, sleep terrors, and sleepwalking more frequently than Western parents do.

Consistent with our previous studies (Gau and Soong, 1995, 2003) and others (Carskadon *et al*., 1998), our findings confirmed the later bedtime and rising time, and shorter sleep duration in adolescence than childhood. Concerning the developmental change in the occurrence of childhood sleep problems, our results, like others (Gau and Soong, 2003; Liu *et al*., 2000; Shang and Gau, 2006), showed that the rates of middle insomnia, disturbed sleep–wake patterns, mouth breathing, and daytime inadvertent napping increased across ages 6–16 years. In contrast, the rates of sleep terrors, bedwetting, and bruxism decreased across the nine school grade levels. The notion of a reduction in the rates of some sleep problems is similar to some studies (Kales *et al*., 1980a,b; Mahowald and Rosen, 1990), which reported that sleep terrors occurred most commonly at 5–6 years of age (Abe *et al*., 1984), then declined over age, and that the rate of enuresis diminished with maturation (e.g., Kales *et al*., 1987; Shang and Gau, 2006; Stein *et al*., 2001).

Our findings, similar to others, did not support a gender difference in the rates of childhood sleep problems except SDB (e.g., Ahlberg *et al*., 2004; Chervin *et al*., 2002a; Gottlieb *et al*., 2003). Accordingly, our findings suggest that sleep problems are related to developmental stage rather than gender difference among children and adolescents.

Daytime sleepiness, defined by daytime inadvertent napping, was one of the outcome measures of this study. Our results further confirm that sleep problems (Ali *et al*., 1993; Ferber, 1990), delayed sleep schedules (e.g., Gau and Soong, 1995, 2003), and short sleep (e.g., Wolfson and Carskadon, 1998) were related to daytime inadvertent napping. Combined with other studies showing an age trend of sleep schedules (e.g., Carskadon *et al*., 1998) and increased rates of some sleep-related problems (e.g., Liu *et al*., 2000) from childhood to adolescence, our studies support a transition of delayed sleep–wake patterns, and increased dyssomnia from childhood to adolescence, which subsequently increased daytime inadvertent napping with age during adolescence (Gau and Soong, 1995, 2003). This study also confirms that daytime inadvertent napping is associated with inattention/hyperactivity (e.g., Chervin *et al*., 2002a; Gottlieb *et al*., 2003), and oppositional symptoms (Chervin *et al*., 2003).

The sleep disruption and episodic hypoxia that characterize sleep apnea may lead to the alterations in the neurochemical substrate of the prefrontal cortex and resultant executive dysfunction, which may manifest an ADHD-like phenotype (Barkley, 1997). Although this cross-sectional study cannot prove the causality between sleep problems and ADHD-related symptoms, most previous studies suggest that SDB and other sleep problems may be a cause rather than an effect of inattention and hyperactivity (Chervin and Archbold, 2001; Chervin *et al*., 1997). This assumption has been further supported by the reduction in inattention and hyperactivity after the amelioration of SDB by adenotonsillectomy (Ali *et al*., 1996; Gozal and Pope, 2001), which may justify our negative finding of no relationship between a past history of adenotonsillectomy and current ADHD-related symptoms. Moreover, sleep deprivation and disruption impaired executive functioning, resulting in the similar cognitive, behavioral profile of children with ADHD, which is supported by the findings of a reduction in ADHD symptoms following the treatment of sleep problems (Dahl and Lewin, 2002; Walters *et al*., 2000). These findings imply the importance of the assessment of sleep problems among children with ADHD-related symptoms.

The possible explanations for association between sleep problems and daytime inattention/hyperactivities include (1) that sleep problems result in daytime behavioral problems, e.g., PLM during sleep could induce sleep disruption, resulting in daytime sleepiness and inattention/hyperactivity (Chervin and Archbold, 2001); (2) that behavioral problems result in sleep difficulties, e.g., challenging behaviors of ADHD children may increase the likelihood of bedtime resistance (Corkum *et al*., 2001) and trouble sleep; and (3) that sleep problems and irregular sleep schedules and inattention/hyperactivities may share the same common vulnerability in brain dysfunctioning (Chervin *et al*., 2002b; Wolfson and Carskadon, 1998), e.g., a shorter daytime sleep latency in ADHD children suggests that a deficit in alertness affects not only daytime inattention/hyperactivities, but also sleep-related problems (Konofal *et al*., 2001).

Corresponding to other studies, we found that the inattention, hyperactivity, and oppositional symptoms (Chervin *et al*., 2003) were related to the majority of sleep problems, such as, dyssomina (e.g., Corkum *et al*., 2001; Crabtree *et al*., 2003), PLM (e.g., Chervin *et al*., 1997, 2002b, 2003; Picchietti *et al*., 1998), SDB (e.g., Ali *et al*., 1996; Chervin *et al*., 1997, 2002a; O'Brien *et al*., 2003a), and daytime inadvertent napping (e.g., Chervin *et al*., 2002a; Gottlieb *et al*., 2003; Konofal *et al*., 2001). This study demonstrates discrepancy in the association of ADHD-related symptoms with parasomnia between mothers' and teachers' ratings. The main explanation for this discrepancy should be the informant effect, as literature has documented a low agreement between parent and teacher reports on children's ADHD symptoms (Al-Awad and Sonuga-Barke, 2002; Gau *et al*., 2006; Roussos *et al*., 1999) mainly due to behavioral observation in different settings. Findings from this study indicate that mothers' reports on ADHD symptoms may be more sensitive to detect the association between the degree of behavioral symptoms and the presence of parasomnia.

There has been controversy about whether ADHD children are more likely than normal children to have sleep problems and abnormal sleep schedules (O'Brien *et al*., 2003a). Like Corkum *et al*.'s (1999, 2001) studies, we found that children with ADHD-related symptoms had longer sleep durations, a finding contradictory to some other studies (Day and Abmayr, 1998; Marcotte *et al*., 1998). Although no psychiatric interview was conducted to make the diagnosis of ADHD, we attempted to examine whether children with extreme inattention and hyperactivity had higher odds of having sleep problems and daytime sleepiness, compared to those with mild inattention and hyperactivity. We found that children with extreme ADHD symptoms were more likely than those with mild ADHD symptoms to have higher risks only for SBD, PLM, and daytime inadvertent napping on maternal ratings. Hence, this study provides evidence to support some recent studies (O'Brien *et al*., 2003a,b) that although sleep problems are related to ADHD symptoms, extreme ADHD symptoms, which may suggest the diagnosis of ADHD, do not necessarily increase the risk for sleep problems in general over the mild ADHD symptoms. However, the possible higher rates of SDB and PLM, and differences in some sleep schedules of children with extreme ADHD symptoms, call for further investigation of the sleep problems and sleep patterns in pediatric patients with ADHD.

STRENGTHS

Several features of this study constitute its methodological strengths. First, the subjects consisted of a large-scale representative school-based sample across 6–16-year-old children with a satisfactory response rate. The reason for the full cooperation from the teachers and parents was that Gau, SS has been working on school-based studies for more than a decade and has provided extensive school consultation and clinical service in primary and high schools in Taipei (e.g., Gau and Soong, 1995; Gau *et al*., 2004). Second, the measures covering a wide range of sleep problems, and the reliable and valid instruments used to measure ADHD-related symptoms (Gau *et al*., 2006) allow us to examine the differential rates and patterns of sleep problems in different developmental stages, and the relationship of ADHD-related symptoms and sleep problems. Third, this study is one of the few studies investigating the relationship between ADHD-related symptoms and a wide range of sleep problems using a community sample. Lastly, linear and nonlinear mixed models were employed to adjust for lack of independence within the same class arising from the multistage sampling method for a school-based sample.

LIMITATIONS

Several methodological limitations should be considered when interpreting our findings. First, although the participants were enrolled from a representative sample in Taipei, the external validity of this study in broader Taiwanese or Chinese populations needs to be examined. Second, lack of psychiatric diagnosis of ADHD prevents us from resolving previous controversial findings on the relationship between the diagnosis of ADHD and sleep problems, which should be the next step. Third, the age range of the sample was quite wide and some of the items on the CPRS and CTRS (e.g., items related to homework, arithmetic or reading/writing) may have had less relevance for the youngest participants than the older. The potential lack of response equivalence over the age range may be another reason for the low concordance between mother- and teacher-reported symptoms. Additional validation studies of the instruments versus psychiatric diagnoses should investigate changes in sensitivity of the scales as a function of age. Another limitation is that the information about sleep problems, daytime inadvertent napping, and sleep schedules was obtained from mothers without confirmation by student participants, and that of behavioral symptoms was reported by both mothers and teachers. A self-administered measure, which has been commonly used in sleep studies related to ADHD (Corkum *et al.*, 1998), demonstrates its merits of use in that it is feasible, easy, and inexpensive to conduct a study with a large sample size using self-reported measures, which in addition, do not have interviewer biases compared with interview-based measures (Gau and Soong, 2003).

IMPLICATIONS

The literature review and our findings together imply the importance of viewing sleep problems in the developmental context and of knowing the association between sleep problems and daytime inadvertent napping, inattention, hyperactivity, and oppositional symptoms. The same sleep problem may be developmentally normal at some age but abnormal when it occurs at a different age. For example, school-age children with sleep terrors/sleepwalking may not have significant physical or mental problems; however, adolescents with sleep terrors/sleepwalking tend to have mental problems (Gau and Soong, 1999). Therefore, healthcare providers should ask different questions and employ different assessments of sleep problems, based on the pediatric patients' developmental stages.

In addition, findings from this study imply that sleep problems and unstable sleep schedules were significantly associated with inattention and hyperactivity. Our findings also suggest a high possibility that daytime inadvertent napping, inattention, hyperactivity, and poor temper control may be the consequence of insomnia, SDB, or disturbed sleep–wake patterns. Accordingly, a health professional should assess sleep-related problems in children with ADHD-related symptoms, in addition to the detailed symptoms of ADHD. It is particularly important to conduct a comprehensive assessment of sleep problems for those children whose behavioral symptoms do not reach the diagnostic criteria for ADHD and ADHD children who have daytime inadvertent napping.

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