Sleep Problems and Disorders among Adolescents with Persistent and Subthreshold Attention-deficit/Hyperactivity Disorders

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Study Objectives: To investigate the sleep schedules, problems, and disorders among adolescents with persistent attention-deficit/hyperactivity disorder (ADHD) and those with partially remitted ADHD symptoms.
Design: A case-control study.
Setting: National Taiwan University and schools in Taipei
Patients or Participants: The sample included 281 adolescents (male, 85.4%; 145 with persistent ADHD, 136 with subthreshold ADHD), aged 11 to 17, who were diagnosed with ADHD, according to DSM-IV criteria, at the mean age of 6.7 years (SD = 3.0) and 185 unaffected control subjects.
Interventions: N/A.
Measurements and Results: We conducted psychiatric interviews of participants and their mothers using the Chinese Kiddie-Schedule for Affective Disorders and Schizophrenia-Epidemiology version for making the diagnoses of ADHD, other psychiatric disorders, and sleep problems or disorders. We also collected the medication treatment data and parent and teacher reports of ADHD-related symptoms. Our results showed that adolescents with a childhood diagnosis of ADHD according to DSM-IV criteria, regardless of persistent ADHD, were more likely to have current and lifetime sleep problems and sleep disorders according to DSM-IV (insomnia, sleep terrors, nightmares, bruxism, and snoring). The presence of at least 1 psychiatric comorbid condition increased the risks for insomnia and nightmares. The use of methylphenidate was not associated with further increased risk of sleep problems, except bruxism.
Conclusions: Our findings support a relationship between ADHD and sleep problems, which can be partially explained by the psychiatric comorbidities, but did not support a disturbed sleep schedule. Our study suggests that mental health professionals should screen for sleep problems and psychiatric comorbidities among adolescents with a childhood diagnosis of ADHD regardless of the severity of current ADHD symptoms.
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ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) IS AMONG THE MOST COMMON NEUROPSYCHIATRIC DISORDERS, ESTIMATED TO AFFECT 5% to 10% of children and adolescents in Western countries[1] and 7.5% in Taiwan.[2] Its association with sleep problems[3-5] is one of major concerns in clinical practice. Symptoms and consequences of ADHD and sleep problems frequently overlap, and some primary sleep disorders are found to be associated with inattention[6] and hyperactivity,[6,7] which are often mistaken for the symptoms seen in ADHD[6,7] and also cause behavioral problems[8] and impaired academic performance.[9]

There are controversial findings about whether children with ADHD[5,10] or ADHD-related symptoms[6,11] are more likely to have different sleep patterns[5,10] and sleep problems,[5,6,11] as compared with normally developing children. Studies based on parent reports almost universally demonstrate increased sleep problems in children with ADHD,[4,12] whereas most objective measures fail to demonstrate significant differences.[10,12,13] Among sleep-related problems, periodic limb movement disorder is related to ADHD-related symptoms[6] and the ADHD diagnosis;[14,15] sleep-related breathing disorder is associated with ADHD-related symptoms[7,11,16] but may not be associated with the ADHD diagnosis.[15]

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Some studies suggest that the use of medication, especially psychostimulants, and other psychiatric comorbidities contribute to sleep problems in children with ADHD.[3,5,17] Psychostimulants have effects on sleep onset,[18] night awakenings,[3] sleep duration,[3,19] and the rate of dyssomnias.[5] In terms of psychiatric comorbidities, sleep problems are more common in children with depression,[20] bipolar disorders,[21] anxiety disorders,[3,5] Tourette's disorder,[22] and oppositional defiant disorder.[5] These psychiatric disorders are more likely to develop in children with ADHD.[23] Confounding factors, such as psychiatric comorbidities and medication use,[3,5,17,24] need to be well controlled in studies to provide a more accurate estimate of the association between ADHD and sleep problems.

To the best of our knowledge, few studies have paid careful attention to the confounding variables derived from psychiatric comorbidities[3,5,24,25] and use of medication.[3,5,25] Nonmedicated children with ADHD had longer sleep duration on weekdays by parents' reports in most studies[5] and had significantly longer sleep-onset latency and a more irregular sleep pattern obtained by actigraphy, which cannot be explained by comorbid oppositional defiant disorder.[25] However, the association between dyssomnias and ADHD may disappear after controlling for oppositional defiant disorder and use of medication.[5] Mick and colleagues[3] also reported that the association between ADHD and a variety of sleep problems become less evident after adjusting for comorbid psychopathology or use of medication. Sleep-related involuntary movements is indeed associated with ADHD, but it is more highly associated with comorbid anxiety.[5] In contrast, there is no evidence supporting the association between parasomnias and ADHD in children[4,5] and adults.[26] In summary, few studies have focused on the association between

ADHD and a wide range of sleep problems, and even sleep disorders, under such cautious methodologic consideration.

Our previous studies have demonstrated the association between ADHD-related symptoms and a wide range of sleep problems in children,[4] adolescents,[4] and young adults[26]; however, they are limited by no psychiatric interviews to make the diagnosis of ADHD and other psychiatric disorders and no controlling for confounding factors such as psychiatric comorbid conditions and use of medications. In view of this, we conducted this study using both clinical interviews and standardized psychiatric interviews to diagnose ADHD, sleep disorders, and other psychiatric disorders according to DSM-IV criteria, and rating scales and questionnaires to assess ADHD-related symptoms and sleep problems. The objectives of the present study were to determine the relationship among ADHD symptoms or diagnosis, sleep schedules, and sleep problems or disorders after controlling for the potential confounding factors and to explore whether adolescents with a childhood diagnosis of ADHD and currently persistent ADHD have more sleep problems or disorders than do adolescents with a childhood diagnosis of ADHD and currently subthreshold ADHD symptoms.

METHOD

Participants

We recruited 281 consecutive patients (male, 86.2%) aged 10 to 17 years, who were clinically diagnosed with ADHD according to DSM-IV criteria at the mean age of 6.7 years (SD = 3.0) and had ADHD symptoms at adolescence, mainly from National Taiwan University Hospital, Taipei (n = 240). The clinical diagnosis was made by board-certificated child psychiatrists with extensive clinical research experience, who obtained information from parent and child interviews, observation of the child's behaviors, and rating scales reported by parents and teachers. The first assessment took around 1 hour and a half to 2 hours. The final clinical diagnosis was made usually after at least 3 visits of assessment. The childhood diagnosis of ADHD was confirmed by the psychiatric interviews of the participants and their parents using the Chinese version of the Kiddie epidemiologic version of the Schedule for Affective Disorders and Schizophrenia (K-SADS-E) before recruitment at the mean age of 12.9 years (SD = 1.5). Thereafter, the participants and parents received the K-SADS-E for current (past 6-month) ADHD and lifetime and current diagnosis of other psychiatric disorders. The patients who had psychosis, autism spectrum disorders, or a full-scale IQ score less than 80 were excluded.

The control subjects, who were assessed as not having ADHD at the age of 6 to 8 years nor at adolescence using the Chinese K-SADS-E interviews at the mean age of 12.9 (SD = 1.5), were recruited from the same school district of the patients with ADHD, yielding 186 control subjects.

Measures

The K-SADS-E

The K-SADS-E is a semistructured interview scale for the systematic assessment of both past and current episodes of psychiatric disorders in children and adolescents. Development of the Chinese K-SADS-E was completed by the Child Psychiatry Research Group in Taiwan.[27] This included a 2-stage translation and modification of several items with psycholinguistic equivalents relevant to the Taiwanese culture and further modification to meet the DSM-IV diagnostic criteria.[28] Previous studies have shown that the Chinese K-SADS-E is a reliable and valid instrument to assess child psychiatric disorders[28]and sleep disorders[27] according to DSM-IV criteria and has been used extensively in a variety of studies regarding childhood mental disorders in Taiwan.[27-30] In this study, the internal consistency (Cronbach α) for the 3 dimensions of ADHD at home and school settings was good for adolescent interviews (α ranging from 0.67 for impulsivity at school and follow-up to 0.90 for inattention at home and baseline) and was satisfactory for mother interviews (α ranging from 0.78 for impulsivity at school and follow-up to 0.94 for inattention at school and baseline). The internal consistency of the total scores of the ADHD section in the K-SADS-E was satisfactory, ranging from 0.92 to 0.95.

Chinese Version of the Conners' Parent Rating Scale-Revised: Short form and Conners' Teacher Rating Scale-Revised: Short form

The Chinese version of the Conners' Parent Rating Scale-Revised: Short form (CPRS-R: S), a 27-item parent-reported rating scale, consists of 3 factor-derived subscales (those with the highest loadings on the CPRS-R: long form) and the ADHD index.[31,32] The 3 subscales are Inattention/Cognitive Problems (6 items), Hyperactivity/Impulsivity (6 items), and Oppositional (6 items). The ADHD-index (12 items) is used to assess children and adolescents at risk for ADHD based on diagnostic criteria of DSM-IV, rather than factor analysis.[31] Likewise, the Conners' Teacher Rating Scale-Revised: Short form (CTRS-R: S), a 28-item teacher-reported rating scale, also consists of 3 subscales and the ADHD-index (12 items). The 3 subscales are Oppositional (5 items), Inattention/Cognitive Problems (5 items), and Hyperactivity/Impulsivity (7 items) and the ADHD-index (12 items).[31,33] Each item on both scales is rated on a 4-point Likert scale—0 for never, seldom; 1 for occasionally; 2 for often, quite a bit; and 3 for very often, very frequently).[31] The Chinese versions of the CPRS-R: S and CTRS-R: S have been found to be reliable and valid instruments for measuring ADHD-related symptoms in Taiwan.[34,35]

Sleep Variables

The sleep variables consisted of sleep problems measured by the Sleep Disturbance Questionnaire[4]; DSM-IV–defined sleep disorders such as primary insomnia, primary hypersomnia, circadian rhythm sleep disorder, sleep terror disorder, sleepwalking disorder, and nightmare disorders included in the Chinese K-SADS-E interview; and sleep schedules,[36] including weekday sleep duration, weekend sleep duration, trouble sleeping, and the frequency of daytime naps based on adolescent reports. The frequency of inadvertent daytime napping was rated on a 4-point scale: 1 for never, 2 for once to twice per month, 3 for once to twice per week, and 4 for almost every day.

Interviewer Training

Four interviewers (YC Lai, HY Luo, WL Tseng, CM Lee) who majored in psychology and psychiatric nursing had received 1-year full-time intensive clinical and research training in child and adolescent psychiatry before the Chinese K-SADS-E interview training by SS Gau. All 4 interviewers reached over 90% agreement of all mental disorders assessed by the K-SADS-E (mean ± SD ranging from 98.25 ± 1.91 to 99.38 ± 1.06) against the rating of each item in the K-SADS-E by SS Gau for 30 clinical subjects before implementation of this study. The interrater reliability of the Chinese K-SADS-E between SS Gau and the 4 interviewers using 12 subjects was satisfactory for all mental disorders with generalized κ for each diagnosis ranging from 0.86 to 1.00. The K-SADS-E interviews of parents and children at follow-up were audiotaped periodically and monitored by SS Gau, who was blind to the personal information of the participants, to ensure the quality of interviews and to make the psychiatric diagnoses based on the K-SADS-E interviews of the participants and their parents.

Best-Estimate Diagnoses

The first author, SS Gau, got her training in best estimate[37] for diagnoses in her doctoral study at Yale. The best estimate of each diagnostic category was made by SS Gau, who was blind to the diagnostic status and name of the participant and who was not involved in direct K-SADS-E interviews of any of the participants or their parents at follow-up. The diagnosis was made based on the K-SADS-E interviews of participants and their mothers, medical records, and teachers' reports. The diagnostic coding was categorized into definite (reaching full DSM-IV diagnostic criteria), probable (either not reaching full DSM-IV symptoms criteria but more than half or no functional impairment), possible (some symptoms but no impairment), and no diagnosis. For mental disorders including sleep disorders other than ADHD, those patients who got a rating as definite or probable by best estimate were categorized as having a particular psychiatric disorder.

Persistent and Subthreshold ADHD

Of the original 296 patients with ADHD who were clinically diagnosed with ADHD according to DSM-IV criteria at childhood and confirmed by the Chinese K-SADS-E interview, 145 (49.0%), 136 (45.9%), and 15 (5.1%) were categorized as having persistent ADHD, subthreshold ADHD, and non-ADHD at adolescence, respectively. Persistent ADHD was defined as both parent and participant K-SADS-E interviews reached the definite ADHD at adolescence. Two conditions were categorized as subthreshold ADHD: (1) either mother or youth K-SADS-E interviews, but not both, reached definite ADHD at adolescence and (2) both reached possible or probable ADHD. No ADHD was defined as either one reached possible ADHD and the other had no ADHD or neither had ADHD. The 15 patients who were categorized as having no ADHD were excluded from data analysis, yielding 281 participants in the ADHD group.

Procedures

The Research Ethics Committee of National Taiwan University Hospital approved this study prior to the implementation of this study. Written informed consent was obtained from both parents and children. All of the participants received the Wechsler Intelligence Scale for Children-3rd edition to exclude those who had an IQ less than 80. All of the adolescent participants and their parents were interviewed independently by separate well-trained interviewers who made the child's psychiatric diagnoses according to DSM-IV criteria at baseline first before recruitment and currently (past 6 months) using the Chinese K-SADS-E. The sleep problems and disorders were integrated into the K-SADS-E interviews to obtain diagnosis of sleep disorders according to DSM-IV criteria. The information about medication history was obtained by interviewing the participants and their parents and was confirmed by medical records of prescription.

Data Analyses

We conducted data analysis using the SAS 9.1 (SAS Institute Inc., Cary, NC). The comparison groups were (1) adolescents who had a childhood diagnosis of ADHD and currently persistent ADHD; (2) adolescents who had a childhood diagnosis of ADHD and currently subthreshold ADHD; and (3) control subjects without a lifetime diagnosis of ADHD. The descriptive results are displayed as frequency and percentage and compared by χ^2 test; for continuous variables, mean and SD and analysis of variance are shown.

We used analysis of covariance (ANCOVA) with age, sex, parent education, psychiatric comorbid condition, and current use of medication as covariates to compare the sleep schedules and ADHD-related symptoms severity among the 3 groups. We used the Bonferroni method to adjust P values for the multiple comparisons among the 3 groups in posthoc analysis. Logistic regression model was used to compare the rates of sleep problems and disorders among the 3 groups. Odds ratio (OR) and 95% confidence intervals (CI) were computed. For all the analyses, we started from the 5-way interactions (age * sex * medication * comorbidity * group). We found that none of the 5-way, 4-way, or 3-way interactions was significant. For the majority of statistical models, there were no 2-way interactions between age, sex, medication, and sleep problems or disorders.

RESULTS

Sample Description

Table 1 presents the demographics and study variables for the 3 groups. The 2 ADHD groups had more males than did the control group. The total number of the parent- and youth-reported ADHD symptoms at home and school settings measured by the K-SADS-E interviews and total ADHD index scores of CPRS-R:S and CTRS-R:S were significantly highest in adolescents with persistent ADHD group, followed by the adolescents with subthreshold ADHD group, and then the control subjects, who had the lowest scores (all adjusted P values < 0.01, Table 1). There was no difference between the 2 ADHD groups in the

Table 1—Sample Description

	Persistent ADHD (n = 145)	Subthreshold ADHD (n = 136)	Control subjects (n = 185)	Statistics	
				χ^2 / F value	P value
Sex, male, n (%)[a]	125 (86.2)	115 (84.6)	134 (72.4)	$\chi^2_2 = 11.98$	0.003
Age, mean ± SD	12.8 ± 1.5	12.9 ± 1.6	12.9 ± 1.5	F = 0.29	0.749
Daytime napping (%)					
Never	33.0	34.3	44.1	$\chi^2_6 = 8.40$	0.210
1-2/month	30.9	30.1	34.2		
1-2/week	24.5	28.8	16.2		
Almost every day	11.7	6.9	5.4		
K-SADS-E scores of the 18 DSM-IV ADHD symptoms (both home and school settings)[b]					
Parent report (0-36)	26.0 ± 6.2	20.3 ± 8.2	2.5 ± 4.8	F = 588.13	< 0.001
Child report (0-36)	23.3 ± 6.0	13.0 ± 7.4	1.8 ± 3.0	F = 624.74	< 0.001
Self-administered questionnaire[b]					
CPRS-R:S, ADHD Index (0-36)	23.3 ± 6.7	20.4 ± 6.9	4.2 ± 4.3	F = 410.4	< 0.001
CTRS-R:S, ADHD Index (0-36)	18.8 ± 8.6	15.9 ± 8.4	2.8 ± 5.3	F = 159.2	< 0.001
Methylphenidate, n (%)					
Current use	77 (53.1)	68 (50.0)	—	$\chi^2 = 0.85$	0.357
Ever use	129 (89.0) (n = 124)	116 (85.3) (n = 111)	—	$\chi^2 = 0.27$	0.603
Duration in months, mean ± SD	19.5 ± 21.1	20.4 ± 21.9	—	F = 0.12	0.735

ADHD refers to attention-deficit/hyperactivity disorder; n, number of cases; K-SADS-E, the Chinese version of the Kiddie epidemiologic version of the Schedule for Affective Disorders and Schizophrenia; K-SADS-E scores, sum scores, ranging from 0 to 36, of the presence of 18 ADHD symptoms shown in DSM-IV criteria at home (0-18) and school (0-18) settings; CPRS-R:S, the Chinese version of Conners' parent rating scale-revised: short form; CTRS-R:S, the Chinese version of Conners' teacher rating scale-revised: short from. [a]Higher proportion of male subjects in both ADHD groups (P = 0.003, 0.011) than the control group but no gender difference between persistent ADHD and subthreshold ADHD. [b]Using the the Bonferroni method to adjust P values for the comparisons among the three groups in post-hoc analysis, the scores differences were Persistent ADHD > Subthreshold ADHD > control subjects at adjusted P values less than 0.01 level.

rates of ever and current use of methylphenidate and the duration of methylphenidate treatment (Table 1).

There were lower proportion of mothers (48.3% vs 52.3%, $\chi^2 = 9.02$, df = 2, P = 0.011) and fathers (56.7% vs 62.2%, $\chi^2 = 15.36$, df = 2, P = 0.005) who had college degrees or higher in the ADHD group than in the control group. There were no differences in the current ages (fathers, P = 0.624; mothers, P = 0.141), household with 2 parents (P = 0.055), and job types of the mothers (P = 163) and fathers (P = 0.230) between the ADHD and control groups.

Sleep Schedules by 3 Groups

Adolescents with persistent ADHD had a longer nocturnal sleep and greater differences in bedtime between weekends and weekdays than did the other 2 groups (Table 2). There was no difference in other parameters of sleep schedule and daytime napping measured in this study.

Sleep Problems and Sleep Disorders by 3 Groups

Table 3 displays the sleep problems and current and lifetime DSM-IV sleep disorders for adolescents with persistent ADHD, adolescents with subthreshold ADHD, and normal control subjects. The 2 ADHD groups were more likely than the control subjects to have problems of early insomnia, middle insomnia, sleep terrors, bruxism, and snoring. There were significant differences among the 3 groups in rates of snoring, with the highest rates in adolescents with persistent ADHD, followed by those with subthreshold ADHD, and control subjects. Adolescents with persistent ADHD were more likely to have sleep talking than were the other 2 groups. Hypersomnia and nightmare problems were more prevalent in adolescents with subthreshold ADHD than in the control subjects.

Regarding sleep disorders, the 2 ADHD groups were more likely than the control subjects to suffer from current primary insomnia and sleep terror disorder and to have had a lifetime incidence of primary insomnia. Adolescents with persistent ADHD had a higher likelihood than the controls of having lifetime sleepwalking disorder. Adolescents with subthreshold ADHD were more likely than the control subjects to have current sleepwalking disorder and lifetime primary hypersomnia and nightmare disorder.

Association Between Sleep Disorders and ADHD-related Symptoms

Table 4 presents the mean scores of the parent- and teacher-reported ADHD-related symptoms between subjects with a particular sleep disorder and those currently without this sleep disorder. We found that adolescents with primary insomnia and nightmare disorders had higher scores in the subscales and total scores of the CPRS-R:S and CTRS-R:S, except that there was no association between primary insomnia and teacher-reported hyperactivity and oppositional symptoms and there was no relationship between nightmare disorders and parent-reported hyperactivity and oppositional symptoms. Moreover, adolescents with primary hypersomnia had greater teacher-reported hyper-

Table 2—Sleep Schedules by Adolescents with Persistent ADHD, Adolescents with Subthreshold ADHD, and the Control Subjects

	Persistent ADHD (n = 145)	Sub-threshold ADHD (n = 136)	Control subjects (n = 185)	F value	Comparison
Weekdays					
Bed time†	10:36 pm (54)	10:42 pm (54)	10:54 pm (48)	2.64	—
Rise time†	6:48 am (48)	6:42 am (30)	6:42 am (30)	1.25	—
Sleep duration§	8h 12m (72)	8h 00m (60)	7h 48m (60)	3.96[a]	Persistent ADHD > Control
Weekends					
Bed time†	11:42 pm (90)	11:42 pm (66)	11:30 pm (60)	1.34	—
Rise time†	9:24 am (96)	9:18 am (102)	8:54 am (102)	2.78	—
Sleep duration§	9h 42m (96)	9h 42m (90)	9h 30m (108)	0.79	—
Difference between weekend and weekdays (in minutes)					
Bed time	66 (84)	54 (60)	48 (60)	6.29[b]	Persistent ADHD > Control
Rise time	156 (108)	156 (102)	138 (102)	1.60	—
Sleep duration	90 (108)	102 (96)	102 (114)	0.44	—
Daytime napping	2.2 ± 1.0	2.1 ± 1.0	1.8 ± 0.9	3.22	—

ADHD refers to attention-deficit/hyperactivity disorder. †Means of bedtime and rise time expressed by timetables and SD expressed in minutes. §Means expressed by hours (h) and minutes (m) and SD expressed by minutes. P value: a for $P < 0.05$, b for $P < 0.01$.

activity and oppositional symptoms than their counterparts. There were higher scores in adolescents with sleepwalking disorder on the subscales and total score of the CPRS-R:S, except for the inattention subscale in adolescents with sleep terror disorder on hyperactivity/impulsivity subscale of the CPRS-R:S.

Effect of Age, Sex, Methylphenidate Use and Comorbidity

Examining the effect of child age and sex and father's education level on the risks for sleep problems and disorders in the whole sample, we found that the rates of problems of delayed sleep-wake schedules (OR = 1.5, 95% CI = 1.0-2.1) and hypersomnia (OR = 1.6, 95% CI = 1.1-2.3) and the rates of current (OR = 1.8, 95% CI = 1.0-3.0) and lifetime (OR = 1.8, 95% CI = 1.2-2.9) circadian rhythm disorder increased with age and the rates of sleepwalking symptoms (OR = 0.7, 95% CI = 0.6-0.9) and disorder (OR = 0.8, 95% CI = 0.6-0.9) decreased with age. There was no sex difference in the rates of sleep problems and disorders except that the rates of nightmare (OR = 0.5, 95% CI = 0.3-0.8) and lifetime nightmare disorder (OR = 0.5, 95% CI = 0.3-0.9) were more prevalent in girls than in boys; snoring more prevalent in boys than in girls (OR = 1.8, 95% CI = 1.1-3.0). There was no relationship between parent educational level and sleep problems or disorders ($P > 0.05$).

We also evaluated the effect of methylphenidate and comorbidity on the risks for sleep problems and disorders. The presence of at least 1 psychiatric comorbid condition in adolescents with either persistent ADHD or subthreshold ADHD increased the risks for symptoms of early insomnia (OR = 4.1, 95% CI = 1.8-9.4), middle insomnia (OR = 6.9, 95% CI = 1.6-29.7), nightmare (OR = 5.0, 95% CI = 2.0-12.2) and current and lifetime diagnosis of primary insomnia (OR = 5.0, 95% CI = 1.7-14.4; and OR = 6.1, 95% CI = 2.1-17.5, respectively), and nightmare disorder (OR = 3.7, 95% CI = 1.1-12.9; OR = 5.1, 95% CI = 2.1-12.4) according to DSM-IV criteria. Treatment with methylphenidate did not have any effect on the sleep problems or disorders ($P > 0.05$) except for an increased risk for bruxism (OR = 1.67, 95% CI = 1.03-2.68).

DISCUSSION

The current study is among the few studies that employed clinical and psychiatric interviews of the adolescent participants and their parents to make diagnoses of psychiatric disorders and sleep disorders of the participants according to DSM-IV criteria and controlled both the psychiatric comorbidities and the use of medication for treating ADHD (methylphenidate, the only medication in Taiwan while this study was conducted in 2005 and 2006). The major findings were that adolescents with a childhood diagnosis of ADHD, whether their current ADHD symptoms met DSM-IV full criteria or not, had more current and lifetime sleep problems than did the controls; whereas the rates of the sleep problems and sleep disorders (insomnia, sleep terrors, sleepwalking, nightmares, and snoring) were very similar in these 2 ADHD groups. These findings indicate that the association between ADHD and sleep problems cannot be solely explained by the severity of current ADHD symptoms but may also include the existence of lifetime ADHD diagnoses. The significant relationship between several sleep problems or disorders and ADHD cannot be explained fully by demographic characteristics, psychiatric comorbid conditions, or use of methylphenidate.

It is still controversial whether adolescents with ADHD are more likely than control subjects to have abnormal sleep schedules. Although most studies using objective measures have not supported a different sleep duration in children with ADHD,[10,12,13] consistent with findings from parental reports,[5,14,38] our results demonstrated longer sleep durations in adolescents with persistent ADHD, as compared with the control subjects. This relationship cannot be explained by the confounding effects from sex, age, parental characteristics, comorbidity, or medication.

Table 3—Sleep Problems and Sleep Disorders by Adolescents with Persistent ADHD, Adolescents with Subthreshold ADHD, and Unaffected Control Subjects

Sleep Problems	Persistent ADHD n (%)	Subthreshold ADHD n (%)	Control subjects n (%)	OR (95% CI)		
				Persistent ADHD vs Control subjects	Subthreshold ADHD vs Control subjects	Persistent ADHD vs Subthreshold ADHD
Symptoms	**(n = 145)**	**(n = 136)**	**(n = 185)**			
Early insomnia	38 (26.2)	31 (22.8)	22 (11.9)	2.6 (1.5-4.7)[b]	2.2 (1.2-4.0)[a]	1.2 (0.7-2.1)
Middle insomnia	19 (13.1)	16 (11.8)	8 (4.3)	3.3 (1.4-7.9)[b]	3.0 (1.2-7.1)[a]	1.1 (0.6-2.3)
Hypersomnia	3 (2.1)	7 (5.2)	1 (0.5)	3.9 (0.4-37.8)	10.0 (1.2-82.1)[a]	0.4 (0.1-1.5)
Sleep-Wake Schedule	3 (2.1)	6 (4.4)	2 (1.1)	1.9 (0.3-11.7)	4.2 (0.8-21.3)	0.5 (0.1-1.9)
Sleep Terror†	17 (11.7)	15 (11.0)	6 (3.3)	3.9 (1.5-10.3)[b]	3.7 (1.4-9.8)[b]	1.1 (0.5-2.2)
Sleepwalking†	21 (14.5)	18 (13.2)	19 (10.3)	1.5 (0.8-2.9)	1.3 (0.7-2.6)	1.1 (0.6-2.2)
Sleep-talking†	96 (66.2)	67 (49.3)	75 (40.8)	2.9 (1.8-4.5)[d]	1.4 (0.9-2.2)	2.0 (1.3-3.3)[b]
Nightmare	32 (22.1)	34 (25.0)	28 (15.1)	1.6 (0.9-2.8)	1.9 (1.1-3.3)[a]	0.9 (0.5-1.5)
Bruxism†	74 (51.0)	54 (39.7)	36 (19.6)	4.3 (2.6-7.0)[d]	2.7 (1.6-4.5)[d]	1.6 (1.0-2.5)
Snoring†	84 (57.9)	59 (43.4)	52 (28.3)	3.5 (2.2-5.5)[d]	2.0 (1.2-3.1)[b]	1.8 (1.1-2.9)[b]
Current Sleep Disorders						
Primary Insomnia	27 (18.8)	22 (16.4)	13 (7.0)	3.1 (1.5-6.2)[b]	2.6 (1.3-5.4)[b]	1.2 (0.6-2.2)
Primary Hypersomnia	3 (2.1)	1 (0.7)	0 (0)	0.083*	0.422*	2.9 (0.3-27.8)
Circadian Rhythm Sleep Disorder	1 (0.7)	3 (2.2)	1 (0.5)	1.3 (0.1-20.8)	4.2 (0.4-40.7)	0.3 (0.1-3.0)
Sleep Terror Disorder†	4 (2.8)	4 (3.0)	0 (0)	0.036*	0.031*	0.9 (0.2-3.8)
Sleepwalking Disorder†	5 (3.5)	7 (5.2)	2 (1.1)	3.3 (0.6-17.1)	5.0 (1.0-24.5)	0.7 (0.2-2.1)
Nightmare Disorder	15 (10.4)	15 (11.1)	10 (5.4)	2.0 (0.9-4.7)	2.2 (1.0-5.0)	0.9 (0.4-2.0)
Lifetime Sleep Disorders						
Primary Insomnia	32 (22.2)	25 (18.5)	19 (10.3)	2.5 (1.4-4.6)[b]	2.0 (1.0-3.8)[a]	1.3 (0.7-2.3)
Primary Hypersomnia	3 (2.1)	4 (3.0)	0 (0)	0.083*	0.031*	0.7 (0.2-3.2)
Circadian Rhythm Sleep Disorder	2 (1.4)	5 (3.7)	1 (0.5)	2.6 (0.2-28.9)	7.1 (0.8-61.3)	0.4 (0.1-1.9)
Sleep Terror Disorder†	16 (11.0)	15 (11.1)	10 (5.4)	2.2 (1.0-4.9)	2.2 (1.0-5.0)	1.0 (0.5-2.1)
Sleepwalking Disorder†	25 (17.2)	18 (13.3)	17 (9.2)	2.1 (1.1-4.0)	1.5 (0.8-3.1)	1.4 (0.7-2.6)
Nightmare Disorder	32 (22.2)	34 (25.2)	29 (15.7)	1.5 (0.9-2.7)	1.8 (1.0-3.2)[a]	0.9 (0.5-1.5)

ADHD refers to attention-deficit/hyperactivity disorder. *Fisher exact P value. †Presence of a sleep disorder decided by either positive response by youth or mother report at the psychiatric interview. P value: a for $P < 0.05$, b for $P < 0.01$, c for $P < 0.001$, d for $P < 0.0001$

Increased rates of unstable sleep schedules in individuals with ADHD may partially explain our finding of greater differences in bedtime between weekends and weekdays in adolescents with persistent ADHD than in the control subjects. This explanation obtains support from some studies showing an increased intraindividual day-to-day variability using actigraphic monitoring in children with ADHD.[25,39] Studies have assumed that, if individuals with ADHD have medication holidays on weekends, the psychostimulant effect of delayed sleep onset decreases on weekends,[3,19,40] leading to decreased difference in bedtime between weekends and weekdays. Lack of information about drug holidays in this study has impeded our investigation of the relationship between medication holidays and sleep schedules in ADHD. We recommend that future studies obtain the needed data on medication holidays.

Similar to others,[41,42] we found that the 2 ADHD groups were more likely to have problems of early insomnia, middle insomnia, sleep terrors, bruxism, snoring, current primary insomnia, sleep terror disorder, and lifetime primary insomnia. Despite many studies reporting increased sleep problems in children and adolescents with ADHD,[41,42] no study has examined the relationship between sleep problems and the severity of current ADHD symptoms in patients with ADHD. It is noteworthy that previous studies had only compared children and adolescents with ADHD with control subjects,[41,42] so we are unable to differentiate whether sleep problems are associated with ADHD symptoms or are just intrinsic within subjects with ADHD. Although adolescents with childhood ADHD had higher rates of sleep problems or disorders than those without ADHD, adolescents with persistent ADHD symptoms did not differ much from those with subthreshold ADHD symptoms as far as most sleep problems or disorders are concerned. Consistent with our prior finding in Taiwanese young adults,[26] these findings imply that most sleep problems might be considered not only as state markers, but also trait markers in subjects with ADHD.

In addition to the well-known association of sleep-disordered breathing and periodic leg movement with inattention and hyperactivity,[6,8,43] our results and others [4,14,38,44] lend strong evidence to support the association between several sleep disorders and ADHD-related symptoms. Further controlling for demographics, treatment with methylphenidate and the comorbidities in the models make our findings even more convincing.

The relationship of each sleep disorder with the dimensions of ADHD-related symptoms was discordant between mothers' and teachers' ratings. This discrepancy has been reported in

Table 4—Association between ADHD-Related Symptoms and Sleep Disorders

	Primary Insomnia			Primary Hypersomnia			Sleep Terror Disorder†			Sleepwalking Disorder†			Nightmare Disorder		
	No	Yes	F value	No	Yes	F value	No	Yes	F value	No	Yes	F value	No	Yes	F value
CPRS-R:S	**(n = 347)**	**(n = 55)**		**(n = 398)**	**(n = 4)**		**(n = 395)**	**(n = 7)**		**(n = 389)**	**(n = 13)**		**(n = 368)**	**(n = 34)**	
Inattention	58.3	66.5	12.55[c]	59.5	55.6	0.23	59.3	66.3	1.30	59.2	67.9	3.74	58.8	66.1	6.40[a]
	(15.8)	(16.1)		(16.1)	(12.0)		(16.1)	(13.2)		(16.1)	(15.3)		(16.0)	(15.9)	
Hyperactivity	55.2	62.4	10.89[b]	56.2	58.4	0.08	56.0	69.0	5.10[a]	55.9	67.0	6.93[b]	55.9	60.0	2.32
	(14.8)	(16.1)		(15.2)	(6.8)		(15.2)	(10.1)		(15.0)	(16.6)		(14.9)	(17.6)	
Oppositional	53.7	60.1	9.52[b]	54.6	52.5	0.09	54.5	60.1	1.05	54.3	63.1	4.62[a]	54.2	58.5	2.76
	(14.2)	(15.0)		(14.5)	(4.8)		(14.5)	(12.5)		(14.5)	(11.8)		(14.5)	(14.3)	
ADHD Index	57.0	64.8	12.93[c]	58.1	58.7	0.01	57.9	65.1	1.51	57.7	67.9	5.68[a]	57.5	64.0	5.70[a]
	(15.1)	(14.3)		(15.3)	(8.0)		(15.3)	(9.1)		(15.1)	(14.8)		(15.2)	(14.7)	
Total	57.9	66.4	13.25[c]	59.1	58.1	0.01	58.9	69.2	2.76	58.7	69.7	5.74[a]	58.5	64.8	4.61[a]
	(16.1)	(16.0)		(16.4)	(6.3)		(16.3)	(12.0)		(16.2)	(14.9)		(16.2)	(16.3)	
CTRS-R:S	(N = 287)	(N = 38)		(N = 323)	(N = 3)		(N = 321)	(N = 5)		(N = 314)	(N = 12)		(N = 302)	(N = 24)	
Inattention	53.0	58.0	7.01[b]	53.6	55.6	0.10	53.6	54.5	0.04	53.5	56.7	0.98	53.1	59.9	8.55[b]
	(10.9)	(11.7)		(11.1)	(13.9)		(11.1)	(13.4)		(11.1)	(10.6)		(10.8)	(13.2)	
Hyperactivity	55.8	60.5	3.79	56.1	76.5	6.21[a]	56.2	59.0	0.19	56.1	60.5	1.09	55.4	67.5	16.85[d]
	(14.2)	(14.2)		(14.0)	(26.3)		(14.2)	(16.1)		(14.2)	(15.1)		(13.5)	(17.9)	
Oppositional	52.6	56.0	2.14	52.7	82.0	15.40[c]	53.0	54.7	0.09	53.0	53.7	0.03	52.3	61.5	11.32[c]
	(12.9)	(14.6)		(12.6)	(33.2)		(13.0)	(19.3)		(13.1)	(14.0)		(11.9)	(22.2)	
ADHD Index	57.2	63.4	6.19[a]	57.7	74.0	3.72	57.9	59.7	0.08	57.6	65.0	2.98	57.1	68.2	13.42[c]
	(14.5)	(14.1)		(14.5)	(15.3)		(14.6)	(14.8)		(14.6)	(14.6)		(14.1)	(16.8)	
Total	57.5	62.7	4.35[a]	57.9	70.7	2.31	58.0	62.5	0.48	57.8	46.4	2.44	57.2	68.3	13.53[c]
	(14.5)	(13.1)		(14.5)	(9.1)		(14.4)	(18.6)		(14.5)	(13.0)		(14.0)	(16.3)	

Data are presented as mean ± SD. ADHD refers to attention-deficit/hyperactivity disorder; CPRS-R:S, the Chinese version of the Conners parent rating scale-revised: short form; CTRS-R:S, the Chinese version of the Conners teacher rating scale-revised: short from.
P value: a for $P < 0.05$, b for $P < 0.01$, c for $P < 0.001$, d for $P < 0.0001$

many other studies[45,46] and could be explained by the informant effects due to observations of behavior symptoms in different settings.[47] Mothers may be more sensitive to ADHD-related symptoms in the presence of primary insomnia, sleep terror disorder, or sleepwalking disorder, whereas teachers may be more sensitive to ADHD symptoms in the presence of primary hypersomnia and nightmare disorder. Our findings suggest that the associations of primary insomnia and nightmare disorder with ADHD symptoms are more pervasive in different settings because of agreement between mothers' and teachers' reports.

Concerning the age effects, our results, similar to others',[4,48-50] showed that the rates of delayed sleep-wake pattern and current and lifetime circadian rhythm disorder increases with ages; however, increased hypersomnia with age is a novel finding. Consistent with the previous studies,[51,52] the rates of symptoms and lifetime sleepwalking decreased with age.

Corresponding to other findings,[4,53] we did not find sex difference in most of the sleep problems and disorders, except the higher rates of nightmare in girls[54,55] and higher rates of snoring in boys.[11] The latter might be related to an increased rate of sleep-disordered breathing in boys.[16]

Most studies have reported that psychostimulants influence sleep patterns and lead to dyssomnia based on objective measures but may not have effects on parasomnias.[3,5,56,57] However, similar to Corkum et al's findings based on a questionnaire,[58] we did not find such associations of current use of methylphenidate with dyssomnia or with sleep schedules based on parental and youth reports (P values ranging from 0.096 to 0.985). Although the current study is one of the first to systemically evaluate the effect of methylphenidate on each specific sleep problem, the interpretation of a negative association between methylphenidate treatment and sleep problems should be conservative because methylphenidate treatment was not designed to be randomly assigned in our study, so confounding self-selective factors, such as ADHD status and comorbidity, may determine continued medication use.[59]

Our findings of the influence of psychiatric comorbidities on the risk of sleep disorders lend evidence to support our hypothesis and those from other studies.[5,27] Our findings suggest that, compared with other psychiatric comorbidities, the contribution of psychostimulants to the sleep problems and disorders in adolescents with ADHD seems to be relatively slight. To manage ADHD adolescents with sleep problems, we need to pay more attention to screen for other psychiatric comorbidities, in addition to considering the side effect of the psychostimulants.

Methodologic Considerations

There are several methodologic strengths in this study. First, the clinical interviews performed by experienced board-certified child psychiatrists and confirmed by the K-SADS-E interviews of the adolescent participants and their parents allow us to obtain accurate diagnoses of ADHD, sleep disorders, and other psychiatric disorders. Second, we carefully controlled the possible confounding factors to make our interpretation of the association between ADHD and sleep problems or disorders more convincing. Third, this is the first study to investigate the association between each dimension of the ADHD-related symptoms dimensions and several sleep disorders. Fourth, by using the approach of comparing persistent ADHD and subthreshold ADHD, we obtained more knowledge about the effects of childhood diagnosis of ADHD and current ADHD symptoms on sleep problems and disorders.

The current study is limited by questionable external validity, lack of objective measures, and no knowledge about medical problems. Clinic-based samples of subjects with ADHD limit the generalization of our findings to community subjects. Sleep schedules and problems or disorders were assessed based on subjective measures rather than objective measures, such

as polysomnography or actigraphy[56,58,60]; therefore, we are not able to compare our findings with the results of studies using objective measures of sleep problems. Moreover, we did not include restless leg syndrome or sleep apnea syndrome in our study because the literature has provided abundant evidence for their association with ADHD symptoms.[6,11] Last, lack of information about medical problems might confound our results and prevent us from examining whether medical conditions have an effect on ADHD symptoms and sleep disorders. However, adolescents in our study were studying at school during these assessments, so we assume that the majority of them were in fair physical condition and did not have severe or systemic disease.

Implications

Combining our results and several lines of data, there is strong evidence supporting the associations between ADHD symptoms or diagnosis and sleep problems or disorders and the effects of psychiatric comorbidity on sleep problems or disorders. We, therefore, recommend that mental health professionals assess sleep problems and other psychiatric disorders among adolescents with a childhood diagnosis of ADHD regardless of the severity of current ADHD symptoms because adolescents with subthreshold ADHD symptoms may have a risk of sleep problems that is similar to that of adolescents with persistent ADHD. Regarding the assessments and treatment for ADHD adolescents with sleep problems, screening for other psychiatric comorbidities is as necessary as assessments of the side effects of medication, such as psychostimulants.

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