Association Between Sleep Problems and Symptoms of Attention-Deficit/Hyperactivity Disorder in Young Adults

Susan S.F. Gau, MD, PhD[1,2]; Ronald C. Kessler, PhD[3]; Wan-Ling Tseng, BS[1]; Yu-Yu Wu, MD[4]; Yen-Nan Chiu, MD[2]; Chin-Bin Yeh, MD[5,6]; Hai-Gwo Hwu, MD[1,2]

[1]Department of Psychiatry, College of Medicine, National Taiwan University, Taipei, Taiwan; [2]Department of Psychiatry, National Taiwan University Hospital, Taipei, Taiwan; [3]Department of Health Care Policy, Harvard Medical School, Boston, MA; [4]Department of Child Psychiatry, Chang Gung Memorial Hospital, Tao-Yuan, Taiwan; [5]Division of Child and Adolescent Psychiatry, Department of Psychiatry, Tri-Service General Hospital, Taipei, Taiwan; [6]Division of Psychiatry, National Defense Medical School, Taipei, Taiwan

Study Objective: To examine the association between sleep-related problems and symptoms of attention-deficit/hyperactivity disorder (ADHD) in a community sample of young adults in Taiwan.

Design: A college-based cross-sectional survey.

Participants: Two thousand two hundred eighty-four first-year college students (aged 18-20) in a university in Taiwan.

Measurements and Results: Each student completed a questionnaire regarding sleep schedule (self-estimated total sleep duration and sleep need), sleep problems (dyssomnia, parasomnia, and snoring), and the Chinese version of the Adult ADHD Self-Report Scale. Subjects were grouped separately for the inattention and hyperactivity subscales into highly likely ADHD (2.3%, 0.7%), probable ADHD (21.3%, 5.7%), and probably non-ADHD (76.4%, 93.6%) groups according to the scoring scheme of the subscales of the Adult ADHD Self-Report Scale. Results showed that, for both inattention and hyperactivity symptoms, the highly likely ADHD and probable ADHD groups were more likely than the non-ADHD group to have a variety of current and lifetime sleep problems. No significant difference in sleep problems was found between the highly likely ADHD and probable ADHD groups. Inattention, but not hyperactivity, was associated with greater sleep need and greater difference between sleep need and self-estimated nocturnal sleep duration. Hyperactivity, but not inattention, was associated with decreased nocturnal sleep duration.

Conclusions: Consistent with prior findings from children and adolescents, ADHD symptoms in young adults are related to sleep problems. Further studies on adults with ADHD should help to refine our understanding of the causal basis for any implications of this association.

Keywords: Sleep problems, inattention, hyperactivity-impulsivity, Adult ADHD Self-Report Scale

Citation: Gau SSF; Kessler RC; Tseng WL et al. Association between sleep problems and symptoms of attention-deficit/hyperactivity disorder in young adults. *SLEEP* 2007:30(2);195-201.

INTRODUCTION

ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD), CHARACTERIZED BY INATTENTION, HYPERACTIVITY, AND IMPULSIVITY, IS A COMMON neuropsychiatric disorder worldwide among children and adolescents,[1] with a prevalence in the range of 5% to 10% in Western countries[2] and 7.5% in Taiwan.[3] It has been suggested that many people with ADHD, as high as 60% in some studies, continue to have clinically significant symptoms of ADHD when they become adults.[4,5] Consistent with this suggestion, a recent national survey of adults in the United States found that 4.4% met the criteria for current adult ADHD.[6] A companion report from this study documented substantial impairment in role functioning associated with adult ADHD.[7] In view of these and related results,[8-10] ADHD should be recognized as a commonly occurring and impairing disorder not only among children and adolescents, but also in adults.

In the past dozen years, literature has documented associations of childhood and adolescent ADHD with a variety of sleep problems[11-20] such as longer sleep durations,[17,19] dyssomnia,[17,19] restless sleep,[17-19] periodic leg movement (PLM),[16,17] snoring,[12,17] and other sleep-disordered breathing (SDB) problems.[11,13,14,20] Among them, the most confirmatory associations of ADHD are with PLM[16,17] and, to a lesser degree, SDB.[11,13,14,20] Longitudinal studies have documented that snoring in children predicts the subsequent onset of hyperactivity.[21] We are not aware of any longitudinal research, in comparison, that has investigated whether ADHD predicts the subsequent onset of sleep problems.

Despite many studies supporting the association between sleep problems and daytime dysfunction, most of these studies have been conducted in children or adolescents,[11-20] with few in adult populations.[22-26] Similarly, daytime behaviors of adults with a wide variety of sleep problems, such as obstructive sleep apnea (OSA),[22] PLM,[25,26] and insomnia,[23] can mimic symptoms of ADHD by manifesting short attention span, hyperactivity, and impulsivity. Studies in adult populations have demonstrated that adult patients with PLM[25] and OSA[22] are more likely than other adults to display symptoms of ADHD, that adult patients with ADHD do not have more sleep problems than other adults (with the exception of significantly more PLM with arousals),[26] and that the severity of insomnia in college students may predict symptoms of inattention.[23] However, the possible relationship between insomnia and daytime inattention in adults[23] has not gained support from other adult studies.[24-26] Accordingly, except for OSA

Disclosure Statement

This was not an industry supported study. Dr. Gau has participated in research supported by Lilly Corporation and by Janssen-Cilag Taiwan as the principal investigator. All investigator fees were put into research grants for other studies. Dr. Kessler receives research grant support from Eli Lilly and Company and Bristol-Myers Squibb. He consults with GlaxoSmithKline, Galt Associates, and Pfizer. His participation in this report consisted of help in revising the manuscript. This work was carried out without financial remuneration and was independent of any research or consultation in which he is involved. Drs. Tseng, Wu, Chiu, Yeh, and Hwu have indicated no financial conflicts of interest.

Submitted for publication June 21, 2006
Accepted for publication October 13, 2006

Address correspondence to: Susan Shur-Fen Gau, Department of Psychiatry, National Taiwan University Hospital & College of Medicine, No. 7, Chung-Shan South Road, Taipei 10002, Taiwan; Tel: 886 2 23123456 ext. 6802; Fax: 886 2 23812408; E-mail: gaushufe@ntu.edu.tw

and PLM, there has been no consistent evidence either of a relationship between sleep problems in general and symptoms of ADHD or of a clear causal direction of this relationship in cases in which the relationship has been found to exist. A complicating factor here is that, similar to the studies in children and adolescents,[19] the findings from subjective reports are dissociated with those from objective measures, indicating an increased likelihood of a misinterpretation of sleep quality and problems in adults with ADHD.[26]

Although the studies mentioned above have clearly documented associations of inattention and hyperactivity with sleep problems, particularly OSA and PLM, there has been a dearth of adequate data delineating the associations of ADHD with other sleep problems among adults. Studies based on parental reports have almost universally reported a high frequency of diverse sleep problems in children with ADHD.[14,17,19,27-29] However, it is not clear whether similar specifications exist in the adult population. In view of this, and given the considerable public health importance of adult ADHD, we conducted a survey study of 2284 young adults to examine whether the associations of ADHD symptoms with sleep problems are similar to those found among children.

METHODS

Participants and Procedures

The Institutional Review Board of National Taiwan University Hospital approved this study prior to implementation. A letter describing the purposes and procedures of the study was mailed to those who were accepted by the National Taiwan University as first-year college students in July 2004. All students were informed that participation in the survey was completely voluntary, and the confidentiality was assured in the letter. Of the 3756 first-year students, 2284 (60.8%, 1156 men and 1128 women) consented to participate and completed the self-administered questionnaire survey in the first week of fall semester in conjunction with a routine physical examination. There was no information about the proportion of eligible subjects who received the mailings. The trained school counselors provided clear instructions on self-administration prior to the questionnaire being filled out. Trained research assistants then checked the completed questionnaires immediately to minimize missing data.

Instruments

Adult ADHD Self-Report Scale

The Adult ADHD Self-Report Scale (ASRS) is an 18-question scale developed in conjunction with revision of the World Health Organization Composite International Diagnostic Interview. The ASRS consists of 2 subscales, inattention and hyperactivity-impulsivity, each of which contains 9 items. All the items were mapped onto the 18 *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)* Criterion A symptoms of ADHD. Each item asks how often a symptom occurred over the past 6 months on a 5-point Likert scale: 0 for never, 1 for rarely, 2 for sometimes, 3 for often, and 4 for very often.[10] Individuals with a sum score on either subscale of 24 or greater, 17 to 23, and 0 to 16 are considered highly likely to have ADHD (described in this paper as ADHD), likely to have ADHD (probable ADHD), and unlikely to have ADHD (non-ADHD), respectively. Moreover, for estimating the prevalence of ADHD, we combined the ADHD categories based on 2 subcores to generate highly likely having ADHD (ie, meeting both ranges of highly likely ADHD for both subscales), probably having ADHD (ie, meeting both ranges of probable ADHD for each subscale), and possibly having ADHD (ie, meeting either the probable ADHD for each subscale).

The Chinese version of the ASRS was prepared with culturally appropriate colloquial expressions by the authors. A 2-way translation was performed independently by 3 child psychiatrists and professional bilingual translators in Taiwan and by psychiatrists and researchers from Harvard University. In a group of leading board-certificated child psychiatrists in Taiwan, the linguistic validity and content validity of this scale were performed. The 18-question ADHD-ASRS Symptom Checklist and 6-Question ADHD-ASRS Screener (Traditional Chinese) can be reached at website: http://www.hcp.med.harvard.edu/ncs/asrs.php.

The psychometric properties of the Chinese ASRS have been examined in another college-based sample of 3203 first-year college students (mean age in years ± SD: 18.88 ± 0.86). The Chinese ASRS demonstrated good internal consistency (Cronbach α) for the Inattention subscale (α = 0.85) and Hyperactivity-Impulsivity subscale (α = 0.83). In a subsample of 73 subjects, the Pearson correlation coefficients for test-retest reliability at a 4-week interval were 0.80 and 0.82 for the inattention and hyperactivity-impulsivity subscales, respectively.

Items regarding sleep hours and sleep problems were modified from the Sleep Habit Questionnaire, an instrument used in previous studies of children and adolescents,[30-33] with operational definitions of each sleep problem in accordance with the DSM-IV. The Sleep Habit Questionnaire was designed to survey current (past 6 months) and lifetime sleep-related problems that included early insomnia (sleep latency more than half an hour at least 3 times a week for 1 month), middle insomnia (waking up more than half an hour, at least once per sleep, 3 times a week for 1 month), sleep terror (DSM-IV criteria), sleepwalking (DSM-IV criteria), sleep talking, nightmare, bruxism, and snoring. Items regarding sleep hours consisted of self-estimated total sleep duration and need of sleep to maintain normal daytime function. PLM, restless legs syndrome, and OSA were not measured in this study. The 4-week test-retest reliability (kappa) of these questions in the sleep parameters of a sample of 73 college students ranged from a low of 0.50 (lifetime sleep terrors) to a high of 0.79 (current bruxism).

Data Analysis

The statistical analysis was conducted by using SAS 9.1 (SAS Institute Inc., Cary, NC). The preselected α value was at $p < .01$ level. Two major types of comparison groups were (1) men and women, and (2) the "ADHD," "probable ADHD" and "non-ADHD" groups based on the sum scores of each subscale. The descriptive results of comparing the demographics between the men and women were demonstrated in frequency, percentage, and χ^2 statistics for categorical variables and mean, SD, and 1-way analyses of variance for continuous variables.

Linear and nonlinear multilevel models using the MIXED and NLMIXED procedures in SAS were employed to control for effects of the lack of independence within the same department derived from a college-based sample.[34] The linear multilevel model was used to conduct the analysis of covariance to compare the sleep schedules among the 3 groups defined by severity of the

Table 1—Demographic Characteristics by Sex

	Men n = 1156	Women n = 1128	Total N = 2284	Sex differences
Age, y	19.4 ± 2.9	19.2 ± 2.6	19.3 ± 2.7	$F_{1,2278} = 2.11$, p = .147
Residency				
Taipei City and County	643 (55.8)	606 (53.9)	1249 (54.9)	$\chi_1^2 = 0.83$, p = .362
Paternal education level				
Senior high or lower	328 (29.4)	319 (18.0)	647 (29.2)	$\chi_1^2 = 0.03$, p = .861
College or higher	789 (70.6)	780 (82.0)	1569 (70.8)	
Maternal education level				
Senior high or lower	485 (43.3)	473 (42.9)	958 (43.1)	$\chi_1^2 = 0.04$, p = .842
College or higher	634 (56.7)	629 (57.1)	1263 (56.9)	
Paternal job[a]				
Professional	260 (22.5)	248 (22.0)	508 (22.3)	$\chi_2^2 = 9.59$, p = .008
Technical	614 (53.1)	661 (58.6)	1275 (55.8)	
Other	282 (24.4)	219 (19.4)	501 (21.9)	
Maternal job[a]				
Professional	80 (6.9)	72 (6.4)	152 (6.7)	$\chi_2^2 = 0.29$, p = .866
Technical	507 (43.9)	501 (44.4)	1008 (44.1)	
Other	569 (49.2)	555 (49.2)	1124 (49.2)	
Parental marital status				
Married and cohabit	1056 (91.8)	1026 (91.1)	2082 (91.5)	$\chi_1^2 = 0.36$, p = .546
Other	94 (8.2)	100 (8.9)	194 (8.5)	
Birth order				
Single child	110 (9.5)	84 (7.5)	194 (8.5)	$\chi_3^2 = 28.64$, p < .001
First child	518 (44.9)	544 (48.4)	1062 (46.7)	
Middle child	106 (9.2)	168 (14.9)	274 (12.0)	
Youngest child	419 (36.4)	329 (29.2)	748 (32.8)	
Inattention, sum score	13.5 ± 5.2	13.0 ± 4.7	13.2 ± 4.9	$F_{1,2279} = 5.75$, p = .017
Hyperactivity, sum score	9.3 ± 5.1	8.5 ± 4.7	8.9 ± 4.9	$F_{1,2279} = 13.09$, p <. 001

Data are presented as number (%), except age and inattention and hyperactivity sum scores, which are presented as mean ± SD.
[a]The job classification was based on the criteria of occupation category of Executive Yuan, Taiwan,[35] which was modified from the Standard International Occupational Prestige Scale.[36]

ASRS score. The nonlinear multilevel model was used to examine the rates of sleep-related problems across different comparison groups and to test the random-intercept effect. If the p value of the t statistic of the random-intercept effect was less than .05, indicating that the random intercept was not equal to 0, we used the nonlinear mixed model to conduct the logistic regression and to compute the odds ratios and 95% confidence intervals for the odds ratios. Otherwise, the logistic-regression model was used. These statistical models were controlled for participants' age, sex, body mass index, residential area, and parental marital status to decrease potential confounding effects from these variables.

RESULTS

Demographics

Table 1 presents the distribution of age, residency, birth order, symptoms of ADHD, and parents' educational attainment, job status, and marital status. Men were more likely than women to be the single child or youngest child, to have the father's job be in the category of neither professional nor technical, and to score higher in symptoms of inattention and hyperactivity/impulsivity. There was no sex difference in other demographics measured in this study.

Estimated Prevalence of Adult ADHD

Using the ASRS cutpoints of both subscales, 2.8% of respondents (n = 64) were classified as highly likely to have ADHD, an additional 3.2% (n = 74) were classified as probably having ADHD, and an additional 19.6% (n = 447) were classified as possibly having ADHD.

Sleep Duration and Symptoms of Inattention or Hyperactivity

ADHD or probable ADHD associated with inattention was associated with significantly longer required sleep time to maintain normal daytime function and greater difference between required sleep and self-estimated nocturnal sleep duration than their counterparts but not with actual self-estimated sleep duration (Table 2). ADHD associated with hyperactivity-impulsivity, in contrast, was not significantly related to any of the sleep measures.

Sleep Problems and Symptoms of Inattention or Hyperactivity

Table 3 displays the current and lifetime rates of several sleep problems by the severity of inattention and hyperactivity-impulsivity. In terms of inattention, subjects with ADHD were more likely than non-ADHD subjects to have current early insomnia, middle insomnia, sleep talking, nightmares, and snoring and lifetime early insomnia, middle insomnia, sleep terrors, and nightmares; subjects with probable ADHD, compared with non-ADHD subjects, were more likely to have problems in all of the investigated current and lifetime sleep questions except for current sleep talking and bruxism. As to the hyperactivity-impulsivity subscale, ADHD subjects were more likely than non-ADHD subjects to have current early insomnia, snoring, and all of the in-

Table 2—Sleep Duration by Different Groups of Inattention and Hyperactivity-Impulsivity

	Inattention of ASRS			Group Difference	Hyperactivity-Impulsivity of ASRS			Group Difference
	ADHD† n = 53	Probable ADHD n = 486	non-ADHD n = 1745		ADHD† n = 16	Probable ADHD n = 130	non-ADHD n = 2138	
Sleep obtained, h	7 h 24 min (64)	7 h 13 min (66)	7 h 14 min (63)	$F_{2,2270} = 0.78$, p = .457	7 h 15 min (80)	7 h 06 min (68)	7 h 14 min (63)	$F_{2,2270} = 0.98$, p = .377
Sleep need, h	7 h 43 min (85)	7 h 36 min (72)	7 h 27 min[a] (66)	$F_{2,2275} = 4.16$, p = .016	7 h 34 min (69)	7 h 24 min (81)	7 h 30 min (67)	$F_{2,2275} = .60$, p = 0.550
Difference*, min	19 (87)	24 (81)	14 (71)[b]	$F_{2,2269} = 3.30$, p = .037	19 (75)	17 (90)	16 (72)	$F_{2,2271} = 0.02$, p = .985
Sleep problems, no.								
Current	1.55 (1.41)	1.11 (1.16)	0.80 (1.03)[c]	$F_{2,2279} = 27.58$, p < .001	1.43 (1.40)	1.23 (1.16)	0.81 (1.04)[e]	$F_{2,2279} = 14.41$, p < .001
Lifetime	3.62 (2.06)	3.31 (2.33)	2.64 (2.16)[d]	$F_{2,2279} = 21.29$, p < .001	4.03 (2.30)	3.45 (2.22)	2.67 (2.18)[f]	$F_{2,2279} = 14.78$, p < .001

Data are presented as mean (SD). ADHD refers to attention-deficit/hyperactivity disorder; ASRS, Adult Self-Report Scale
*Difference between self-perceived need of sleep time to maintain normal daytime function and actual self-estimated total sleep time.
†Highly likely ADHD.
[a]Probable ADHD > non-ADHD
[b]Probable ADHD > non-ADHD
[c]ADHD > probable ADHD, ADHD > non-ADHD, Probable ADHD > non-ADHD
[d]ADHD > non-ADHD, Probable ADHD > non-ADHD
[e]ADHD > probable ADHD, ADHD > non-ADHD, Probable ADHD > non-ADHD
[f]ADHD > non-ADHD, Probable ADHD > non-ADHD.

vestigated lifetime problems; the probable ADHD, compared with the non-ADHD subjects, had a higher likelihood of having current early insomnia, sleep terrors, nightmares, and snoring and all the lifetime sleep problems except for current sleep talking.

There was no difference between the ADHD and the probable ADHD subjects (in terms of subscales of inattention and hyperactivity-impulsivity) either in current or lifetime sleep problems (p values ranging from .086 to 1).

Prediction for Symptoms of Inattention or Hyperactivity Based on Sleep Problems

Table 4 summarizes the parameter estimates and F statistics for the sleep problems that were significantly related with symptoms of inattention and hyperactivity-impulsivity separately in the final model using the backward elimination procedure in the model selection. The results showed that the most-related sleep problems for the symptoms of inattention were current early insomnia, nightmare, and snoring; lifetime middle insomnia; and increased sleep need to maintain daytime functioning. The most-related sleep problems for the hyperactive-impulsive symptoms were current early insomnia, middle insomnia, and snoring; lifetime middle insomnia, sleep talking, and nightmares; and decreased nocturnal sleep hours. In addition, men scored higher in both symptom dimensions, as compared with women.

DISCUSSION

Although researchers have long been interested in the associations between sleep problems and symptoms of ADHD in children and adolescents, the current study is one of the few studies to investigate these relationships among adults[22-26] and the first to do so in a large nonreferred sample of young adults and to demonstrate the existence of similar findings based on subjective measures as those found in studies of child and adolescent populations. Findings indicate that young adults with inattention and hyperactivity-impulsivity have a significantly higher prevalence than do others of both current and lifetime sleep problems, including dyssomnia, parasomnia, and snoring.

Because of the large sample size and the questionable validity of diagnosing OSA and PLM based on subjective self-reports in this study, we did not specifically investigate this association; instead, we examined snoring and more-general sleep problems and their associations with ADHD symptoms in young adults, issues that have not previously been well studied. Although different measures (self-reports by subjects vs parental reports on subjects) and different age groups (young adults vs children and adolescents) were employed in this study, as compared with previous studies in children and adolescents,[11-20] our findings provide evidence to support the associations between several sleep problems and symptoms of ADHD in an adult population. Consistent with studies in children and adolescents,[11-14,17,21] insomnia and snoring are associated with ADHD symptoms during daytime. Findings in the relationship between parasomnia (such as nightmare, sleep terrors, sleep talking) and ADHD symptoms, in comparison, are not consistent across the symptoms of inattention and hyperactivity-impulsivity. The association between ADHD symptoms and parasomnia has not been established in children[18] or in adults. However, our finding of a possible relationship between parasomnia and symptoms of inattention and hyperactivity needs further studies to confirm the existence of this relationship.

Consistent with most previous studies[27,28,37] in children and adolescents, we found that the duration of sleep does not differ among young adults with ADHD symptoms except that increased hyperactivity-impulsivity is related to decreased nocturnal sleep duration. In Corkum et al's review of 10 studies conducted since 1970, 9 studies with objective measures showed that children with ADHD did not differ from the normal controls on the objective total sleep duration with 1 exception being that of longer

Table 3—Rates of Sleep Problems by Different Groups of Inattention and Hyperactivity-Impulsivity

Sleep problems	Inattention					Hyperactivity-Impulsivity				
	ADHD*	Probable ADHD	Non-ADHD	ADHD vs non-ADHD	Probable ADHD vs non-ADHD	ADHD*	Probable ADHD	Non-ADHD	ADHD vs non-ADHD	Probable ADHD vs non-ADHD
	n = 53 %	n = 486 %	n = 1745 %	OR (95% CI)	OR (95% CI)	n = 16 %	n = 130 %	n = 2138 %	OR (95% CI)	OR (95% CI)
Current										
Early insomnia	45.3	33.5	26.7	2.3 (1.3, 4.0)[b]	1.4 (1.1, 1.7)[b]	56.3	43.1	27.5	3.4 (1.3, 9.2)[b]	2.0 (1.4, 2.9)[c]
Middle insomnia	28.3	14.4	9.7	3.7 (2.0, 6.8)[d]	1.6 (1.2, 2.1)[b]	25.0	16.2	10.8	2.8 (0.9, 8.7)	1.6 (1.0, 2.6)
Sleep terror	0.0	2.5	1.0	— (—, —)	2.4 (1.2, 5.1)[a]	6.3	3.9	1.1	5.9 (0.8, 46.3)	3.5 (1.3, 9.4)[c]
Sleepwalking	0.0	0.6	0.1	— (—, —)	5.4 (0.9, 32.5)	0.0	0.8	0.2	— (—, —)	4.1 (0.5, 37.8)
Sleep talking	18.9	12.6	8.5	2.5 (1.2, 5.1)[a]	1.5 (1.1, 2.1)[b]	18.8	9.2	9.6	2.2 (0.6, 7.7)	1.0 (0.5, 1.8)
Nightmare	28.3	22.4	15.0	2.2 (1.2, 4.1)[b]	1.6 (1.3, 2.1)[c]	31.3	21.5	16.5	2.3 (0.8, 6.7)	1.4 (0.9, 2.2)[c]
Bruxism	11.3	7.8	5.9	2.1 (0.9, 4.9)	1.4 (0.9, 2.0)	12.5	6.2	6.4	2.1 (0.5, 9.4)	1.0 (0.5, 2.0)
Snoring	22.6	17.5	12.9	2.0 (1.0, 3.8)[a]	1.4 (1.1, 1.9)[b]	43.8	20.0	13.5	5.0 (1.8, 13.5)[b]	1.6 (1.0, 2.5)[a]
Lifetime										
Early insomnia	84.9	73.7	64.8	3.1 (1.5, 6.6)[b]	1.5 (1.2, 1.9)[c]	93.8	76.9	66.3	2.2 (1.3, 4.0)[b]	1.7 (1.1, 2.6)[a]
Middle insomnia	66.0	52.9	41.0	2.8 (1.6, 5.0)[c]	1.6 (1.3, 2.0)[d]	75.0	56.2	43.1	2.5 (1.5, 4.0)[c]	1.7 (1.2, 2.4)[b]
Sleep terror	26.4	21.4	13.1	2.4 (1.3, 4.5)[b]	1.8 (1.4, 2.3)[d]	31.3	25.4	14.5	2.4 (1.5, 4.1)[c]	2.0 (1.3, 3.1)[c]
Sleepwalking	11.3	17.7	12.3	0.9 (0.4, 2.2)	1.5 (1.2, 2.0)[b]	18.8	19.2	13.1	1.8 (1.0, 3.2)[a]	1.6 (1.0, 2.5)[a]
Sleep talking	43.4	43.4	35.0	1.4 (0.8, 2.5)	1.4 (1.2, 1.8)[c]	62.5	41.5	36.5	2.0 (1.3, 3.2)[b]	1.2 (0.9, 1.8)
Nightmare	58.5	53.9	43.9	1.8 (1.0, 3.2)[a]	1.5 (1.2, 1.8)[d]	87.5	56.9	45.4	2.4 (1.5, 3.9)[c]	1.6 (1.1, 2.3)[a]
Bruxism	28.3	28.4	22.5	1.4 (0.7, 2.5)	1.4 (1.1, 1.7)[b]	43.8	33.1	23.2	2.3 (1.4, 3.7)[c]	1.6 (1.1, 2.4)[a]
Snoring	43.4	39.5	32.2	1.6 (0.9, 2.8)	1.4 (1.1, 1.7)[b]	68.8	47.7	32.9	2.3 (1.4, 3.7)[c]	1.9 (1.3, 2.7)[c]

OR refers to odds ratio; CI, confidence interval.
*Highly likely attention-deficit/hyperactivity disorder (ADHD).
[a]p < .05
[b]p <.01
[c]p < .001
[d]p < .0001

Table 4—Correlated Sleep Problems for Symptoms of Inattention and Hyperactivity-Impulsivity

Variables	Inattention			Hyperactivity-Impulsivity		
	β	F statistic	p Value	β	F statistic	p Value
Men vs Women	0.49	5.81	.016	0.74	12.75	< .001
Current						
Early insomnia	1.00	18.36	< .001	1.14	24.40	< .001
Middle insomnia	—	—	—	0.82	5.53	.019
Nightmare	0.94	11.12	< .001	—	—	—
Snoring	0.98	10.91	< .001	1.22	17.56	< .001
Lifetime						
Middle insomnia	0.99	19.76	< .001	0.68	8.28	.004
Sleep terrors	0.71	5.38	.021	—	—	—
Sleep talking	—	—	—	0.57	6.32	.012
Nightmare	—	—	—	0.73	10.68	.001
Nocturnal sleep obtained, h	—	—	—	-0.23	5.86	.016
Sleep need	0.34	14.36	< .001	—	—	—

β = parameter estimate.

sleep duration in children with ADHD.[27] These negative findings are further supported by 2 studies using objective measures.[28,37] In contrast to findings from objective measures, which show no difference, and those from self-reports of adults with ADHD,[26] which show shorter total sleep duration, findings from parental reports show longer nocturnal sleep time in children with ADHD.[17,19] Although this study showed that college students with ADHD or probable ADHD did not have different sleep durations from those without ADHD, the finding of a correlation between increased hyperactivity-impulsivity and decreased sleep duration identified in the final model should be further examined by an objective measure of sleep duration because a discrepant finding between objective measures and self-report measures in adults has been documented.[19,26] If this relationship exists, it can be explained that individuals with short sleep may fidget with fingers and move body to maintain their alertness.[11] Despite several studies of the effect of sleep duration on ADHD symptoms, no study has examined the relationship between perceived sleep need and ADHD symptoms. Interestingly, this study demonstrates the relationship among perceived sleep need, the difference between perceived need and obtained sleep, and ADHD symptoms. The perceived longer need for sleep may explain why, despite no difference in recorded sleep time, there are still increased symptoms of inattention and hyperactivity. Hence, young adults presenting with inattention problems may require a longer sleep time to maintain their normal daytime function.

Our results show that, although young adults with symptoms of ADHD have higher rates of sleep problems than those without, individuals with extreme symptoms of ADHD (according to the criteria of the ASRS, highly likely ADHD) didn't report more sleep problems than those with mild symptoms of ADHD (probable ADHD). The failure to find a strong dose-response relationship of the ADHD symptoms and sleep problems might provide hints as to the causality between sleep problems and ADHD that

could be followed up in future research.

The causal factors linking ADHD and sleep problems are unclear from the results reported here. Possible explanations include the following: first, sleep problems may cause daytime sleepiness and behavioral problems, perhaps through sleep disruption or deprivation, resulting in frequent attention-shifting and stimulus-seeking behaviors making individuals with sleep problems look like they are "hyperactive" and "inattentive."[19] Second, behavioral problems, such as hyperactivity, might result in sleep problems. For example, challenging behaviors of ADHD children might increase the likelihood of difficulties with sleep onset and awakening in the morning and more restless sleep.[38] Or, adults with ADHD might overschedule and feel compelled to do things before sleep.[16,39] A third possibility is that sleep problems and ADHD might have some common causes. For example, common vulnerability in brain dysfunction might lead to both types of disorders.[28] Consistent with this possibility, a shorter daytime sleep latency in individuals with ADHD is consistent with the possibility that a deficit in alertness affects not only daytime inattention and hyperactivities, but also sleep mechanisms.[29]

Strengths and Limitations

Most previous studies on this topic have been conducted in populations of children and adolescents. The large college-aged community sample in this study provides information on young adults that has not been investigated in previous studies. Moreover, the use of the measures covering a wide variety of sleep problems and the Chinese ASRS with satisfactory reliability and validity allowed us to comprehensively examine the relationship of sleep problems and ADHD and increase the internal validity of this study.

Despite the strengths, the present study is limited by a cross-sectional study design, questionable external validity, a lack of objective measures, lack of assessment of full criteria for a diagnosis of ADHD, and no knowledge of medical problems or medication. First, the cross-sectional study design does not allow us to investigate the causal relationship between sleep problems and ADHD symptoms. Second, because this is a college-based study, the findings may not be generalized to the broader Taiwanese adult population. Third, the present study used subjective measures of sleep problems that may not generalize to more-objective measures of sleep problems.[27] Not only does a self-administered measure, which has been commonly used in sleep studies related to ADHD,[31] make it feasible, easy, and inexpensive to conduct a study with a large sample size, but it also prevents interviewer assessment biases.[40] Fourth, without conducting a psychiatric interview to make the ADHD diagnosis or having knowledge about a formal clinical diagnosis of ADHD, this study provides no data about whether individuals with ADHD are more likely to suffer from sleep problems. However, this study targets on the relationship of sleep problems with symptoms related to the core symptoms of ADHD, and the relationship of sleep problems with ADHD diagnosis will be examined in future studies. Last, lack of information about what medical problems the subjects had or medications (such as stimulants and hypnosedatives) the subjects were taking prevents us from investigating whether these factors might have influenced ADHD symptoms and sleep parameters and subsequently confounded our findings.

Implications

Combining findings from several lines of work, including our prior study on children and adolescents[41] and this study, we should know that although individuals with ADHD may not increase the risk for some sleep problems; individuals with sleep problems may manifest varied degree of symptoms similar to the core symptoms of ADHD. Without detailed and comprehensive assessments, these individuals with sleep problems could easily be misdiagnosed with ADHD, particularly for those adults who did not have information about a childhood history of ADHD.[42] It is particularly important for those subjects in this study who had symptoms of mild inattention and hyperactivity to have a complete assessment of sleep-related problems and vice versa, given that these problematic behaviors that mimic symptoms of ADHD may also result in adverse outcomes such as academic failure[43] or low work achievements,[24,44] injuries and motor vehicle crashes,[29] and substance abuse.[45] Therefore, for individuals with ADHD-like symptoms and sleep problems, psycho-education of sleep hygiene and behavior modification should be provided first to prevent daytime inattention, irritability, and sleepiness in order not to influence their school or occupational performance. If a behavioral approach does not work, medication and other treatment for sleep problems should be the next step if the diagnosis of ADHD cannot be confirmed. For individuals with severe symptoms of ADHD and sleep problems, a complete assessment for the diagnosis of ADHD and sleep problems should be performed first before initiation of medication for treating ADHD in addition to treatment for sleep problems. Further study employing adults with a diagnosis of ADHD are needed to determine the relationship between diagnoses of ADHD and sleep problems, and prospective cohort studies aiming at demonstrating a cause-and-effect relationship of sleep problems and ADHD-related symptoms are crucial and merit being done.

ACKNOWLEDGMENT

This work was supported by grants from the National Taiwan University Hospital (NTUH92-S07) and National Health Research Institute (NHRI-EX94-9407PC), Taiwan.

REFERENCES

1. Biederman J, Faraone SV. Attention deficit hyperactivity disorder: a worldwide concern. J Nerv Ment Dis 2004;192:453-4.
2. Faraone SV, Sergeant J, Gillberg C, Biederman J. The worldwide prevalence of ADHD: Is it an American condition? World Psychiatry 2003;2:104-13.
3. Gau SS, Chong MY, Chen TH, Cheng AT. A 3-year panel study of mental disorders among adolescents in Taiwan. Am J Psychiatry 2005;162:1344-50.
4. Biederman J, Mick E, Faraone SV. Age-dependent decline of symptoms of attention deficit hyperactivity disorder: impact of remission definition and symptom type. Am J Psychiatry 2000;157:816-8.
5. Rasmussen P, Gillberg C. Natural outcome of ADHD with developmental coordination disorder at age 22 years: a controlled, longitudinal, community-based study. J Am Acad Child Adolesc Psychiatry 2000;39:1424-31.
6. Kessler RC, Adler L, Barkley R, et al. The prevalence and correlates of adult ADHD in the United States: Results from the National Comorbidity Survey Replication. Am J Psychiatry 2006;163:716-23.
7. Kessler RC, Adler L, Ames M, et al. The prevalence and effects of adult attention deficit/hyperactivity disorder on work performance

in a nationally representative sample of workers. J Occup Environ Med 2005;47:565-72.
8. Wender PH, Wolf LE, Wasserstein J. Adults with ADHD. An overview. Ann N Y Acad Sci 2001;931:1-16.
9. Pary R, Lewis S, Matuschka PR, Rudzinskiy P, Safi M, Lippmann S. Attention deficit disorder in adults. Ann Clin Psychiatry 2002;14:105-11.
10. Kessler RC, Adler L, Ames M, et al. The world health organization adult ADHD self-report scale (ASRS): a short screening scale for use in the general population. Psychol Med 2005;35:245-56.
11. Chervin RD, Archbold KH, Dillon JE, et al. Inattention, hyperactivity, and symptoms of sleep-disordered breathing. Pediatrics 2002;109:449-56.
12. Chervin RD, Dillon JE, Bassetti C, Ganoczy DA, Pituch KJ. Symptoms of sleep disorders, inattention, and hyperactivity in children. Sleep 1997;20:1185-92.
13. Gottlieb DJ, Vezina RM, Chase C, et al. Symptoms of sleep-disordered breathing in 5-year-old children are associated with sleepiness and problem behaviors. Pediatrics 2003;112:870-7.
14. O'Brien LM, Holbrook CR, Mervis CB, et al. Sleep and neurobehavioral characteristics of 5- to 7-year-old children with parentally reported symptoms of attention-deficit/hyperactivity disorder. Pediatrics 2003;111:554-63.
15. Chervin RD, Archbold KH. Hyperactivity and polysomnographic findings in children evaluated for sleep-disordered breathing. Sleep 2001;24:313-20.
16. Chervin RD, Archbold KH, Dillon JE, et al. Associations between symptoms of inattention, hyperactivity, restless legs, and periodic leg movements. Sleep 2002;25:213-8.
17. Crabtree VM, Ivanenko A, Gozal D. Clinical and parental assessment of sleep in children with attention-deficit/hyperactivity disorder referred to a pediatric sleep medicine center. Clin Pediatr 2003;42:807-13.
18. Corkum P, Moldofsky H, Hogg-Johnson S, Humphries T, Tannock R. Sleep problems in children with attention-deficit/hyperactivity disorder: impact of subtype, comorbidity, and stimulant medication. J Am Acad Child Adolesc Psychiatry 1999;38:1285-93.
19. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder (ADHD). Sleep 2001;24:303-12.
20. Ali NJ, Pitson DJ, Stradling JR. Snoring, sleep disturbance, and behavior in 4-5 year olds. Arch Dis Child 1993;68:360-6.
21. Chervin RD, Ruzicka DL, Archbold KH, Dillon JE. Snoring predicts hyperactivity four years later. Sleep 2005;28:885-90.
22. Naseem S, Chaudhary B, Collop N. Attention deficit hyperactivity disorder in adults and obstructive sleep apnea. Chest 2001;119:294-6.
23. Kass SJ, Wallace JC, Vodanovich SJ. Boredom proneness and sleep disorders as predictors of adult attention deficit scores. J Atten Disord 2003;7:83-91.
24. Sangal RB, Sangal JM. Rating scales for inattention and sleepiness are correlated in adults with symptoms of sleep disordered breathing syndrome, but not in adults with symptoms of attention-deficit/hyperactivity disorder. Sleep Med 2004;5:133-5.
25. Wagner ML, Walters AS, Fisher BC. Symptoms of attention-deficit/hyperactivity disorder in adults with restless legs syndrome. Sleep 2004;27:1499-504.
26. Philipsen A, Feige B, Hesslinger B, et al. Sleep in adults with attention-deficit/hyperactivity disorder: a controlled polysomnographic study including spectral analysis of the sleep EEG. Sleep 2005;28:877-84.
27. Corkum P, Tannock R, Moldofsky H. Sleep disturbances in children with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 1998;37:637-46.
28. Konofal E, Lecendreux M, Bouvard MP, Mouren-Simeoni MC. High levels of nocturnal activity in children with attention-deficit hyperactivity disorder: a video analysis. Psychiatry Clin Neurosci 2001;55:97-103.
29. Owens JA. The ADHD and sleep conundrum: a review. J Dev Behav Pediatr 2005;26:312-22.
30. Gau SF. Neuroticism and sleep-related problems in adolescence. Sleep 2000;23:495-502.
31. Gau SF, Soong WT. The transition of sleep-wake patterns in early adolescence. Sleep 2003;26:449-54.
32. Gau SS, Soong WT, Merikangas KR. Correlates of sleep-wake patterns among children and young adolescents in Taiwan. Sleep 2004;27:512-9.
33. Shang CY, Gau SS, Soong WT. Association between childhood sleep problems and perinatal factors, parental mental distress and behavioral problems. J Sleep Res 2006;15:63-73.
34. Singer JD. Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. J Educ Behav Stat 1998;23:323-55.
35. Cheng TA. A community study of minor psychiatric morbidity in Taiwan. Psychol Med 1988;18: 953-68.
36. Treiman, D. Standard International Occupational Prestige Scale. In: Occupational Prestige in Comparative Perspective. New York: Academic Press, 1977:235-60.
37. Lecendreux M, Konofal E, Bouvard M, Falissard B, Mouren-Simeoni MC. Sleep and alertness in children with ADHD. J Child Psychol Psychiatry 2000;41:803-12.
38. Weiss MD, Weiss JR. A guide to the treatment of adults with ADHD. J Clin Psychiatry 2004;3:27-37.
39. Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. Child Dev 1998;69:875-87.
40. Gau SS. Prevalence of sleep problems and their association with inattention/hyperactivity among children aged 6-15 in Taiwan. J Sleep Res 2006;15:403-14.
41. Montano B. Diagnosis and treatment of ADHD in adults in primary care. J Clin Psychiatry 2004;65:18-21.
42. Gozal D, Pope DW, Jr. Snoring during early childhood and academic performance at ages thirteen to fourteen years. Pediatrics 2001;107:1394-9.
43. Biederman J, Faraone SV, Spencer T, et al. Patterns of psychiatric comorbidity, cognition, and psychosocial functioning in adults with attention deficit hyperactivity disorder. Am J Psychiatry 1993;150:1792-8.
44. Barkley RA, Murphy KR, Dupaul GI, Bush T. Driving in young adults with attention deficit hyperactivity disorder: knowledge, performance, adverse outcomes, and the role of executive functioning. J Int Neuropsychol Soc 2002;8:655-72.
45. Wilens TE. Impact of ADHD and its treatment on substance abuse in adults. J Clin Psychiatry 2004;65:38-45.