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Symptoms of Sleep-Disordered Breathing in 5-Year-Old Children Are Associated With Sleepiness and Problem Behaviors

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ABSTRACT. *Objective.* **Sleep-disordered breathing (SDB) in children is reportedly associated with problem behaviors suggestive of attention-deficit/hyperactivity disorder; however, there are few data on the relation of SDB to problem behaviors in the general pediatric population. The goal of this study was to assess the prevalence of SDB symptoms in 5-year-old children and their relation to sleepiness and problem behaviors.**

Methods. **A population-based, cross-sectional survey was conducted of a birth cohort of children who were born in eastern Massachusetts. Subjects were 3019 5-year-old children (1551 boys, 1468 girls) who were enrolled in the Infant Care Practices Study and whose mothers were contacted within 3 months of their child's fifth birthday. A parent-completed questionnaire was used to ascertain the presence and intensity of snoring and other SDB symptoms and the presence of daytime sleepiness and problem behaviors. Parent-reported hyperactivity, inattention, and aggressiveness were each assessed by a single question that was validated against the Conners' Parent Rating Scale. SDB was defined as frequent or loud snoring; trouble breathing or loud, noisy breathing during sleep; or witnessed sleep apnea.**

Results. **Parent-reported hyperactivity (19%) and inattention (18%) were common, with aggressiveness (12%) and daytime sleepiness (10%) reported somewhat less often. SDB symptoms were present in 744 (25%) children. Compared with children without snoring or other symptoms of SDB, children with SDB symptoms were significantly more likely to have parent-reported daytime sleepiness (odds ratio [OR]: 2.2; 95% confidence interval [CI]: 1.7–2.8) and problem behaviors, including hyperactivity (OR: 2.5; CI: 2.0–3.0), inattention (OR: 2.1; 95% CI: 1.7–2.6), and aggressiveness (OR: 2.1; 95% CI: 1.6–2.6). These associations remained significant after adjustment for sex, race/ethnicity, maternal education level, maternal marital status, household income, and respiratory health history.**

Conclusions. **SDB symptoms are common in 5-year-old children and are associated with an increased risk of daytime sleepiness and with problem behaviors suggestive of attention-deficit/hyperactivity disorder.** *Pediatrics* 2003;112:870–877; *snoring, sleep-disordered breathing, sleep apnea, behavior, hyperactivity.*

There is increasing recognition that obstructive sleep-disordered breathing (SDB), comprising snoring, obstructive sleep apnea/hypopnea, and obstructive hypoventilation, is a common and often unrecognized condition in children.[1] Overt obstructive sleep apnea (OSA) has generally been estimated to affect 2% to 3% of children.[2–4] Milder forms of SDB are common, however, with 10% to 36% of children age 3 to 6 years reported to snore habitually.[2,5,6] Early case series variably identified sleepiness[7] and hyperactive, aggressive, or rebellious behaviors[8–10] in association with OSA in children, although potential referral bias impedes interpretation of these studies. Few data are available from population-based studies on the behavioral consequences of SDB in children. Although 2 studies from community-based[2] or general pediatric clinic[11] samples also suggest that SDB is associated with hyperactivity and other problem behaviors, these studies did not control for potentially important confounding factors. Asthma, atopic disorders, and adenotonsillar enlargement, a common correlate of recurrent upper respiratory infection, all have been associated with increased prevalence of SDB symptoms in children.[5,10,12,13] As an association of these factors with inattention and hyperactivity has also been reported,[14–16] confounding by these respiratory health variables may explain the apparent association of SDB with problem behaviors.

A true causal association of SDB with problem behaviors would be of great importance, however, given the high prevalence of both SDB symptoms and hyperactive or inattentive behaviors, which may have a significant adverse impact on school performance. Treatment of overt OSA in poorly performing first-grade students may improve subsequent academic performance.[17] If milder forms of SDB are also associated with sleepiness and problem behaviors, then the identification and treatment of SDB in

children before entry into elementary school may be of particular clinical and social benefit. In the present study, we extended the results of previous studies by assessing the relation of parent-reported sleepiness, hyperactivity, inattention, and aggressiveness to snoring and other symptoms of SDB in a large, population-based cohort of 5-year-old children, adjusting for a variety of sociodemographic and respiratory health variables.

METHODS

Subjects

This study was approved by the Institutional Review Board of Boston University School of Medicine. All children who were enrolled in the study had been previously enrolled in the Infant Care Practices Study (ICPS). The design of the ICPS has been described.[18] Briefly, the ICPS is a multicenter, prospective, longitudinal study conducted in Boston, Lowell, and Lawrence, Massachusetts, and Toledo, Ohio, the principal aim of which was to describe newborn sleep practices and to document changes in infant sleep position over time. Between February 1995 and December 1998, mothers of newborn infants were contacted at selected birth hospitals in these cities and invited to participate. Beginning in March 2000, as part of the screening process for an intensive study of the neurobehavioral consequences of SDB, a Five-Year Follow-up Questionnaire (FYFQ) was mailed within 3 months of the child's fifth birthday to all English-speaking mothers of ICPS children who were born in Massachusetts and had birth weight >2500 g. The questionnaire asked, inter alia, about snoring and other sleep habits, daytime sleepiness, and problem behaviors. When the questionnaire was not returned within 14 days, a second questionnaire was mailed. When this was not returned, an attempt was made to contact the mother by telephone and obtain completion of the questionnaire. The subjects of this study all are children with complete FYFQ data for sleepiness and problem behaviors.

Questionnaire Data

Descriptive data (eg, maternal age, race, ethnicity, educational status) were collected by interview at the time of enrollment into the ICPS. The FYFQ asked the child's height, weight, frequency of upper respiratory and ear infections, history of tympanostomy and adenotonsillectomy and about the presence of SDB symptoms, daytime sleepiness, wheezing, asthma, respiratory allergy, and problem behaviors. Five questions were used to assess the presence of SDB: "On average, how often does your child snore?" "How loud is your child's snoring?" "When sleeping, does your child have trouble breathing, or struggle to breathe?" "Have you ever seen your child stop breathing when he/she was asleep?" "When sleeping, does your child have ''heavy,' loud, or noisy breathing?" Three questions were used to identify the presence of problem behaviors. Hyperactivity was defined as a positive response to the question, "Would you say that your child is often restless, overly active, or someone who can't sit still?" Inattention was defined as a positive response to the question, "Would you say that your child often seems not to listen when spoken to directly?" Aggressiveness was defined as a positive response to the question, "Does your child tend to be more aggressive or rebellious than other children his/her age?" A single question was used to assess sleepiness, with excessive sleepiness defined as a response of 1 or more days per week to the question, "Is your child overly sleepy during the daytime?" The Conners' Parent Rating Scale, Revised (CPRS)[19] was also completed for a subset of 219 children, 131 who were participants in an ongoing laboratory-based study of pediatric sleep apnea and 88 who were mailed the CPRS after declining to participate in the laboratory-based protocol. These data were used to validate the FYFQ questions regarding problem behaviors.

Analysis

All analyses were performed using SPSS software (SPSS, Inc, Chicago, IL). Descriptive statistics of the subject characteristics are presented. The FYFQ items regarding hyperactivity, inattention, and aggressiveness were validated against the CPRS using the Mann-Whitney U test to compare scores on the relevant CPRS scales and Fisher exact test to compare the percentage with scores ≥65, between subjects with positive versus negative responses on each screening question. Bivariate and multivariate logistic regression analyses were used to assess the relation of SDB symptoms to daytime sleepiness and problem behaviors. The multivariate models adjusted for potential confounders including sociodemographic variables (sex, race/ethnicity, maternal education level, marital status, and household income) and respiratory illness history (frequency of upper respiratory and ear infections, tympanostomy tube placement or adenotonsillectomy, diagnosis of asthma, wheezing in the past 12 months, or respiratory allergy). The primary analyses included all subjects, and additional sex-specific analyses were conducted.

RESULTS

Subjects

Between March 1, 2000, and May 3, 2002, FYFQs were mailed 3 months before the child's fifth birthday to the birth mothers of 5117 children who were enrolled in the ICPS approximately. At the time of this analysis, 3137 questionnaires (61%) had been completed. Of these, valid responses to all 4 behavioral questions were available for 3019 (96%), who are the subjects of this study. Characteristics of the study sample are shown in Table 1. There were approximately equal numbers of boys and girls. The mothers were relatively well educated and had a median annual household income >$55 000. Eighty-one percent of the mothers were non-Hispanic white, and 84% were married at the time the child was born. Compared with the total eligible sample, mothers of the 3019 subjects included in the analysis were somewhat better educated, had higher household income, and were more likely to identify themselves as non-Hispanic white. As the mothers had in many cases not been contacted during the 4 years since completing their participation in the ICPS, inability to contact the mother as a result of change of address was a major cause of noncompletion of the FYFQ, accounting for approximately 45% of nonrespondents. Thus, of those not known to be lost to follow-up as a result of change of address, the questionnaire completion rate was approximately 75%.

TABLE 1. Subject Characteristics

N	3019
Sex	
Female	48.6%
Male	51.4%
Maternal race/ethnicity	
Asian	4.5%
Black, non-Hispanic	6.4%
Hispanic	6.6%
White, non-Hispanic	81.3%
Other and unknown	1.2%
Maternal education	
<High school	5.0%
High school	18.3%
Some college	22.5%
College 4+ y	53.9%
Unknown	0.3%
Household income	
<$16 000	7.2%
$16 000–$34 999	12.1%
$35 000–$54 999	19.2%
≥$55 000	52.0%
Unknown	9.6%

Validation of the Behavioral Screening Questions

For maximizing the number of respondents to the FYFQ, problem behaviors were assessed using only 3 questions regarding hyperactivity, inattention, and aggressive behavior. For validating these questions against standardized measures of hyperactive and inattentive behavior, the CPRS was administered to a subset of questionnaire respondents. Six CPRS scales are relevant to hyperactive or inattentive behaviors: Hyperactivity Index; Conners' ADHD Index; Restless-Impulsive Index; and *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) ADHD Inattentive, Hyperactive-Impulsive, and Total indices. Scores on all 6 of these indices were significantly higher in children with a positive response to the FYFQ hyperactivity, inattention, or aggressiveness questions than in children with negative responses to these questions (for hyperactivity and inattention screening questions, $P \leq .001$ for each comparison; for aggressiveness screening question, $P < .025$ for each comparison). Detailed comparisons for the 3 DSM-IV ADHD indices are shown in Table 2. In contrast, scores on the Anxious-Shy, Perfectionism, Social Problems, Psychosomatic, and Emotional Lability scales did not differ significantly between children with positive versus negative responses to any of the 3 FYFQ problem behavior questions. Children with positive responses to the hyperactivity, inattention, or aggressiveness questions on the FYFQ were also much more likely to have abnormally high scores, defined as a *t* score ≥ 65, on the DSM-IV Inattentive, Hyperactive-Impulsive, and Total indices than were children with negative responses to the screening questions (Table 2).

Prevalence of SDB Symptoms

Parent-reported snoring and other symptoms of SDB were common in these children: 55% were reported to snore at least occasionally, and 12% were reported to be habitual snorers, defined as snoring 3 or more nights per week (Table 3). Seventeen percent of children were reported to have "loud or noisy

TABLE 3. Prevalence of SDB Symptoms

	Total (3019)	Boys (1551)	Girls (1468)	P*
Snoring frequency (%)				.01
Never	44.8	41.7	48.2	
<1 night/wk	33.7	35.3	32.0	
1–2 nights/wk	8.9	9.6	8.2	
3–5 nights/wk	6.0	6.3	5.7	
6–7 nights/wk	6.0	6.4	5.6	
Snoring loudness (%)				<.001
Does not snore	44.8	41.8	48.0	
Quiet	34.6	35.3	33.9	
Moderate	16.7	19.0	14.3	
Loud or very loud	3.4	3.1	3.7	
Trouble breathing during sleep (%)				.01
Never	89.8	88.3	91.4	
<1 night/wk	6.6	7.8	5.3	
≥1 night/wk	1.9	2.1	1.7	
Ever stop breathing when asleep (%)	3.4	3.7	3.0	.30
Loud or noisy breathing when asleep (%)	16.8	18.4	15.1	.02
SDB composite variable† (%)	24.6	26.6	22.6	.01

Numbers may not add to total sample size as a result of exclusion of subjects with symptom status "unknown."
* P value for χ^2 comparison of symptom prevalence in boys versus girls.
† SDB defined as parent-reported habitual (≥3 nights/week) or loud snoring, loud or noisy breathing during sleep, trouble breathing during sleep, or witnessed sleep apnea.

breathing" while asleep, with smaller numbers of children reported to snore loudly (3%), to stop breathing during sleep (3%), or to have trouble breathing during sleep 1 or more nights per week (2%). Although snoring frequency was significantly associated with each of the other SDB symptoms, many children who were not reported to snore habitually were reported to have other symptoms of SDB. Of the 17% of children who were reported to have loud or noisy breathing during sleep, for example, more than half were not reported to be habitual snorers. For this reason, a composite SDB variable was constructed, comprising children with snoring ≥3 nights/wk, "loud" or "very loud" snoring, loud

TABLE 2. Association of Behavioral Screening Questions With ADHD Index Scores of the CPRS in 219 Children

CPRS DSM-IV Scale	FYFQ Hyperactive*		FYFQ Inattentive*		FYFQ Aggressive*	
	No (81%)	Yes (19%)	No (80%)	Yes (20%)	No (91%)	Yes (9%)
ADHD Inattentive type						
Median score	46	52	46	52	46	50
% Abnormal†	3%	20%	2%	23%	5%	15%
ADHD Hyperactive-Impulsive type						
Median score	47	56	47	54	48	54
% Abnormal†	2%	32%	4%	23%	6%	30%
ADHD Total						
Median score	46	55	46	55	47	53
% Abnormal†	1%	29%	2%	26%	5%	25%

ADHD indicates attention-deficit/hyperactivity disorder.
* All comparisons $P \leq .001$ for positive versus negative response to the Hyperactivity and Inattention screening questions; for the Aggressiveness screening question, differences in scores on the 3 CPRS indices was significant at $P < .01$, whereas differences in the percentage abnormal were significant at this level only for the ADHD Hyperactive-Impulsive type and ADHD Total but not ADHD Inattentive type.
† *T* scores ≥65 are considered abnormal.

or noisy breathing during sleep, witnessed apneas, or trouble breathing during sleep 1 or more nights per week.

Using this definition, 25% of children had parent-reported SDB symptoms. The prevalence of SDB symptoms was slightly higher in boys than in girls, and this was statistically significant for all symptoms other than witnessed apneas, which was uncommon in either sex (Table 3). Among the 25% of children with SDB symptoms, non-Hispanic white parents were significantly less likely to report that their children habitually snore (45% of non-Hispanic white vs 68% of black, 64% of Hispanic, and 57% of Asian parents; $P < .001$ for non-Hispanic white vs all others) but somewhat more likely to report loud, noisy breathing during sleep (71% of non-Hispanic white vs 54% of black, 62% of Hispanic, and 64% of Asian parents; $P < .001$ for non-Hispanic white vs all others).

Although the prevalence of SDB symptoms in non-respondents cannot be determined, we explored the potential impact of nonrespondents on the observed prevalence of SDB symptoms by comparing symptom prevalence between those who responded to the mailed questionnaire (56% of respondents) and those who responded only after telephone contact (44% of respondents). For each of the 5 symptoms of SDB, the prevalence was slightly higher in the latter group: 13% versus 11% with frequent snoring; 19% versus 15% with loud, noisy breathing during sleep; and 28% versus 22% with any of the 5 SDB symptoms.

Prevalence of Sleepiness and Problem Behaviors

Daytime sleepiness was reported to occur at least occasionally in 38% of children, but excessive daytime sleepiness, defined as sleepiness occurring at least once per week, was reported in only 10% of children (Table 4). Hyperactivity was reported in 19% of children and inattention in 18%. Although the presence of hyperactivity and inattention was strongly associated (OR: 9.9; $P < .001$), of the 805 children with a positive response to either of these questions, only 292 (36%) had a positive response to both questions. Only 12% of children were reported to be more aggressive or rebellious than other children their age. Although the prevalence of daytime sleepiness did not differ significantly between boys and girls, hyperactivity, inattention, and aggressive-

ness were reported 25% to 55% more often in boys than in girls (Table 4).

Association of SDB Symptoms With Sleepiness and Problem Behaviors

In bivariate analyses, 4 of the 5 symptoms of SDB (snoring frequency, snoring loudness, trouble breathing during sleep, and loud noisy breathing) and the dichotomous composite SDB measure were significantly associated with parent-reported sleepiness and with each of the problem behaviors ($P < .001$ by χ^2 analysis for each comparison; Table 5). A similar trend was observed for witnessed apneas, although perhaps as a result of the low frequency of this symptom, the association was significant only for hyperactivity ($P < .001$). A dose-response effect on sleepiness and problem behaviors was observed for both snoring frequency and snoring loudness. Multivariate logistic regression analyses were conducted to assess the association of SDB symptoms with sleepiness and problem behaviors and to adjust for potential confounders including sociodemographic variables and respiratory illness history. SDB was strongly associated with each behavioral measure, with unadjusted ORs >2.0 for the association of the composite SDB variable with each behavior (Table 6). After adjustment for sociodemographic variables, the ORs were only trivially reduced from their unadjusted values, suggesting little confounding by these variables. There was an additional slight reduction in the ORs after adjustment for respiratory health variables (Table 6). When separate models were constructed for boys and girls, the association of SDB symptoms with behavioral measures was similar across the sexes (excessive daytime sleepiness, adjusted ORs 1.8 and 2.4 for boys and girls, respectively; hyperactivity, 2.3 and 1.4; inattention, 1.7 and 1.9; aggressiveness, 1.8 and 1.8). Although the association of SDB symptoms with hyperactivity was somewhat stronger in boys, a sex-SDB interaction term entered in the logistic regression model was not statistically significant ($P = .07$). The association of SDB symptoms with problem behaviors was also assessed excluding occasionally snoring children from the referent group. When compared with children who were reported never to snore, those with SDB symptoms had unadjusted ORs for sleepiness, hyperactivity, inattention, and aggressiveness that were 2.4, 3.2, 2.4, and 2.2, respectively, falling slightly with adjustment for sociodemographic and respiratory health variables to 2.2, 2.3, 2.0, and 1.9.

DISCUSSION

In the present study, we have found that parent-reported symptoms of sleep-disordered breathing are strongly associated with parent-reported hyperactive, inattentive, and aggressive behaviors and daytime sleepiness in 5-year-old children. The presence of SDB symptoms was associated with an approximately 2-fold increase in the prevalence of each of these behaviors, an association that was not explained by the association of SDB symptoms with male sex, minority race or ethnicity, or lower socioeconomic status. Although measures of respiratory

TABLE 4. Prevalence of Daytime Sleepiness and Problem Behaviors

	Total (3019)	Boys (1551)	Girls (1468)	P^*
Daytime sleepiness (%)				.67
Never	61.8	62.5	61.0	
<1 d/wk	27.7	26.7	28.7	
1–2 d/wk	6.1	6.1	6.1	
3–7 d/wk	4.4	4.6	4.2	
Hyperactivity (%)	18.9	22.8	14.7	<.001
Inattention (%)	17.5	20.1	14.6	<.001
Aggressiveness (%)	12.2	13.5	10.8	.03

* P value for χ^2 comparison of symptom prevalence in boys versus girls.

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TABLE 5. Relation of SDB Symptoms to Unadjusted Prevalence of Sleepiness and Problem Behaviors*

	N†	Sleepiness (%)‡	Hyperactivity (%)	Inattention (%)	Aggressiveness (%)
Total sample	3019	10.5	18.9	17.5	12.2
Snoring frequency					
Never	1354	8.4	13.7	13.8	9.7
<1 night/wk	1018	9.8	21.0	18.3	12.2
1–2 nights/wk	270	11.5	25.9	24.1	15.9
3–5 nights/wk	180	17.2	26.7	19.4	12.8
6–7 nights/wk	181	22.1	28.2	27.1	23.8
Snoring loudness					
Does not snore	1354	8.4	13.7	13.7	9.7
Quiet	1045	10.0	20.7	18.8	12.3
Moderate	505	15.0	26.9	23.6	15.8
Loud or very loud	103	21.3	31.0	23.3	24.3
Trouble breathing during sleep					
Never	2711	9.8	17.3	16.2	11.0
<1 night/wk	199	16.1	27.6	21.1	20.1
≥1 night/wk	58	24.1	41.4	36.2	20.7
Ever stop breathing when asleep					
No	2912	10.4	18.3	17.2	12.0
Yes	102	15.7	35.3	24.5	15.7
Loud or noisy breathing when asleep					
No	2419	9.5	16.0	15.0	10.9
Yes	508	15.4	32.5	29.1	18.1
SDB composite variable§					
No	2178	8.4	14.9	14.3	9.8
Yes	744	16.8	30.2	26.2	18.4

* All associations of sleep symptoms with sleepiness and problem behaviors are significant at $P < .001$ by χ^2 test, with the exception of witnessed breathing pauses, which was significantly associated only with hyperactivity at $P < .001$.
† Numbers may not add to total sample size as a result of exclusion of subjects with symptom status "unknown."
‡ Sleepiness ≥1 day/week.
§ SDB defined as parent-reported habitual (≥3 nights/week) or loud snoring, loud or noisy breathing during sleep, trouble breathing during sleep, or witnessed sleep apnea.

TABLE 6. Adjusted Relation of SDB Symptoms* to Daytime Sleepiness and Problem Behaviors

	Sleepiness (OR [95% CI])	Hyperactivity (OR [95% CI])	Inattention (OR [95% CI])	Aggressiveness (OR [95% CI])
SDB unadjusted	2.2 (1.7–2.8)	2.5 (2.0–3.0)	2.1 (1.7–2.6)	2.1 (1.6–2.6)
SDB adjusted for sociodemographic variables†	2.2 (1.7–2.9)	2.3 (1.9–2.9)	2.0 (1.6–2.5)	2.0 (1.5–2.6)
SDB adjusted for sociodemographic and respiratory variables‡	2.1 (1.6–2.8)	1.9 (1.5–2.4)	1.8 (1.4–2.3)	1.8 (1.4–2.4)

* SDB defined as parent-reported habitual (≥3 nights/week) or loud snoring, loud or noisy breathing during sleep, trouble breathing during sleep, or witnessed sleep apnea.
† Sociodemographic variables included in model are sex, race/ethnicity, maternal education level, marital status, and household income.
‡ Respiratory health variables included in the model are frequency of upper respiratory and ear infections, tympanostomy tube placement or adenotonsillectomy, diagnosis of asthma, wheezing in the past 12 months, or respiratory allergy.

health were significantly associated with the presence of SDB symptoms, adjusting for these measures had only a small effect on the association of SDB symptoms with problem behaviors.

Several previous studies have assessed the relation of parent-reported SDB symptoms to behavior problems. Weissbluth et al[20] used a questionnaire survey of 2076 children to identify 71 with behavioral or academic problems. Compared with a control group without such problems, these children had significantly more reported snoring and difficulty breathing at night, an association that was strongest for children with academic problems or symptoms of attention-deficit/hyperactivity disorder. In a questionnaire survey of the parents of 782 children aged 4 to 5 years, Ali et al[2] found that the unadjusted prevalence of daytime sleepiness and hyperactivity increased with frequency of snoring. The Conners' Child Behavior Scale was completed by the parents of a subgroup of 34 children with symptoms most

suggestive of OSA and 52 low-risk control subjects. After adjustment for age and social class, median scores on the Hyperactivity, Inattention, and Aggression scales were at least twice as high in the high-risk group as in the low-risk group, although there was a substantially lower participation rate among high-risk (51%) versus low-risk (78%) children, raising concern of recruitment bias.[2] Recently, Chervin et al[11] evaluated 866 children who were aged 2 to 14 years and recruited from general pediatrics clinics using a sleep symptom questionnaire and the Hyperactivity Index (HI) of the CPRS. A t score >60 on the HI was seen in 22% of habitually snoring children but in only 12% of nonsnoring children, with an OR for elevated HI score of 2.2 after adjustment for age and sex. In that study, the association of snoring with elevated HI was seen primarily in boys younger than 8 years.

Both child behavior and the presence of SDB may be influenced by a variety of social and health fac-

tors, raising concern that the observed association of SDB symptoms with problem behaviors could reflect confounding by such factors. The present study has the advantage of a considerably larger sample size and more detailed covariate data than previous studies. We were particularly concerned that asthma and respiratory allergies, previously identified as risk factors for SDB in children,[5,13] or frequent respiratory infections, which might cause SDB through adenotonsillar enlargement, could also have an adverse impact on child behavior. Indeed, we observed significant associations of both SDB symptoms and problem behaviors with all sociodemographic and respiratory health variables included in the multivariate analyses, including sex, race/ethnicity, household income, maternal education level and marital status, frequency of upper respiratory and ear infections, a diagnosis of asthma, the presence of wheezing and respiratory allergies, and history of tympanostomy or adenotonsillectomy. The persistence of the association of SDB symptoms with problem behaviors after adjustment for these sociodemographic and respiratory health variables, however, indicates that confounding by these factors does not explain the observed association.

The magnitude of the association of SDB symptoms with hyperactivity in this study is similar to that reported by Chervin et al[11] for the association of habitual snoring with elevated HI. Although we also observed a somewhat stronger association in boys than in girls (adjusted OR: 2.3 vs 1.4), the effect in girls remained of borderline statistical significance, and the difference in OR between boys and girls was not statistically significant ($P = .07$). Whether this reflects true modification by sex of the effect of SDB on symptoms of hyperactivity is uncertain, although the consistency across studies and the known higher prevalence of hyperactive behavior in boys are consistent with this interpretation. However, we observed no such effect of sex on the association of SDB symptoms with parent-reported inattention or aggressiveness, despite the higher prevalence of these behaviors in boys. Sleepiness is a cardinal feature of OSA syndrome in adults and is associated with snoring independent of the presence of OSA.[21,22] Although sleepiness is generally considered a less common manifestation of OSA in children,[1] we found that children with SDB symptoms were twice as likely as those without to have parent-reported daytime sleepiness, an association somewhat stronger than that reported by Ali et al[2] for habitual snoring.

In the present study, we relied on parental report of sleepiness and problem behaviors. Although we did not use standardized measures of behavior, the construct validity of our questionnaire items was tested against the CPRS, a widely used standardized instrument for assessment of child behavior. Each of our behavior questions was found to be strongly associated with standardized measures of inattention and hyperactivity obtained from the CPRS. In contrast, our screening questions were not associated with other CPRS scales that were not expected to reflect inattention or hyperactivity, eg, Perfectionism, Social Problems, Psychosomatic, and Emotional La-

bility. Thus, the screening questions seem to be valid measures of the behavioral domains of interest. Furthermore, the specificity of the questions for hyperactive or inattentive behavior suggests that the association was not attributable to response bias, in which certain parents are likely to endorse a high level of abnormality for any symptom. This also increases our confidence that response bias is not the cause of the observed association of problem behaviors with SDB symptoms in the main analysis. Although the parental report of daytime sleepiness was not similarly validated, the question that we used to assess daytime sleepiness, "Is your child overly sleepy during the daytime?" is similar to the question, "Does your child have a problem with sleepiness during the day?" which is included in the Pediatric Sleep Questionnaire (PSQ) developed by Chervin et al.[23] Factor analysis revealed that question to be 1 of only 2 items in the PSQ loading on the factor "sleepiness."[23]

Our diagnostic criteria for SDB similarly used parental report of symptoms consistent with obstructive breathing during sleep. For our primary analysis, we used an a priori composite SDB variable that incorporated 5 questionnaire items regarding snoring frequency and loudness, the presence of loud or noisy breathing during sleep, witnessed nocturnal apneas, or trouble breathing during sleep. Although this questionnaire has not been validated in relation to objective measures of SDB, the questions are similar to those used in previously validated questionnaires. Responses of "frequent" or "constant" to questions of whether their child snored, had difficulty breathing during sleep, or stopped breathing during sleep were the 3 items that best discriminated children with OSA from age- and sex-matched control subjects drawn from general pediatric clinics on the questionnaire developed by Brouillette et al.[7] All 5 sleep symptom questions in the FYFQ are very similar to questions in Chervin's PSQ that weight on the factor "breathing," and all were retained in the questionnaire as independent predictors of the presence of polysomnographically defined SBD.[23]

Studies from France,[5] England,[2] and Italy[6] provide data on snoring frequency of children whose ages were within the range of 3 to 6 years. Although these studies did not use a uniform questionnaire instrument, snoring "often" or "most nights" was reported in 10% to 12% of the French and English children, strikingly similar to our own 12% prevalence of snoring ≥3 nights/wk.[2,5] An additional 26% of the English children were reported to snore often apart from colds, whereas 36% of the Italian children were reported to have frequent or habitual snoring.[2,6] Although snoring frequency is the symptom most often used to identify children with SDB, the report of snoring is likely to be dependent on multiple factors influencing the perception of SDB symptoms. Our data, for example, suggest cultural differences in the way sleep-related respiratory noise is labeled: among children with SDB symptoms, non-Hispanic white parents were less likely to report that their children snore and more likely to report loud, noisy breathing

during sleep than were black, Hispanic, or Asian parents.

Moreover, reliance on snoring frequency alone fails to identify a large proportion of children with SDB symptoms. In the present study, only half of children who were identified as having SDB symptoms using our composite measure were reported to snore ≥3 nights per week, yet each of the 5 SDB symptoms showed a strong association with problem behaviors (Table 5). Thus, although the 25% prevalence of SDB symptoms in the present study seems high, it is probably a more accurate representation of the prevalence of potentially important SDB symptoms than is the commonly cited 10% to 12% prevalence of habitual snoring. Although snoring frequency alone identified only half of the children with SDB symptoms in the present study, 91% of children with SDB symptoms could be identified by 2 of these items: the presence of snoring ≥3 nights/wk or the presence of loud, noisy breathing during sleep.

It is generally accepted that the adverse consequences of SDB are attributable to the effects of OSA, leading to the recommendation that children with symptoms of SDB undergo polysomnography to distinguish OSA from primary snoring (ie, snoring without OSA) to determine the need for therapeutic intervention.[1,24,25] In a group of first-grade children with OSA and poor school performance, adenotonsillectomy did lead to improvement in school performance.[17] It is unlikely, however, that the strong association of SDB symptoms with sleepiness and problem behaviors identified in this or previous epidemiologic studies is driven by the estimated 2% of children with overt OSA. Indeed, when standardized tests of inattention and hyperactivity were administered to small groups of children who underwent tonsillectomy for OSA or primary snoring, both groups had higher scores than a control group, and both groups showed improvement 3 to 6 months postoperatively, whereas the control group had no reduction in inattention or hyperactivity scores.[26] The magnitude of improvement in the primary snoring group was approximately half that of the overt OSA group. It has recently been reported that in children, there is little night-to-night variability in polysomnography and that among 30 children who were studied on 2 separate nights there was no difference between nights in the classification of children as having OSA versus primary snoring.[27] It therefore is likely that SDB symptoms are associated with problem behaviors independent of the presence of overt OSA.

Although the ICPS cohort was recruited as a population-based birth cohort, the children in the study sample are more likely to be non-Hispanic white from families with higher income and educational level than either the general population or the total ICPS cohort. This may reflect a more frequent change of residence among those with lower income and educational level, increasing their likelihood of loss to follow-up. Although this may limit generalizability of the study and may have led to a lower prevalence of SDB symptoms in the study sample than in the source population, it should not have an impact on the internal validity of the study. Moreover, the number of minority subjects included in this study approaches the total sample size of previous studies of this topic, and race and ethnicity did not confound the observed associations. The narrow age range of the children, all within several months of their fifth birthday, is both a strength and a limitation of this study. As the manifestations of SDB vary with age, the findings may not apply to children of other ages. Conversely, restriction to a narrow age range improves the ability to identify the behavioral effects at that age. Although the identification of hyperactivity and inattention may be imprecise in 5-year-olds, for whom a short attention span may be considered normal, this makes the observed association even more striking.

CONCLUSIONS

We have confirmed the presence of a strong association between SDB symptoms and problem behaviors and shown that this association is not attributable to confounding by sociodemographic or respiratory health correlates of SDB. The high prevalence of SDB symptoms suggests that SDB may contribute substantially to the prevalence of sleepiness, hyperactivity, and inattention and should be considered as a possible cause when evaluating these common problem behaviors. Although adenotonsillar hypertrophy is not the sole cause of SDB, adenotonsillectomy leads to resolution of OSA in the majority of affected children.[1] If SDB is indeed a cause of sleepiness and problem behaviors independent of overt polysomnographic OSA, then identification of the problem at 5 years of age may be particularly valuable, as it would allow therapeutic intervention before the crucial transition to primary school. Although it is premature to recommend adenotonsillectomy on the basis of SDB symptoms alone, without polysomnographic evidence of OSA or obstructive hypoventilation, the pediatrician may want to consider SDB-associated problem behaviors, in addition to polysomnographic measures of physiologic compromise, when considering therapeutic options for SDB.

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AROUND THE WORLD, GAINS IN INTERNET USE

"When it comes to Internet use, the United States ranks first in the world, but many other countries are also showing gains, a recent survey shows. The survey—conducted by the Ipsos-Reid Corporation, a marketing research firm—was based on interviews last spring with 6600 adults in 12 countries, in North America, South America, Europe, and Asia. The results were released last week. The survey found that 54% of the population in the countries surveyed, on average, indicated that they had gone online at least once over the previous 30 days. In the United States, 72% of those surveyed were recent Internet users, up from 59% in 2000. Canada was second at 62%, up from 60% in 2000. Rounding out the top 5 were South Korea, 53%, up from 35%; Britain, 50%, up from 35%; and Japan, 47%, up from 33%."

New York Times. February 18, 2003

Noted by JFL, MD

Symptoms of Sleep-Disordered Breathing in 5-Year-Old Children Are Associated
With Sleepiness and Problem Behaviors

Daniel J. Gottlieb, Richard M. Vezina, Cynthia Chase, Samuel M. Lesko, Timothy C. Heeren, Debra E. Weese-Mayer, Sanford H. Auerbach and Michael J. Corwin

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