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Symptoms of Sleep Disorders, Inattention, and Hyperactivity in Children

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Summary: Children with sleep disorders are often inattentive or hyperactive, and some carry a diagnosis of attention deficit/hyperactivity disorder (ADHD) until their sleep disorder is detected. However, the potential behavioral impact of undiagnosed sleep disorders is not known. We sought to determine whether children with higher levels of inattention and hyperactivity more frequently have symptoms of sleep-related breathing disorders (SRBDs) or periodic limb movement disorder (PLMD). We surveyed parents of 2–18-year-old patients at a child psychiatry clinic (n = 70) and a general pediatrics clinic (n = 73) to assess the children's behavior, snoring, complaints of restless legs at night, and daytime sleepiness. A validated pediatric sleep questionnaire provided the explanatory variables, and a scale for inattention and hyperactivity, derived from the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV), provided the dependent variable. Habitual snoring was more frequent (33%) among children who carried a diagnosis of ADHD than among the other children at the psychiatry or general pediatric clinics (11 and 9%, respectively, chi-square test, p = 0.01). Snoring scores, derived from six snoring- and SRBD-related question items, were associated with higher levels of inattention and hyperactivity. The complaint of restless legs and a composite score for daytime sleepiness showed some evidence, though less consistent, of an association with inattention and hyperactivity. The association of snoring with inattention and hyperactivity suggests that SRBDs and perhaps other sleep disorders could be a cause of inattention and hyperactivity in some children. If a causal effect is present, our data suggest that 81% of habitually snoring children who have ADHD—25% of all children with ADHD—could have their ADHD eliminated if their habitual snoring and any associated SRBD were effectively treated. **Key Words:** Snoring—Sleep—Hyperactivity—Attention deficit/hyperactivity disorder—Obstructive sleep apnea—Children.

Inattention and hyperactivity are common behavioral problems in children, among whom the prevalence of attention deficit/hyperactivity disorder (ADHD) is 3–5% (1–3). It is likely that these behaviors have multiple causes, but the pathophysiology of ADHD is not well understood. One possibility is that some children with ADHD have a deficient level of arousal (4). More than 60 years ago, the observation was made that children with ADHD improve with stimulant medication (5,6), and since then a variety of neurophysiological studies have confirmed that ADHD is associated with hypovigilance rather than hypervigilance (4). Why these children might have deficient arousal has not been explained, but several lines of evidence suggest that disorders of nocturnal sleep could play a role.

Children found to have sleep-related breathing disorders (SRBDs), specifically obstructive sleep apnea or upper airway resistance syndrome, often display both inattention and hyperactivity; not uncommonly, they have already received stimulants in the past for ADHD (7,8). In a community survey of parents, investigators found that children with symptoms of obstructive sleep apnea were more likely to be hyperactive (9). Children with periodic limb movement disorder (PLMD) may also have an increased risk for inattention and hyperactivity (10). Furthermore, treatment for either SRBDs or PLMD can lead to dramatic improvement in behavior and discontinuation of stimulant medication (7,8,10–14).

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Despite mounting evidence that links ADHD with sleep disorders, little is known about the behavioral impact of sleep disorders among children outside the population that presents to sleep centers. One study found an increased frequency of snoring among 14 children with ADHD (15). Several small polysomnographic studies have reported evidence of disrupted sleep in ADHD, but none used optimal equipment to detect SRBDs and PLMD (16–20), perhaps because these conditions have only recently been recognized as common among children (9,21,22).

Although nocturnal polysomnography in a sleep laboratory is the gold standard for the diagnosis of SRBDs and PLMD, the presence of characteristic symptoms has significant predictive value, and sleep questionnaires can be useful in epidemiological research (9,22–24) because they can be administered more readily to a larger sample. Most children with SRBDs snore or snort during sleep, and some are excessively sleepy during the day, although this symptom is not as consistent in children as in adults (25–27). Children are well able to describe restless legs when queried and can be diagnosed with restless legs syndrome (10); presumably this syndrome is frequently associated with PLMD, as in adults.

To investigate the potential relation of SRBDs and PLMD to inattention and hyperactivity in children who have not presented to a sleep disorders center, we surveyed parents of children attending a pediatric psychiatry clinic and a general pediatrics clinic. We administered validated questionnaire items about snoring, restless legs, and daytime sleepiness and tested for an association between these symptoms and parental reports of symptoms of ADHD as defined by the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV).

METHODS

Subjects

Parents of children attending the Child and Adolescent Psychiatry Clinic (n = 70) and the General Pediatrics Clinic (n = 73) at the University of Michigan Medical Center in 1995 and 1996 were given two self-administered questionnaires that were then used to assess the hypothesized independent and dependent variables. The psychiatry patients were consecutive over a several-month period, whereas those at the general clinic had appointments on prearranged survey days. No sleep complaint or disorder was used as a criterion for inclusion or exclusion. Inclusion criteria included age 2–18 years, absence of mental retardation severe enough to prevent parental assessment of inattention and hyperactivity, and presence of a parent or guardian able to provide the requested information. In addition, psychiatry patients were included only if a clinical psychiatric diagnosis was available. Five general pediatric patients were excluded because their parents reported a past diagnosis of ADHD or treatment with a stimulant medication. At least 85% of the distributed questionnaires in each clinic contained responses complete enough to use for the subsequent analyses.

TABLE 1. *Items from pediatric sleep questionnaire that were used to determine snoring, restless legs, and sleepiness scores*

1.	Does he/she snore more than half the time while sleeping?
2.	Does he/she always snore when sleeping?
3.	Does he/she snore loudly?
4.	Does he/she have "heavy" or loud breathing while sleeping?
5.	Does he/she look as if he/she is having trouble breathing, or struggling to breathe, while sleeping?
6.	Have you ever seen him/her make a snorting sound and wake himself/herself up?
7.	Does he/she say that his/her legs feel restless when he/she is in bed?
8.	Does your child wake up feeling *un*refreshed in the morning?
9.	Does he/she have a problem with sleepiness during the day?
10.	Is it hard to wake him/her up in the morning?

Items 1–6 were averaged to derive the snoring score, item 7 was used as the restless legs score, and items 8–10 were averaged to derive the sleepiness score.

Instruments, validity, and reliability

Snoring, the complaint of restless legs at night, and sleepiness were assessed with a pediatric sleep questionnaire (PSQ) that was developed and validated in part for this study. The full PSQ consists of 69 questions for which the respondent must circle "Yes", "No", or "Don't Know", and several open-ended questions on demographics, sleep schedules, and medications. Questions are short and simple; the questionnaire requires about 20 minutes to complete. For the present study, answers to each of six snoring-related questions were averaged to obtain a "snoring score"; answers to one question provided a "restless legs score"; and answers to three other questions provided a "sleepiness score" (Table 1).

Subjective reports about snoring are among the best ways to assess its presence (28), in part because objective measures of snoring do not distinguish it from other noises very well (29). However, we also established the validity of the snoring score as a predictor of SRBDs with data from 48 children apart from those discussed in the remainder of this report. Of these children, 16 were recruited consecutively from our sleep laboratory and had polysomnographically confirmed SRBDs; 32 children were recruited consecutively at a general pediatrics clinic and were assumed not to have an SRBD. The latter assumption could have misclas-

sified a small percentage [less than 10% (25)] of the children, but the error probably weakens, rather than strengthens, subsequent tests of validity. The two groups of children showed no statistically significant differences in age, gender, or body weight. The PSQ-derived snoring score was highly predictive of SRBDs in the 48 subjects (logistic regression $p = 0.0001$, $R^2 = 0.49$). In addition, each of the six individual component items was highly predictive of an SRBD ($p = 0.001$ for each item). Reliability of the snoring score, as reflected by internal consistency, was high (Cronbach's alpha = 0.88).

Previous work has similarly found that responses to questions about snoring in children can have good predictive value for polysomnographic findings (30). Questionnaires do not have adequate predictive value to replace polysomnography in clinical practice, but they can provide useful tools in epidemiological research (31).

The validity of the restless legs score was tested among six children who had more than five periodic leg movements per hour of sleep on polysomnography and the 32 general pediatric subjects, who were reasonably presumed not to have PLMD (10). The restless legs score was predictive of the polygraphic abnormality ($p = 0.017$, $R^2 = 0.15$). The sleepiness score could not be validated against multiple sleep latency tests because only four patients had had them. However, the sleepiness score was higher among the 16 SRBD subjects ($p = 0.0006$, $R^2 = 0.22$ for the composite score, and, in addition, $p < 0.05$ for each of the three individual question items) and higher among the six PLMD subjects ($p = 0.0002$, $R^2 = 0.31$) than among the 32 general pediatric patients.

The outcome measures were 18 "category A" symptoms listed in the DSM-IV under ADHD (32). These symptoms (Table 2) focus on inattention (items 1 through 9) and hyperactivity (including impulsivity, items 10 through 18) and have high positive and negative predictive values for ADHD (33). The symptoms were listed with a four-point Likert parental response scale for each, in parallel to a method previously validated and used in a large epidemiological study of ADHD (33). The instrument takes parents about 5 minutes to complete. The mean response to the 18 items formed the inattention/hyperactivity score (IHS); we used this score as a measure of the behavioral problems that define ADHD and as the main outcome variable in this study.

Other information, such as demographic data and psychiatric diagnoses, was obtained from patient charts. Diagnoses that were not considered definite were recorded as not present. Some children had more than one diagnosis.

TABLE 2. *Question items contributing to inattention (items 1–9)/hyperactivity (items 10–18) score*

Item	"This child often . . ."[a]
1.	. . . fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
2.	. . . has difficult sustaining attention in tasks or play activities
3.	. . . does not seem to listen when spoken to directly
4.	. . . does not follow through on instructions and fails to finish schoolwork, chores, or duties
5.	. . . has difficulty organizing tasks and activities
6.	. . . avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as homework or schoolwork)
7.	. . . loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, book, or tools)
8.	. . . is easily distracted by extraneous stimuli
9.	. . . is forgetful in daily activities
10.	. . . fidgets with hands or feet or squirms in seat
11.	. . . leaves seat in classroom or in other situations in which remaining seated is expected
12.	. . . runs about or climbs excessively in situations in which it is inappropriate
13.	. . . has difficulty playing or engaging in leisure activities quietly
14.	. . . is "on the go" or often acts as if "driven by a motor"
15.	. . . talks excessively
16.	. . . blurts out answers before questions have been completed
17.	. . . has difficulty awaiting his/her turn
18.	. . . interrupts or intrudes on others (e.g., butts into conversations or games)

Question items were derived from the *Diagnostic and Statistical Manual of Mental Disorders,* 4th ed., as described in the text.

[a] The parent was asked to choose one of four responses to each item: "does not apply", "applies just a little", "applies quite a bit", or "definitely applies most of the time". Point values from 0 to 3, respectively, were then assigned to each of these answers, and responses were averaged to generate the inattention/hyperactivity score.

Analysis

Subjects who carried a diagnosis of ADHD at the psychiatry clinic were combined alternatively with two comparison groups, each expected to have lower IHS—the non-ADHD children at the psychiatry clinic and those at the general pediatrics clinic—to provide a wide range of IHS scores and optimize detection of linear relationships between IHS and the explanatory variables. Statistical analyses were performed on a personal computer with SAS® (SAS Institute Inc., Cary, NC). Summary measures were expressed as means ± standard deviations. We analyzed categorical data with chi-square tests or logistic regression. We used simple linear regressions to test for association of snoring, restless legs, and sleepiness scores as explanatory variables with IHS as the outcome variable. Multiple linear regressions were used to control for potential confounding factors. The significance level was set at 0.05.

TABLE 3. *Age, sex, and use of stimulant medication among subjects in the attention deficit/hyperactivity disorder (ADHD), non-ADHD psychiatric, and general pediatric groups*

Group	n	Number (%) male	Age (mean ± SD)	% Taking stimulant
ADHD subjects	27	26 (96)	9.5 ± 3.7	44
Non-ADHD psychiatry subjects	43	22 (51)[a]	11.0 ± 4.8	5[a]
General pediatric subjects	73	29 (40)[a]	7.7 ± 4.6	0[a]

[a] Significantly different from ADHD subjects, $p < 0.05$.

TABLE 4. *Diagnoses among children attending the psychiatry clinic (n = 70)*

Number of patients	Diagnosis
27	ADHD
	4 ADHD diagnosis made primarily on basis of inattention
13	Oppositional/defiant disorder or conduct disorder
17	Affective disorder
10	Anxiety disorder or obsessive/compulsive disorder
10	Learning disability or communication disorder
8	Other

ADHD, attention deficit/hyperactivity disorder.
Some children carried more than one diagnosis.

RESULTS

Subjects

The study sample included 77 boys and 66 girls, aged 2–18 years (mean 9.0, SD 4.7 years). The ADHD group did not differ significantly from either of the other two in age but, as expected, contained a higher percentage of boys and more children who took stimulant medication (Table 3). Among the 70 psychiatry subjects, 27 (39%) had a diagnosis of ADHD (Table 4). At the general pediatrics clinic, the 73 children came for a variety of reasons, the more common of which included well-child visits or immunizations (n = 25); asthma, environmental allergies, sore throat, earache, or upper respiratory infection (n = 32); abdominal or gastrointestinal problems (n = 4); injury or pains (n = 4); and rash (n = 3). As expected, the children with ADHD had a significantly higher IHS (2.00 ± 0.71) than those at the psychiatry clinic with other diagnoses (1.19 ± 0.74) and those at the general pediatrics clinic (0.55 ± 0.55) (analysis of variance, $p < 0.0001$, $R^2 = 0.43$).

Relation of diagnosis to snoring, restless legs, and sleepiness

Habitual snoring, taken as a positive answer to question 1 in Table 1, was more frequent (chi-square, p = 0.01) among children with ADHD (33%) than among psychiatry clinic subjects without ADHD (11%) and general pediatric subjects (9%). In the comparison of the ADHD children to those at the general pediatrics clinic, the odds ratio (OR) for habitual snoring was 5.17, and nearly identical results were obtained after accounting for age and gender in a logistic regression model. The attributable risk percent (34) was 81%, which suggests that if habitual snoring (or any associated sleep-disordered breathing) can cause ADHD, then 81% of ADHD cases among children who habitually snore could be eliminated if habitual snoring were controlled. If the prevalence of habitual snoring in children is estimated to be 8% (9,35,36), the population attributable risk percent is 25%: this result suggests that one-quarter of all cases of ADHD in children could be eliminated if habitual snoring were controlled.

Other question items about snoring and restless legs showed trends similar to that seen with habitual snoring, but differences among groups did not reach statistical significance (Table 5). Psychiatric subjects were more often reported to be unrefreshed in the morning than general pediatric subjects (p = 0.008), but the other two questions related to sleepiness showed no significant differences among the three groups.

The composite snoring scores were significantly higher among the ADHD children than among the non-ADHD psychiatric subjects (logistic regression, p = 0.027, OR = 9.0), but the difference was not statistically significant after taking gender into account. The ADHD children did not have significantly higher snoring scores than the general pediatrics children (p = 0.14, OR = 3.3). Restless legs scores and sleepiness scores were not significantly different among children

TABLE 5. *Number and percent of subjects in each group who were reported to have indicated sleep symptom*

Item	ADHD subjects (n = 27)	Non-ADHD psychiatry subjects (n = 43)	General pediatric subjects (n = 73)
1. Habitual snoring[a]	8 (33%)	4 (11%)	6 (9%)
2. Always snoring	5 (19%)	3 (8%)	8 (11%)
3. Loud snoring	6 (23%)	3 (7%)	11 (15%)
4. Heavy breathing	9 (36%)	9 (23%)	17 (24%)
5. Difficulty breathing	4 (15%)	2 (5%)	7 (10%)
6. Waking with a snort	5 (19%)	3 (7%)	9 (13%)
7. Restless legs	4 (15%)	2 (5%)	7 (10%)
8. Unrefreshed in a.m.[a]	10 (50%)	20 (59%)	20 (29%)
9. Daytime sleepiness	7 (28%)	11 (30%)	17 (24%)
10. Hard to wake up	12 (44%)	18 (42%)	19 (26%)

ADHD, attention deficit/hyperactivity disorder.
[a] Chi-square $p < 0.05$ for the difference between subject groups.
Percent of subjects determined as number of positive answers divided by sum of positive and negative answers and multiplied by 100 (i.e. the few who answered "don't know" were excluded).

with ADHD in comparison with either of the other groups ($p > 0.05$).

Relation of behavior to snoring

Among those subjects who had ADHD or attended the general pediatrics clinic, the snoring score showed significant association with IHS (linear regression, $p = 0.006$, $R^2 = 0.08$). When analyses were confined to ADHD subjects and non-ADHD psychiatric subjects, the snoring score was also significantly associated with IHS ($p = 0.006$, $R^2 = 0.11$). The IHS was still significantly associated with the snoring score ($p = 0.01$) in multiple regressions that controlled for three potential confounding factors—age, sex, and use of stimulant medication—among both groupings of subjects. When the analysis was limited to the 73 general pediatrics subjects only, IHS was still associated with snoring score ($p = 0.05$).

Further analyses among the 100 patients who had ADHD or attended the general pediatrics clinic included one regression model that divided patients into four categories by snoring score and another model that employed a quadratic term (snoring score squared). Neither of these nonlinear models explained the relation with IHS better than the original model. Regression of IHS on each separate item within the snore score showed that by far the best explanatory variable was question 1 in Table 1: this item alone explained 16% ($100 \times R^2$) of the variance in IHS ($p < 0.0001$). The next best variable was question 3, which alone explained 5% of the variance ($p = 0.03$). A multiple regression of IHS on all six snoring score components explained 20% of the variance in the behavioral measure ($p = 0.006$).

Relation of behavior to restless legs and sleepiness

Regression of IHS on the restless legs score showed no significance when the ADHD subjects were grouped with the general pediatric subjects but did show significance when the former were grouped with the non-ADHD psychiatry subjects ($p = 0.01$, $R^2 = 0.09$). The results were similar in multiple regression models that controlled for age, sex, and stimulant use. When the analysis was limited to the 73 subjects recruited at the general pediatrics clinic, IHS was not associated with the restless legs score ($p = 0.49$).

The IHS was associated with the sleepiness score in the ADHD/general pediatrics ($p = 0.003$, $R^2 = 0.09$), but not the ADHD/non-ADHD psychiatry ($p = 0.20$), analysis. Results were essentially unchanged after age, sex, and stimulant use were taken into account. Among the general pediatric subjects alone, IHS was associated with the sleepiness score ($p = 0.004$).

Consideration of snoring, restless legs, and sleepiness together

The snoring score, restless legs score, and sleepiness score among all subjects were each correlated (Spearman $p < 0.05$) with the other two variables. A multiple regression model that used the three scores as explanatory variables explained 12% of the variance in IHS ($p = 0.007$) among the ADHD/general pediatrics group and 11% of the variance in IHS ($p = 0.06$) among the ADHD/non-ADHD psychiatry subjects. An alternative model (applied to ADHD/general pediatrics subjects) that used only the first snoring question (item 1) in Table 1, the first sleepiness question (item 8), and the restless legs question (item 7) explained 19% of the variance in IHS ($p = 0.0009$). In this model, snoring and sleepiness each retained significance after accounting for the other two explanatory variables in the model, but restless legs did not.

DISCUSSION

This study demonstrates associations between symptoms that define ADHD and those that characterize two types of sleep disorders. Inattention and hyperactivity were consistently linked with snoring—particularly with the report of snoring more than half the time while asleep—and less consistently linked with symptoms of excessive sleepiness and restless legs. Habitual snoring was found in 33% of children who carried a diagnosis of ADHD but only about 10% of children in two comparison groups. When analyses were confined to children who attended a general pediatrics clinic and had never received a diagnosis of ADHD, snoring and symptoms of excessive daytime sleepiness were associated with higher levels of inattention and hyperactivity. These findings in subjects who had not been selected for any sleep complaints provide evidence that undiagnosed SRBDs, and perhaps PLMD, could affect behavior in a substantial number of children who are not commonly evaluated for sleep disorders.

To improve the chance of detecting a relation between IHS and sleep-related symptoms, we sought a sample of subjects with both high and low IHS scores. The ADHD subjects were grouped with two alternative comparison groups, each of which provided, as expected, lower IHS scores. Neither of these "control" groups was ideal because sleep disturbances and especially SRBDs can be associated with psychiatric disorders other than ADHD, such as depression (37), and may be more common among children recruited at a general pediatrics clinic because a substantial proportion of patient visits are for respiratory disorders. However, removal of such confounds would have

strengthened, not weakened, the conclusion that inattention and hyperactivity are associated with symptoms of SRBDs and PLMD. In addition, the frequency of habitual snoring in our two comparison groups is close to that reported in larger community surveys (9,35,36).

We do not have a ready explanation for why restless legs was associated with IHS when non-ADHD psychiatry subjects, but not general pediatric subjects, were considered with the ADHD subjects, and we do not know why the reverse pattern was observed for the relation between the sleepiness score and IHS. The findings suggest that associations between these explanatory variables and IHS are less certain than the association between snoring and IHS, which was found in either grouping of the subjects and was also evident within the general pediatrics sample alone. Other authors have suggested that restless legs syndrome and PLMD may be more common among children with ADHD (10), but no large epidemiological studies have addressed this issue. Our results may have been less ambiguous if we had used additional validated question items related to restless legs syndrome and PLMD. Sleepiness is not as frequent among children with SRBDs as it is among adults with these disorders (38), and evidence of excessive sleepiness may be obscured from parents confronted with other behavioral changes that accompany ADHD.

In light of the identified association between IHS and snoring, it was somewhat surprising that children who carried the diagnosis of ADHD did not have higher snoring scores than other children after adjustment for gender. Carskadon et al. (39) also reported that symptoms of SRBDs in 21 children with ADHD were not unusually frequent. The weakened association between ADHD and snoring scores in our data after controlling for gender may have been an artifactual result of the nearly complete segregation of gender with the diagnosis of ADHD; all but one of the ADHD subjects were male, and adjustment for gender may not be appropriate in this circumstance. A potential explanation for the lack of a stronger association between ADHD and snoring scores is that sleep-disordered breathing may be associated with other psychiatric diagnoses or respiratory disorders, as mentioned above. The inattention/hyperactivity scale used in this study could be a more sensitive instrument than a dichotomous clinical classification. Considerable overlap exists between ADHD-associated behavior and that seen in several psychiatric diagnoses (33,40), most notably conduct disorder and oppositional defiant disorder, which were present in 19% of our patients. Lastly, larger differences in snoring between children with and without ADHD may have appeared if diagnostic classifications had been made not by chart review and parental report but by rigorous, prospective diagnostic evaluations.

On the basis of the results of our survey, one would expect that polysomnographic studies of children with ADHD would reveal the presence of SRBDs. Such has not been the case. However, most investigators have focused exclusively on sleep staging and architecture and have not monitored breathing (16–20). One group that did monitor breathing did not include the resulting data in their report (41). Furthermore, recent research has shown that special equipment and scoring techniques are necessary to identify the type of sleep-disordered breathing frequently found in children. Children tend to have more subtle hypopneas rather than frank apneas, and transcutaneous or end-tidal monitoring of pCO_2 is necessary in many cases to recognize the disorder (25,38). A substantial number of children may have an SRBD without apneas or hypopneas, showing only increased effort to breathe during sleep, and consequent brief arousals; this is the more recently described upper airway resistance syndrome, detection of which may require monitoring of intrathoracic pressures by using an esophageal catheter (8,42,43). Children with SRBDs often show sleep architecture disturbed by either few arousals or arousals too brief to have been scored in past studies of ADHD (44). To our knowledge, no polysomnographic studies of children with ADHD have been published that have used the optimal equipment and scoring techniques to assess for SRBDs in this age group.

Although parents often complain about their hyperactive children's sleep onset insomnia, frequent awakenings, and restless sleep (45), investigators have often considered these features to be results of the behavior disorder or treatment rather than an etiological factor. In the current study, leg restlessness at night, although suggestive of periodic limb movement disorder according to our validation data, could conceivably represent an effect of hyperactivity on nocturnal motor activity. Similarly, sleepiness could be increased in children who behave disruptively during the day or before bedtime. However, snoring is difficult to attribute to hyperactivity. Our results raise the possibility that SRBDs, and perhaps other sleep disorders, may cause inattention and hyperactivity. One-third of our subjects with ADHD snored habitually; any underlying causal relation, therefore, could have a substantial epidemiological impact. Specifically, if a causal relation does exist, our data suggest that control of snoring and associated SRBDs could eliminate ADHD in 81% of children

who have ADHD and habitually snore and in 25% of all children who have ADHD.

In conclusion, we have identified several simple questions about snoring, restless legs, and daytime sleepiness that appear to predict the levels of inattention and hyperactivity in children. Because previous research has shown that ADHD in children with sleep disorders improves or resolves when the sleep disorders are identified and treated (7,8,10–14), we recommend that questions about relevant symptoms be used in the evaluation of children presenting with hyperactivity. When such questions indicate that a primary sleep disorder might be present, evaluation in a sleep laboratory equipped for the special diagnostic needs of children with SRBDs should be considered. We speculate that sleep disorders could be a cause rather than an effect of hyperactivity in a significant number of children. Recent media attention has focused on widespread and growing use of stimulants for inattentive or hyperactive children (46). It may currently be possible to identify a subset of these children who would benefit more from the treatment of their underlying sleep disorder than from symptomatic treatment with a stimulant.

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REFERENCES

1. Barkley RA. *Attention-deficit hyperactivity disorder: a handbook for diagnosis and treatment.* New York: Guilford Press, 1990:1–747.
2. Satterfield JH, Dawson ME. Electrodermal correlates of hyperactivity in children. *Psychophysiology* 1971;8:191–7.
3. Shaywitz S, Shaywitz BA. Introduction to the special series on attention deficit disorder. *J Learning Disabil* 1991;24:68–71.
4. Weinberg WA, Harper CR. Vigilance and its disorders. *Neurol Clin* 1993;11:59–78.
5. Bradley C. The behavior of children receiving benzedrine. *Am J Psychiatry* 1937;94:577–85.
6. Bradley C, Bowen M. Amphetamine (benzedrine) therapy of children's behavior disorders. *Am J Orthopsychiatry* 1941;11: 92–103.
7. Guilleminault C, Korobkin R, Winkle R. A review of 50 children with obstructive sleep apnea syndrome. *Lung* 1981;159: 275–87.
8. Guilleminault C, Winkle R, Korobkin R, Simmons B. Children and nocturnal snoring—evaluation of the effects of sleep related respiratory resistive load and daytime functioning. *Eur J Pediatr* 1982;139:165–71.
9. Ali NJ, Pitson DJ, Stradling JR. Snoring, sleep disturbance, and behaviour in 4–5 year olds. *Arch Dis Child* 1993;68:360–6.
10. Picchietti DL, Walters AS. Restless legs syndrome and periodic limb movement disorder in children and adolescents: comorbidity with attention-deficit hyperactivity disorder. *Child Adolesc Psychiat Clin N Am* 1996;5:729–40.
11. Picchietti DL, Walters AS. Severe periodic limb movement disorder in childhood and adolescence. *Sleep Res* 1996;25:333.
12. Guilleminault C, Eldridge F, Simmons FB. Sleep apnea in eight children. *Pediatrics* 1976;58:23–30.
13. Buda FB. Various childhood sleep problems causing behavioral and attention deficit disorders. *Sleep Res* 1995;24:209.
14. Ali NJ, Pitson D, Stradling JR. Sleep disordered breathing: effects of adenotonsillectomy on behaviour and psychological functioning. *Eur J Pediatr* 1996;155:56–62.
15. Simonds JF, Parraga H. Sleep behaviors and disorders in children and adolescents evaluated at psychiatric clinics. *J Dev Behav Pediatr* 1984;5:6–10.
16. Busby K, Firestone P, Pivik RT. Sleep patterns in hyperkinetic and normal children. *Sleep* 1981;4:366–83.
17. Greenhill L, Puig-Antich J, Goetz R, Hanlon C, Davies M. Sleep architecture and REM sleep measures in prepubertal children with attention deficit disorder with hyperactivity. *Sleep* 1983;6: 91–101.
18. Haig JR, Schroeder CS, Schroeder SR. Effects of methylphenidate on hyperactive children's sleep. *Psychopharmacology (Berl)* 1974;37:185–8.
19. Small A, Hibi S, Feinberg I. Effects of dextroamphetamine sulfate on EEG sleep patterns of hyperactive children. *Arch Gen Psychiatry* 1971;25:369–80.
20. Palm L, Persson E, Bjerre I, Elmqvist D, Blennow G. Sleep and wakefulness in preadolescent children with deficits in attention, motor control and perception. *Acta Paediatr* 1992;81:618–24.
21. Walters AS, Picchietti DL, Ehrenberg BL, Wagner ML. Restless legs syndrome in childhood and adolescence. *Pediatr Neurol* 1994;11:241–5.
22. Gislason T, Benediktsdottir B. Snoring, apneic episodes, and nocturnal hypoxemia among children 6 months to 6 years old. An epidemiologic study of lower limit of prevalence. *Chest* 1995;107:963–6.
23. Carroll JL, McColley SA, Marcus CL, Curtis S, Loughlin GM. Inability of clinical history to distinguish primary snoring from obstructive sleep apnea syndrome in children. *Chest* 1995;108: 610–8.
24. Ohayon MM, Guilleminault C, Priest RG, Caulet M. Snoring and breathing pauses during sleep: telephone interview survey of a United Kingdom population sample. *BMJ* 1997;314:860–3.
25. American Thoracic Society, Medical Section of the American Lung Association. Standards and indications for cardiopulmonary sleep studies in children. *Am J Respir Crit Care Med* 1996; 153:866–78.
26. Carroll JL, Loughlin GM. Diagnostic criteria for obstructive sleep apnea syndrome in children. *Pediatr Pulmonol* 1992;14: 71–4.
27. Marcus CL, Carroll JL. Obstructive sleep apnea syndrome. In: Loughlin GM, Eigen H, eds. *Respiratory disease in children: diagnosis and management.* Baltimore: Williams and Wilkins, 1993:475–99.
28. Hoffstein V. Snoring. *Chest* 1996;109:201–22.
29. Hoffstein V, Mateika S, Nash S. Comparing perceptions and measurements of snoring. *Sleep* 1996;19:783–9.
30. Brouillette RT, Hanson D, David R, et al. A diagnostic approach to suspected obstructive sleep apnea in children. *J Pediatr* 1984; 105:10–4.
31. Kump K, Whalen C, Tishler PV, et al. Assessment of the validity and utility of a sleep-symptom questionnaire. *Am J Respir Crit Care Med* 1994;150:735–41.
32. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed. Washington, DC: American Psychiatric Association, 1994:1–886.
33. Pelham WE Jr, Gnagy EM, Greenslade KE, Milich R. Teacher ratings of DSM-III-R symptoms for the disruptive behavior disorders. *J Am Acad Child Adolesc Psychiatry* 1992;31:210–8.
34. Hennekens CH, Buring JE. *Epidemiology in medicine.* Boston: Little, Brown and Company, 1987:1–383.
35. Corbo GM, Fuciarelli F, Foresi A, De Benedetto F. Snoring in children: association with respiratory symptoms and passive smoking. *BMJ* 1989;299:1491–4.
36. Teculescu DB, Caillier I, Perrin P, Rebstock E, Rauch A. Snor-

ing in French preschool children. *Pediatr Pulmonol* 1992;13: 239–44.
37. Millman RP, Fogel BS, McNamara ME, Carlisle CC. Depression as a manifestation of obstructive sleep apnea: reversal with nasal continuous positive airway pressure. *J Clin Psychiatry* 1989;50: 348–51.
38. Rosen CL, D'Andrea L, Haddad GG. Adult criteria for obstructive sleep apnea do not identify children with serious obstruction. *Am Rev Respir Dis* 1992;146:1231–4.
39. Carskadon MA, Pueschel SM, Millman RP. Sleep-disordered breathing and behavior in three risk groups: preliminary findings from parental reports. *Childs Nerv Syst* 1993;9:452–7.
40. Hinshaw SP. On the distinction between attentional deficits/hyperactivity and conduct problems/aggression in child psychopathology. *Psychol Bull* 1987;101:443–63.
41. Platon MJR, Bueno AV, Sierra JE, Kales S. Hypnopolygraphic alterations in attention deficit disorder (ADD) children. *Int J Neurosci* 1990;53:87–101.
42. Guilleminault C, Stoohs R, Clerk A, Cetel M, Maistros P. A cause of excessive daytime sleepiness: the upper airway resistance syndrome. *Chest* 1993;104:781–7.
43. Guilleminault C, Pelayo R, Leger D, Clerk A, Bocian RCZ. Recognition of sleep-disordered breathing in children. *Pediatrics* 1996;98:871–82.
44. Mograss MA, Ducharme FM, Brouillette RT. Movement/arousals: description, classification, and relationship to sleep apnea in children. *Am J Respir Crit Care Med* 1994;150:1690–6.
45. Kaplan BJ, McNicol J, Conte RA, Moghadam HK. Sleep disturbance in preschool-aged hyperactive and nonhyperactive children. *Pediatrics* 1987;80:839–44.
46. Hancock L, Wingert P, Hager M, Kalb C, Springen K, Chinni D. Mother's little helper. *Newsweek* 1996;March 18:51–6.