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Daytime Sleepiness and Hyperactivity in Children With Suspected Sleep-Disordered Breathing

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ABSTRACT. *Objectives.* **Excessive daytime sleepiness (EDS) is seen less frequently as a presenting complaint in children with sleep-disordered breathing than in adults. Instead, symptoms of hyperactivity are often described. We hypothesized that children with suspected sleep-disordered breathing (S-SDB) were both sleepier and more hyperactive than control subjects. Furthermore, we hypothesized that overnight polysomnographic parameters correlated with sleepiness and hyperactivity.**

Methods. **A cross-sectional study was conducted at a university-affiliated hospital and a community-based pediatric clinic. A total of 108 patients with S-SDB (mean [standard deviation] age: 7 ± 4 years) and 72 control subjects (8 ± 4 years) were recruited. A modified Epworth Sleepiness Scale (ESS) and the Conners Abbreviated Symptom Questionnaire were administered. Polysomnography was performed in patients with S-SDB.**

Results. **Patients with S-SDB had a higher ESS (8.1 ± 4.9 vs 5.3 ± 3.9) and a higher Conners score (12.8 ± 7.6 vs 9.0 ± 6.2) than control subjects. On the basis of adult criteria, 28% of patients had EDS. There was no difference in the ESS and Conners scores of patients with primary snoring and patients with obstructive sleep apnea. The ESS had weak correlations with polysomnographic parameters.**

Conclusions. **Although the ESS score of children with S-SDB was within the normal range for adults, these children were sleepier and more hyperactive than control subjects. However, these data should be confirmed by a population-based study.** ***Pediatrics* 2004;114:768–775;** ***obstructive sleep apnea, Epworth score, polysomnography.***

ABBREVIATIONS. OSAS, obstructive sleep apnea syndrome; EDS, excessive daytime sleepiness; SDB, sleep-disordered breathing; S-SDB, suspected sleep-disordered breathing; PSG, polysomnography; ESS, Epworth Sleepiness Scale; Sao_2, arterial oxygen saturation; $ETco_2$, end-tidal carbon dioxide tension; PS, primary snoring; PLM, periodic limb movement; REM, rapid eye movement; UARS, upper airway resistance syndrome; EEG, electroencephalogram.

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The childhood obstructive sleep apnea syndrome (OSAS) is a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction and/or intermittent complete obstruction that disrupts normal ventilation during sleep and normal sleep patterns.[1] It has an estimated prevalence of 1% to 2% among young children[2,3] and can lead to serious morbidity and even mortality if left untreated.[4–7]

In contrast to adults, excessive daytime sleepiness (EDS) is seen less frequently as a presenting complaint in children with sleep-disordered breathing (SDB).[4,8–10] Symptoms of inattention and hyperactivity are often described.[8] The prevalence of EDS in children with SDB has been shown to vary over a wide range, from as low as 8% to as high as 84%.[7,9–12] The significantly differing values may be attributable in part to a lack of standard assessment techniques for sleepiness in children. Previous studies have used different subjective criteria such as the use of parental report. Only 1 previous study used objective criteria to evaluate sleepiness in children with SDB.[13] The present study aimed to use a simple and inexpensive instrument, which has been validated in adults,[14,15] to evaluate EDS in children with suspected SDB (S-SDB).

We hypothesized that children with S-SDB were both sleepier and more hyperactive than control subjects. Furthermore, we hypothesized that parameters on overnight polysomnography (PSG) correlated with EDS and hyperactivity in these children.

METHODS

The study protocol was approved by the Institutional Review Board of Johns Hopkins University. Informed consent was secured from the subjects' parents or legal guardians. Assent was obtained from all subjects ≥5 years of age. Patients with S-SDB and control subjects were studied. Control subjects were screened using Brouillette's scoring system.[16] A modified Epworth Sleepiness Scale (ESS)[14] and the Conners Abbreviated Symptom Questionnaire[17] for hyperactivity were administered to all subjects. Patients with S-SDB then underwent overnight PSG.

Study Population

S-SDB patients were recruited sequentially and prospectively from all new patients who were referred to the Pediatric Sleep Disorders Clinic at Johns Hopkins Hospital for evaluation of clinically S-SDB secondary to adenotonsillar hypertrophy. Children were included when they were aged 2 to 18 years. They were excluded when they had other medical or neurologic conditions, had craniofacial abnormalities, had undergone adenotonsillectomy or other upper airway surgery, or were on medications that could affect their level of alertness. All patients were seen by a pediatric sleep specialist, and those with possible sleep disorders

other than OSAS were excluded. Control subjects were recruited from a general pediatric clinic in a primary care setting and from the Dermatology Clinic at Johns Hopkins Hospital.

Screening of Control Subjects

Control subjects were screened for OSAS using Brouillette's scoring system. Brouillette et al[16] formulated a scoring system to determine the likelihood of OSAS on the basis of history alone. Three variables were included in this score: difficulty breathing during sleep, observed apnea, and snoring. A child with a score of <-1 had no OSAS, whereas a child with a score >3.5 had OSAS; scores between -1 and 3.5 were indeterminate. In our study, control subjects with an OSAS score ≥ -1 were excluded.

Questionnaires

Two questionnaires (a modified ESS and the Conners Abbreviated Symptom Questionnaire for hyperactivity) were administered to the child's caregiver by a trained research assistant. In addition, questions were asked directly to the first 46 children ≥ 6 years of age.

The ESS is a measure of a person's general level of daytime sleepiness.[14] It is an 8-item questionnaire detailing an individual's propensity to fall asleep during commonly encountered situations. Scores can range from 0 to 24. In adults, an ESS score >10 is taken to indicate increased daytime sleepiness.[14] The ESS was modified slightly in this study to be more applicable to children. The mention of alcohol was deleted in question number 7. In addition, question 8 was taken to indicate that the subject was a passenger in the car (Appendix 1).

The Conners Abbreviated Symptom Questionnaire for hyperactivity is a 10-item index from the Revised Conners Parent Rating Scale.[17] This is used in rating children who are aged 3 to 17 years for the presence of inattention, distractibility, and overactivity. Raw scores may range from 0 to 30, with a score of 15 considered clinically relevant (Appendix 2).

PSG

Patients with S-SDB underwent an overnight polysomnogram. Control subjects did not undergo PSG. Standard PSG consisted of electroencephalogram (C3A2/C3O1); electromyogram (submental and tibial); electrooculogram (right, left); arterial oxygen saturation (Sao_2), oximeter pulse wave form, and end-tidal carbon dioxide tension ($ETco_2$); oronasal airflow using a thermistor; and thoracic and abdominal wall motion (piezo belts or respiratory inductance plethysmography). Sleep was staged based on the criteria of Rechtschaffen and Kales.[18] Arousals were scored according to the American Sleep Disorders Association criteria.[19] Standard pediatric scoring criteria were used for respiratory events.[1] Hypopneas were scored when there was a decrease in airflow $\geq 50\%$ associated with either a 3% desaturation or an arousal.[1] The apnea-hypopnea index was defined as the total number of obstructive apneas, hypopneas, and mixed apneas per hour of sleep. OSAS was defined as an obstructive apnea index ≥ 1/hour.[1,7] Severity of OSAS was classified on the basis of the obstructive apnea index, with mild OSAS having an obstructive index between 1 and 4/hour, moderate OSAS 5 and 9/hour, and severe OSAS ≥ 10/hour.[20] Primary snoring (PS) was defined as snoring without episodes of apnea, desaturation, hypoventilation, or excessive arousals.[21] Periodic limb movements (PLMs) were scored using the International Classification of Sleep Disorders (Revised) criteria.[21] The scorer was blinded to the results of the questionnaires.

Statistical Analysis

Data were expressed as means and standard deviations, where appropriate. χ^2 analysis was used for categorical variables. The unpaired t test was used to compare ESS scores of patients with S-SDB versus control subjects, as well as the Conners scores of patients with S-SDB versus control subjects. The ESS scores of children who were younger than 5 years were also analyzed separately as children in this age group usually take daytime naps. To assess for the contribution of puberty to the degree of daytime sleepiness in our subjects, we analyzed separately the ESS scores of children who were older than 12 years (which was arbitrarily set as the cutoff age for puberty). One-way analysis of variance was performed to test the difference in ESS scores of patients with mild, moderate, and severe OSAS. Similarly, one-way analysis of variance was used to test the difference in Conners scores between patients with mild, moderate, and severe OSAS. As the Conners score has been studied only in children 3 to 17 years of age, data were reanalyzed with subjects younger than 3 years excluded. The Spearman correlation coefficient was used to describe the relationship between the ESS score and PSG variables, as well as between the Conners score and PSG variables. PSG variables evaluated include sleep efficiency, arousal index, apnea-hypopnea index, apnea-hypopnea index during rapid eye movement (REM) sleep, Sao_2 nadir, duration of $Sao_2 \leq 92\%$, mean $ETco_2$, mean $ETco_2$ during REM sleep, peak $ETco_2$, duration of $ETco_2 \geq 50$ mm Hg, and PLM index. A Bonferroni correction for multiple comparisons was used.

RESULTS

Study Group

Of all subjects who were approached to join the study, only 1 family refused. A total of 203 consecutive children were recruited; 23 were excluded. Among the patients with S-SDB, 18 were excluded. Seventeen of these children failed to undergo a sleep study, and 1 had a sleep study done at another institution. Among the control subjects, 5 were excluded because of an OSAS score >-1. Therefore, 108 patients with S-SDB and 72 control subjects composed the study population. The 2 groups were not statistically different on the basis of age, gender, race, and type of insurance (Table 1). The type of insurance was used as a surrogate measure of socioeconomic status. Snoring was present in all but 1 of the patients with S-SDB. Twenty-two patients had a history of daytime sleepiness by parental report.

ESS and Conners Score

The first 46 children who were ≥ 6 years of age gave separate ESS scores from their parents. As the correlation between parent and child ESS score was good ($r = 0.71$, $P < .001$), subsequent ESS scores were obtained from the accompanying caregiver alone. The mean ESS score given by parents of patients with S-SDB was significantly higher than that of control subjects (8.1 ± 4.9 vs 5.3 ± 3.9; $P < .001$; Fig 1). Taking an ESS score >10 as the cutoff for increased daytime sleepiness, 32 (28%) patients with S-SDB and 9 (12%) control subjects had EDS ($P < .007$). There was no significant difference in the ESS scores of patients who had S-SDB and were younger than 5 years and those who were 5 years and older (8.2 ± 4.2 vs 8.1 ± 5.2, respectively). Likewise, the ESS scores of children who had S-SDB and were ≤ 12

TABLE 1. Demographic Data of Study Population

	Patients With S-SDB	Controls
N	108	72
Age, y, mean ± SD (range)	7 ± 4 (2–16)	8 ± 4 (2–17)
Female gender, *n* (%)	58 (55)	43 (60)
Race, *n* (%)		
White	26 (24)	26 (36)
Black	79 (73)	46 (64)
Other	3 (3)	0 (0)
Private insurance, *n* (%)	37 (34)	28 (39)

There was no statistical difference between patients with S-SDB and control subjects on the basis of age, gender, race, and type of insurance. The type of insurance was used as a surrogate measure of socioeconomic status.

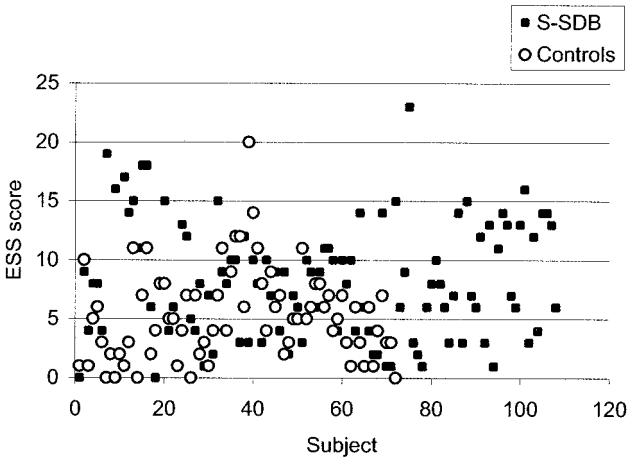

Fig 1. The ESS score of patients with S-SDB was higher than the score of control subjects ($P < .001$).

years (8.1 ± 4.8) were not statistically different from the ESS scores of those who were older than 12 years (8.4 ± 6.6). The ESS scores of patients with S-SDB and control subjects who were younger than 5 years (8.2 ± 4.2 vs 8.0 ± 4.2) were not significantly different, but the ESS scores of patients who had S-SDB and control subjects who were older than 12 years (8.4 ± 6.6 vs 4.3 ± 2.6) were ($P < .05$).

The Conners score of patients with S-SDB (12.8 ± 7.6) was significantly higher ($P < .001$) than the score of control subjects (9.0 ± 6.2; Fig 2), although it was lower than the score considered clinically relevant. Excluding children <3 years of age, the significant difference between the Conners score of patients with S-SDB and controls persisted (13.0 ± 7.5 vs 9.0 ± 6.3, respectively).

Subgroup Analysis

The PSG results are shown in Table 2. Of the 108 patients with clinically S-SDB, 63 (58%) received a diagnosis of PS on overnight PSG. The remaining 45 (42%) had various degrees of OSAS. Twenty-one had mild, 8 had moderate, and 16 had severe OSAS. None of the patients with S-SDB fulfilled the criteria for PLM disorder. The ESS score of patients with

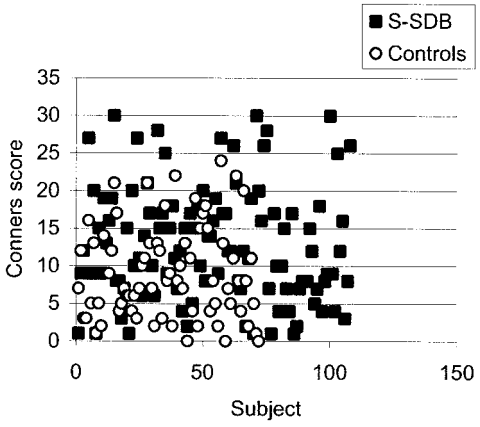

Fig 2. The Conners score of patients with S-SDB was higher than the score of control subjects ($P < .001$).

TABLE 2. PSG Results of Children With S-SDB

PSG Parameter	Mean ± SD (range)
Sleep efficiency, %	83 ± 12 (39–97)
Arousal index, *n*/h	10 ± 8 (1–53)
Apnea-hypopnea index, *n*/h	8 ± 18 (0–48.2)
REM apnea-hypopnea index, *n*/h REM sleep	17 ± 30 (0–148.2)
REM obstructive index, *n*/h REM sleep	10 ± 20 (0–107.5)
Peak $ETco_2$, mmHg	52 ± 5 (41–67)
Sao_2 nadir, %	88 ± 10 (48–98)
Mean Sao_2, %	98 ± 2 (88–100)
Mean Sao_2 (REM sleep), %	97 ± 3 (73–100)
PLM index, *n*/h	0.3 ± 0.8 (0–3.3)

OSAS (8.3 ± 5.6) was not statistically different from the ESS score of those who had a diagnosis of PS alone (8.0 ± 4.5). There was also no difference between the ESS score of patients with mild, moderate, and severe OSAS (Fig 3). Similarly, the Conners score was not statistically different between patients with OSAS and those with PS (12.6 ± 8.3 and 13.0 ± 7.0 for OSAS and PS respectively). There was also no statistically significant difference in the Conners scores of patients with mild, moderate, and severe OSAS (Fig 4).

In children with OSAS, the ESS score had a statistically significant but weak correlation with the mean Sao_2 during REM sleep ($r = -0.41$, $P < .05$), PLM index ($r = 0.40$, $P < .05$), apnea-hypopnea index ($r = 0.32$, $P < .05$), mean Sao_2 ($r = -0.31$, $P < .05$), and Sao_2 nadir ($r = -0.31$, $P < .05$) but not with other parameters tested (Table 3). However, when the *P* value was adjusted for multiple comparisons using the Bonferroni correction factor, these correlations failed to reach significance. There was no significant correlation between the Conners score and PSG parameters.

As most children with OSAS obstruct primarily during REM sleep,[22] data were reanalyzed using the apnea-hypopnea index during REM sleep. No significant correlation was found between the ESS or Conners scores and the REM apnea-hypopnea index. However, ESS scores correlated with the mean Sao_2 during REM sleep.

DISCUSSION

To our knowledge, this is the first study to evaluate the use of the ESS score in children. We have shown that children with S-SDB were sleepier than age-, gender-, and race-matched control subjects. Our data also confirmed previous reports that children with S-SDB exhibit more symptoms of attention-deficit/hyperactivity disorder than normal children. PSG parameters correlated only weakly with the ESS score and had no significant correlation with hyperactivity.

Daytime Sleepiness

EDS is a cardinal feature of adult OSAS.[21] In children, it is relatively uncommon, but its reported prevalence has varied over a wide range.[7,9–12] Although the mean ESS score of children with S-SDB

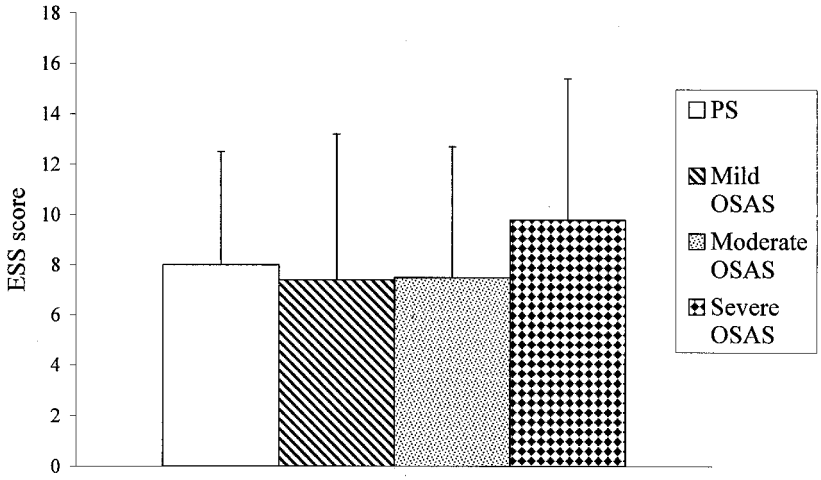

Fig 3. One-way analysis of variance revealed that the ESS scores of patients with mild, moderate, and severe OSAS did not differ significantly.

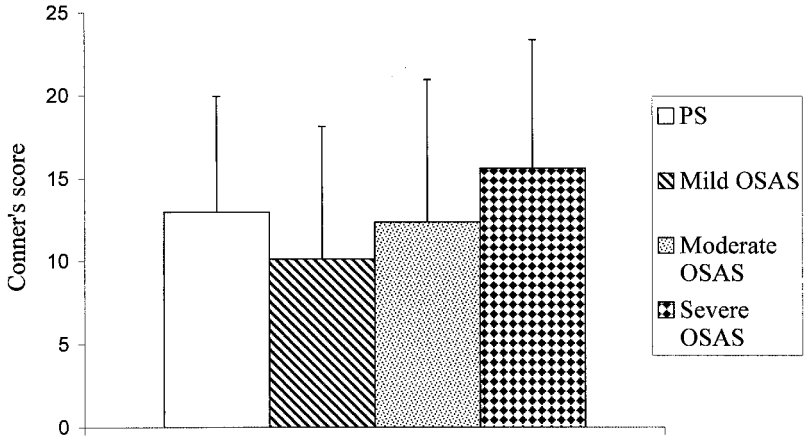

Fig 4. One-way analysis of variance revealed that the Conners scores of patients with mild, moderate, and severe OSAS did not differ significantly.

TABLE 3. Correlation Between PSG Parameters and ESS and Conners Scores

PSG Parameter	Correlation With ESS Score (*r*)	Correlation With Conners Score (*r*)
Sleep efficiency, %	−0.05	−0.09
Arousal index, *n*/h	0.25	0.04
Apnea-hypopnea index, *n*/h	0.32*	0.24
REM apnea-hypopnea index, *n*/h	0.26	0.13
REM obstructive apnea index, *n*/h	0.24	0.19
Peak $ETco_2$, mm Hg	0.19	0.29
Mean $ETco_2$, mm Hg	0.04	0.12
Mean $ETco_2$, REM sleep, mm Hg	0.13	0.19
Duration $ETco_2$ ≥50 mm Hg, min	−0.06	0.03
Sao_2 nadir, %	−0.31*	−0.22
Mean Sao_2, %	−0.31*	−0.16
Mean Sao_2, REM sleep, %	−0.41*	−0.27
Duration Sao_2 ≤92%, min	0.13	−0.03
PLM index, *n*/h	0.40*	0.25

* $P < .05$.

did not reach the level generally set for EDS based on adult studies (ESS >10),[14] it was statistically higher than the ESS score of control subjects. Therefore, as a group, we have shown that children with S-SDB are relatively sleepy compared with nonsnoring control subjects.

An interesting finding was the lack of a significant difference between the ESS scores of children with S-SDB and control subjects who were younger than 5 years. That children in this age group usually nap during the day may account for this lack of difference in parental perception of sleepiness.

After classifying children who were referred for S-SDB into those with PS and those with OSAS, there was no significant difference in daytime sleepiness between these 2 groups. Daytime symptoms are traditionally thought to be absent in patients with PS.[21] Our results, however, suggest that snoring may in

itself be associated with sleepiness in children. Similar findings have been shown in adult studies.[23,24] In a cross-sectional cohort of 5777 adults, the authors found that snoring was independently associated with excess sleepiness.[23] In another adult study, daytime sleepiness, as measured by both ESS and multiple sleep latency test, was compared between normal controls and patients with either upper airway resistance syndrome (UARS), sleep hypopnea syndrome, or OSAS.[25] There was a significant difference between the ESS scores of the controls versus the patients with SDB. However, the ESS and multiple sleep latency test were similar for the 3 patient groups.

Classifying the children with OSAS in our study according to severity did not yield a significant relationship between the severity of OSAS and the degree of daytime sleepiness. It is possible that children may have varying susceptibility to the effects of OSAS severity, accounting for the lack of relationship. Previous studies have shown conflicting results in this area. Some adult studies have similarly shown this lack of relationship,[26–28] whereas others have shown a positive relationship between OSAS severity and the degree of sleepiness.[13,29] As there were only a small number of children with moderate to severe OSAS, it is also possible that our study was underpowered to detect a significant relationship.

Relationship Between PSG Parameters and Daytime Sleepiness

We found weak correlations between daytime sleepiness and the mean Sao_2 during REM sleep, PLM index, the apnea-hypopnea index, and the lowest recorded Sao_2. There was no significant relationship between daytime sleepiness and sleep efficiency or the arousal index.

The link between the ESS score and PSG parameters is unclear. Some studies have shown significant correlation between these, whereas others have not. In adults with OSAS, sleep fragmentation as a result of recurrent arousal is thought to be the primary reason for EDS.[30,31] Other factors have also been shown to correlate with daytime sleepiness, such as nocturnal hypoxemia and the apnea-hypopnea index.[32,33] In our study, none of the PSG parameters could be used to predict daytime sleepiness, as the correlations were weak. Similar findings have been shown in a number of adult studies.[26,27,34]

The PLM disorder, defined as a PLM index ≥ 5, is believed to cause daytime sleepiness due to recurrent arousals, resulting in sleep fragmentation.[21] Although none of the patients in the present study satisfied the criteria for this disorder, the PLM index showed a weak correlation with daytime sleepiness (Table 2). With this weak correlation, it is unlikely that PLMs contribute significantly to the daytime sleepiness in children with S-SDB. Using both objective and subjective measures of daytime sleepiness, a recent study also showed comparable findings.[35]

The absence of a strong relation between PSG parameters and daytime sleepiness in this study brings up the possibility either that we are not measuring the right parameter during routine PSG or that the commonly measured parameters in PSG are not sensitive determinants of daytime sleepiness. Sleep fragmentation seems not to be a major factor in the development of daytime sleepiness in children with OSAS, as there was no significant correlation between daytime sleepiness and the arousal index. In fact, previous studies have shown that apneas in children are terminated by arousal less often than in adults, leading to less fragmented sleep.[36] Theoretically, measures of increased upper airway resistance, such as esophageal pressure swings, may be more sensitive determinants of daytime sleepiness.

UARS, which is part of the spectrum of SDB, is characterized by EDS as a result of fragmented sleep caused by brief arousals not associated with discrete apneas or gas exchange abnormalities.[25] It is diagnosed by demonstrating an association between esophageal pressure swings and arousals.[37] As esophageal pressure was not measured in this study, it is possible that some of the subjects who were labeled as PS may actually have had UARS. However, in that case, we would have expected to see a correlation between the arousal index and the ESS score.

Alternatively, subcortical arousals that have been shown to be common in children may also be contributing to sleepiness.[38] The pulse transit time, which is a noninvasive measure of subcortical arousal, was found to be a more sensitive measure of sleep disruption than visible electroencephalogram (EEG) arousals.[39] In addition, significant changes in spectral EEG characteristics have been shown in obstructive events not terminated by EEG arousal.[40] These measures of subcortical arousal, which are not part of the routinely measured parameters on PSG and were not analyzed in this study, may perhaps have a stronger relation with daytime sleepiness. This may be an area for future research. With the correlation, although weak, between sleepiness and oxygen saturation, hypoxemia may play a bigger role in the cause of sleepiness in children with SDB than EEG arousals.

Attention Deficit and Hyperactivity

On the basis of the Conners score, we found that children with S-SDB had more symptoms of attention-deficit/hyperactivity disorder than control subjects (Fig 2). There was no difference in attention-deficit/hyperactivity symptoms between the PS and OSAS groups.

These data confirm previous reports that children with SDB commonly manifest neurobehavioral complications, specifically hyperactivity and inattention.[2,5,41–43] It is interesting that the Conners score of children with OSAS was not statistically different from the Conners score of children with PS alone. Similar findings were shown in a recent study of 113 children who were referred for S-SDB.[42] There was no difference in the hyperactivity scores of children

who subsequently received a diagnosis of SDB by polysomnography and those without. These findings suggest that snoring by itself may affect a child's daytime behavior.

None of the PSG parameters measured in our study correlated to a significant degree with symptoms of attention-deficit/hyperactivity disorder. Likewise, Chervin et al[42] found no correlation between hyperactivity and respiratory parameters on PSG. However, they found a correlation between hyperactivity and the PLM index. This association was found only in patients with SDB.

The absence of a relation between PSG parameters and symptoms of attention deficit and hyperactivity again indicates that we may be measuring the wrong parameters or that commonly measured parameters on nocturnal PSG are not sensitive determinants of hyperactivity. Hyperactivity has been proposed to be a child's way of acting out daytime sleepiness. As such, measures of subcortical arousal associated with respiratory events may give better correlations with hyperactivity.

It is important to note that we excluded children who were taking medications that could affect their level of alertness, including those who were taking drugs used for attention-deficit/hyperactivity disorder. As such, our data may have underestimated attention-deficit and hyperactivity in children with S-SDB. In addition, differences in birth history and other medical conditions may have played a role. However, as we excluded those with significant medical conditions, it is unlikely that these factors played a major role.

Study Limitations

This study compared clinically referred children with S-SDB with control subjects from other clinics. Thus, clinical referral bias may account for the difference in ESS and Conners scores between patients and control subjects. The ESS and the Conners score are subjective methods of assessing sleepiness and hyperactivity and as such may also be prone to report bias. Of note, however, is that only 22 of the 108 patients with S-SDB had a history of daytime sleepiness by parental report. Most children presented with chief complaints of snoring and witnessed apnea during sleep. Furthermore, all children were seen by a sleep specialist, and children with other types of sleep disorders were excluded. Nevertheless, it would be important to confirm these results with a population-based study.

Our control subjects did not undergo a sleep study but were screened for OSAS on the basis of history using the OSAS score developed by Brouillette et al.[16] This score has been shown to differentiate am individual with no SDB from one with OSAS, although it has not been shown to be effective at differentiating PS from OSAS.

The use of a thermistor to measure nasal airflow has its limitations. Being a qualitative measurement, it is not as sensitive in detecting flow limitation, which may be associated with increased upper airway resistance or hypopneas.[1] Nasal cannula pressure measurements, which have been validated in adults,[44] have been shown to detect apneas, hypopneas, and flow-limited events not identified by thermistors in children.[45,46] However, as this detects only nasal airflow, it may miss events in children who frequently mouth-breathe[45,46] and in those who experience nasal obstruction.[47] As such, to minimize the limitations associated with the use of a thermistor, we used the $ETco_2$ wave form as an additional means of measuring airflow.

It should be noted that the majority of subjects in both the S-SDB and control groups were black, reflecting the ethnic mix of our hospital's clinical population. Thus, the study sample may not be representative of the rest of the United States.

CONCLUSIONS

In summary, we have shown that although the mean ESS score of patients was within the normal range for adults, children with S-SDB were sleepier and more hyperactive than control subjects. These findings have important implications in clinical practice as we have shown that even the mildest form of SDB may be associated with daytime symptoms. The long-term consequence of this is currently unknown, but it is possible that the neurocognitive functioning of a child may be affected. We have also shown that the ESS is a simple and useful test to administer to children. However, the results of this study need to be confirmed by a population-based study with a more representative population. Additional studies are needed to elucidate the causative factors for EDS and hyperactivity in children with S-SDB.

APPENDIX 1: MODIFIED EPWORTH SLEEPINESS SCALE

How likely are you/your child to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you/your child have not done some of these things recently, try to work out how they would have affected you/your child. Use the following scale to choose the most appropriate number for each situation:

0 = no chance of dozing
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

Situation	Chance of Dozing
Sitting and reading	
Watching TV	
Sitting inactive in a public place (eg, movie theater or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after lunch	
In a car, while stopped for a few minutes in traffic	

APPENDIX 2: CONNERS ABBREVIATED SYMPTOM QUESTIONNAIRE

Observation	Not at All	Just a Little	Pretty Much	Very Much
1. Restless or overactive				
2. Excitable, impulsive				
3. Disturbs other children				
4. Fails to finish things he/she starts–short attention span				
5. Constantly fidgeting				
6. Inattentive, easily distracted				
7. Demands must be met immediately–easily frustrated				
8. Cries often and easily				
9. Mood changes quickly and drastically				
10. Temper outbursts, explosive and unpredictable behavior				

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EUROPEAN ENVIRONMENTAL RULES PROPEL CHANGE IN U.S.

"Generally stricter European laws reflect a different philosophical approach to regulation, says Dr Indra Spiecker, a lawyer specializing in comparative law and assistant professor for American law at the University of Osnabruck in Germany. American lawmakers primarily look to cost-benefit analysis, which holds that the benefit of imposing regulation should outweigh its cost. European nations have more readily embraced what is called the precautionary principle. Essentially, Europeans emphasize the cost of inaction, while Americans tend to focus on the cost of action. . . . The EU is now considering sweeping new regulation of its chemical industry that has unleashed what analysts here say is the biggest lobbying effort in Brussels ever mounted by American industry. The new law, known as Reach, would place the burden of proof of safety on the producers before its sale, rather than waiting for the problems to spur regulation later. It would force American chemical companies to comply with the legislation in order to continue exporting to Europe—and raises the fear of similar legislation in the United States. The chemical industry points out that few if any of the unregulated chemicals are causing obvious health crises and says the legislation is overly bureaucratic and expensive. The American Chemical Council has marshaled its members to alter or derail the legislation."

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Daytime Sleepiness and Hyperactivity in Children With Suspected Sleep-Disordered Breathing

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