ORIGINAL ARTICLE

Pediatric Sleep Questionnaire

Prediction of Sleep Apnea and Outcomes

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Objectives: To further validate a questionnaire about symptoms of childhood obstructive sleep apnea (OSA) and to compare the questionnaire with polysomnography in their ability to predict outcomes of adenotonsillectomy.

Design: Retrospective analysis of data from a longitudinal study.

Setting: University-based sleep disorders laboratory.

Participants: The Washtenaw County Adenotonsillectomy Cohort, comprising 105 children aged 5.0 to 12.9 years at entry.

Intervention: Parents completed the 22-item Sleep-Related Breathing Disorder (SRBD) scale of the Pediatric Sleep Questionnaire, and children underwent polysomnography before and 1 year after clinically indicated adenotonsillectomy (n=78, usually for suspected OSA) or unrelated surgical care (n=27).

Main Outcome Measures: Findings from commonly used hyperactivity ratings, attention tests, and sleepiness tests.

Results: At baseline, a high SRBD scale score (1 SD above the mean) predicted an approximately 3-fold increased risk of OSA on polysomnography (odds ratio, 2.80; 95% confidence interval, 1.68-4.68). One year later, OSA and symptoms had largely resolved, but a high SRBD score still predicted an approximately 2-fold increased risk of residual OSA on polysomnography (odds ratio, 1.89; 95% confidence interval, 1.13-3.18). Compared with several standard polysomnographic measures of OSA, the baseline SRBD scale better predicted initial hyperactivity ratings and 1-year improvement, similarly predicted sleepiness and its improvement, and similarly failed to predict attention deficit or its improvement.

Conclusions: The SRBD scale predicts polysomnographic results to an extent useful for research but not reliable enough for most individual patients. However, the SRBD scale may predict OSA-related neurobehavioral morbidity and its response to adenotonsillectomy as well or better than does polysomnography.

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THE MOST PROMINENT MORbidities of obstructive sleep apnea (OSA) in children include neurobehavioral deficits, such as inattention, hyperactivity, and daytime sleepiness.[1] In a cohort of children scheduled for clinically indicated adenotonsillectomy, our group[2] recently confirmed that OSA usually resolves and neurobehavioral deficits show prominent improvement 1 year after adenotonsillectomy. However, laboratory-based polysomnographic measures of OSA showed only limited utility in predicting the extent of baseline neurobehavioral morbidity or its amelioration after surgery.

The value of polysomnography before adenotonsillectomy is controversial. Sleep specialists and the American Academy of Pediatrics recommend objective testing, usually by means of nocturnal polysomnography, to confirm a diagnosis of OSA before it is treated by adenotonsillectomy.[1] In practice, however, only a small proportion of children who receive adenotonsillectomy for OSA undergo polysomnography before surgery,[3] and pediatric otolaryngology textbooks suggest that the diagnosis usually can be made with confidence at a clinic visit.[4,5] In a series of published studies, OSA symptoms repeatedly failed to predict polysomnographic findings.[6] However, these studies often relied on questionnaires with only a few items, and these often had not been adequately validated. Also, standard polysomnography can miss subtle forms of OSA that may be highly consequential for children.[7,8] No studies, to our knowledge, have ever used prediction of OSA-related health outcomes, rather than polysomnographic results, as the standard by which to judge the effectiveness of symptoms as a tool in the diagnosis of clinically consequential pediatric OSA.[9]

Several years ago, our group[10] developed and validated a new 22-item Sleep-

Related Breathing Disorder (SRBD) scale of the Pediatric Sleep Questionnaire. In a comparison of sleep laboratory–referred children confirmed to have SRBDs and nonreferred children whose parents were surveyed in general pediatric waiting rooms, the SRBD scale showed a sensitivity of 81% and a specificity of 87%. Instrument performance did not vary with participant age (2-18 years). The SRBD scale showed good internal consistency and test-retest reliability. Since then, the instrument has been used frequently to assess for OSA risk in research studies. One limitation of the original validity study, however, is that the nonreferred children were not tested to confirm the assumption that they had no SRBDs. Furthermore, the validity of the SRBD scale in clinical practice, outside a sleep laboratory, remains untested.

We therefore took advantage of detailed diagnostic and outcome data available from the Washtenaw County Adenotonsillectomy Cohort to perform a retrospective revalidation of the SRBD scale. We also tested the effectiveness of this scale vs polysomnography in the prediction of OSA-related, treatment-responsive neurobehavioral morbidity.

METHODS

SUBJECTS

The Washtenaw County Adenotonsillectomy Cohort enrolled children aged 5.0 to 12.9 years after informed consent and assent were obtained for this institutional review board–approved study.[2,11-13] Patients and controls were scheduled for adenotonsillectomy and unrelated surgical care, respectively; had no clinical need for polysomnography according to the treating otolaryngologists; and had no medical conditions that might complicate the interpretation of sleep and behavioral test results. The adenotonsillectomy was for any clinical indication, but in almost all the patients (91%), nocturnal airway obstruction was suspected at the otolaryngologist's office.

The 105 individuals in the completed cohort had a mean±SD age of 8.4±1.9 years, and 60 (57%) were boys. Of the 105 subjects, 78 were scheduled for adenotonsillectomy and 27 for other surgical care. Comparisons between participants and nonparticipants for whom some data could be obtained revealed no significant differences in demographics, socioeconomic status, or snoring frequency, but participants were older (<1 year) than nonparticipants.[2] Similarly, comparisons between patients undergoing adenotonsillectomy and control subjects revealed no significant differences in sex, race, body mass index, or socioeconomic status, but patients receiving adenotonsillectomy were 1.2 years younger on average. Of the 105 subjects who enrolled at baseline, 100 (95%) returned for follow-up testing 1 year later.

POLYSOMNOGRAPHY

Polysomnography included all standard electroencephalographic, electro-oculographic, and electromyographic leads required to score sleep stages.[14] Equipment used to monitor breathing included oronasal thermocouples, piezoelectric strain gauges, finger oximetry, end-tidal carbon dioxide, and a thin, water-filled esophageal catheter previously shown to have a negligible effect on sleep in children.[15,16] A minority of the children did not tolerate esophageal pressure monitoring for at least 2 hours, and their esophageal pressure data were considered missing.[12]

After each polysomnogram, a Multiple Sleep Latency Test was performed. This test included four or five 20-minute nap attempts at 2-hour intervals.[17] The mean sleep latency across these nap attempts is often considered to be a gold standard objective test for daytime sleepiness, and the test is sensitive to sleepiness in patients with OSA as young as 3 years old.[18]

Polysomnograms and Multiple Sleep Latency Tests were scored by a single registered polysomnographic technologist masked to the clinical status of the subjects. Polysomnographic OSA measures included a pediatric obstructive apnea index (2-breath or longer events per hour of sleep), an apnea/hypopnea index (where hypopneas lasted ≥2 breath cycles), a respiratory disturbance index (which included apneas, hypopneas, and respiratory event–related arousals determined by esophageal pressure monitoring), minimum oxygen saturation, an electroencephalographic arousal index, and percentage of sleep time with an end-tidal carbon dioxide level greater than 50 mm Hg. Obstructive sleep apnea was considered present when the obstructive apnea index was 1 or more.[19] Of the 78 patients undergoing adenotonsillectomy and 27 control subjects, 40 and 1, respectively, met this criterion for OSA. The mean±SD apnea/hypopnea index was 5.7±11.1 for the entire sample: 13.1±15.3 for the adenotonsillectomy group with OSA, 1.2±1.1 for the adenotonsillectomy group without OSA, and 1.2±1.9 for controls.

SRBD SCALE OF THE PEDIATRIC SLEEP QUESTIONNAIRE

The SRBD scale contains 22 symptom items that ask about snoring frequency, loud snoring, observed apneas, difficulty breathing during sleep, daytime sleepiness, inattentive or hyperactive behavior, and other pediatric OSA features, each previously shown to correlate with polysomnographically confirmed OSA in referred children.[10] Responses are "yes" = 1, "no" = 0, and "don't know" = missing. The mean response on nonmissing items is the score, which can vary from 0 to 1. Previous data suggest that a cutoff value of 0.33 would be most effective in identifying pediatric OSA. Subscales within the SRBD scale include a 4-item sleepiness scale, a 4-item snoring scale, and a 6-item inattention/hyperactivity scale derived originally from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*) criteria for attention-deficit/hyperactivity disorder (ADHD).[20]

BEHAVIORAL AND COGNITIVE TESTING

Parents completed the Child Symptom Inventory-4: Parent Checklist to generate a T-score (mean±SD, 50±10) for inattention and hyperactivity.[21] The well-validated Child Symptom Inventory contains 108 items that screen children aged 5 to 12 years for a variety of emotional and behavioral disorders based on the *DSM-IV*.

An objective score for sustained attention was provided by the standard score (mean±SD, 100±15) on the Integrated Visual and Auditory Continuous Performance Test, administered using a personal computer.[22,23] The child hears or sees "1" or "2" on the screen and clicks a mouse button only in response to "1." The main testing period consists of 500 trials, 1.5 seconds each, in which the visual or auditory stimuli are presented briefly in a pseudorandom pattern. The number of omissions, as reflected by the Full Scale Attention Quotient, was used to generate the measure of attention for this analysis.

STATISTICAL ANALYSIS

Data were double-entered professionally to verify accuracy. Means and standard deviations were used as summary measures, and medians were also computed for the SRBD scores.

Table 1. Associations of SRBD Score With Each Listed Polysomnographic Measure of OSA Severity, at Baseline and 1 Year After Adenotonsillectomy or Unrelated Surgical Care

Polysomnographic Variable	No. of Subjects With Available Data (Baseline/Follow-up)	Baseline (n = 105)		Follow-up (n = 100)	
		Spearman ρ	*P* Value	Spearman ρ	*P* Value
Obstructive apnea index	105/100	0.52	<.001	0.08	.45
Apnea/hypopnea index	105/100	0.48	<.001	0.12	.22
Respiratory disturbance index	76/55	0.51	<.001	0.22	.10
Minimum oxygen saturation, %	105/100	−0.30	.002	−0.08	.43
EEG arousal index	105/100	0.20	.04	−0.02	.85
Percentage of sleep time with end-tidal CO_2 >50 mm Hg	98/99	0.19	.06	0.04	.69

Abbreviations: CO_2, carbon dioxide; EEG, electroencephalographic; OSA, obstructive sleep apnea; SRBD, Sleep-Related Breathing Disorder.

Table 2. Summary of Neurobehavioral Measures Before and 1 Year After Adenotonsillectomy or Unrelated Surgical Care

Neurobehavioral Measure	No. of Subjects With Available Data (Baseline/Follow-up)	Mean ± SD	
		Baseline	Follow-up
ADHD scale score (from the Child Symptom Inventory-4)	105/100	46.0 ± 17.2	41.5 ± 16.0
Full Scale Attention Quotient (from the IVA CPT)	104/98	80.2 ± 21.8	86.0 ± 24.8
Mean sleep latency (from the Multiple Sleep Latency Test), min	105/99	16.5 ± 3.2	17.3 ± 2.6

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; IVA CPT, Integrated Visual and Auditory Continuous Performance Test.

Validity of the SRBD scale at baseline and follow-up was assessed by comparison with polysomnographic results using Spearman rank correlations and logistic regression models. The SRBD scale determinations that OSA was likely were compared with the presence of OSA on polysomnography using sensitivity, specificity, and χ^2 or Fisher exact tests. The clinical effectiveness of both the SRBD scale and the polysomnographic measures at baseline was assessed by use of Spearman correlations with the ADHD scale, Full Scale Attention Quotient, or mean sleep latency, or their changes across time. Results were adjusted for age. The most effective OSA measures, again adjusted for age, were then used in multiple logistic regression models to determine which measures independently predicted dichotomized classifications of behavioral outcomes or their changes (by >1 SD) across 1 year. Hosmer-Lemeshow goodness-of-fit was tested for each model. The level of significance was set at $P<.05$. Analyses were performed using a statistical software program (SAS version 9.1; SAS Institute Inc, Cary, NC).

RESULTS

VALIDATION OF THE SRBD SCALE

At baseline the mean±SD SRBD score from the Pediatric Sleep Questionnaire was 0.31±0.21, and the median score was 0.32. In 41 subjects with OSA on polysomnography, the mean±SD SRBD score was 0.43±0.15, whereas in 64 subjects without OSA, the score was 0.24±0.21. A previously established cutoff value (SRBD score ≥0.33[10]), applied to the entire sample, showed a sensitivity of 78% and a specificity of 72% for polysomnographically defined OSA ($\chi^2=25.0$; $P<.001$); 74% of the subjects were classified correctly. Correlations of low to moderate strength between the SRBD score and each polysomnographic measure all reached significance except for the percentage of sleep time with an end-tidal carbon dioxide level greater than 50 mm Hg, which showed a trend (**Table 1**).

A logistic regression model showed that a 1-SD increase in the normalized SRBD score predicted nearly a 3-fold increased risk of the presence of OSA on polysomnography (odds ratio, 2.80; 95% confidence interval, 1.68-4.68). Even among the 78 children scheduled for adenotonsillectomy, almost all (91%) for suspected SRBDs, the SRBD score identified nearly a 2-fold increased risk for presence of OSA on polysomnography (odds ratio, 1.84; 95% confidence interval, 1.04-3.25).

At 1-year follow-up, the mean±SD SRBD score was 0.15±0.15, and the median score was 0.10. Among 12 subjects (8 after adenotonsillectomy) who had polysomnographic evidence of OSA at follow-up, the mean±SD SRBD score was 0.26±0.21, whereas among children without OSA, the score was 0.14±0.14. Sensitivity of a positive SRBD score for OSA on polysomnography was 42% and specificity was 90% (Fisher exact test $P=.01$), and 84% of all subjects were correctly classified. Correlations between the SRBD score and individual polysomnographic measures were not significant (Table 1), but a logistic regression model showed that a 1-SD increase in the SRBD score at follow-up still predicted nearly a 2-fold increased risk of residual OSA on the polysomnogram (odds ratio, 1.89; 95% confidence interval, 1.13-3.18).

CLINICAL EFFECTIVENESS OF THE SRBD SCALE AND POLYSOMNOGRAPHIC VARIABLES

Neurobehavioral measures, at baseline and follow-up, are summarized in **Table 2**. The improvement in each of these measures was significant (paired *t* test using all chil-

Table 3. Spearman Correlation Between Each Baseline OSA Measure and Baseline Behavioral Morbidity*

OSA Assessment	ADHD Scale		Attention Quotient		Mean Sleep Latency	
	Spearman ρ	*P* Value	Spearman ρ	*P* Value	Spearman ρ	*P* Value
Questionnaire Variables						
SRBD scale	**0.65**	**<.001**	−0.16	.11	**−0.25**	**.009**
Inattention/hyperactivity subscale	**0.79**	**<.001**	−0.18	.06	−0.07	.45
Snoring subscale	**0.38**	**<.001**	−0.06	.53	**−0.23**	**.02**
Sleepiness subscale	**0.34**	**<.001**	−0.11	.28	**−0.21**	**.04**
Polysomnographic Variables						
Obstructive apnea index	**0.21**	**.03**	−0.07	.47	**−0.24**	**.01**
Apnea/hypopnea index	0.18	.07	0.03	.74	−0.19	.06
Respiratory disturbance index	0.18	.13	0.05	.70	−0.22	.06
Minimum oxygen saturation, %	−0.07	.48	−0.05	.62	0.16	.10
EEG arousal index	0.03	.75	−0.07	.49	0.04	.71
Percentage of sleep time with end-tidal CO_2 >50 mm Hg	0.03	.80	0.08	.41	**−0.28**	**.005**

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CO_2, carbon dioxide; EEG, electroencephalographic; OSA, obstructive sleep apnea; SRBD, Sleep-Related Breathing Disorder.

*Each correlation is adjusted for age. Bold indicates correlations that reached statistical significance.

Table 4. Spearman Correlation Between Each Baseline OSA Measure and 1-Year Change (Δ) in Behavior*

OSA Assessment	Δ ADHD Scale		Δ Attention Quotient		Δ Mean Sleep Latency	
	Spearman ρ	*P* Value	Spearman ρ	*P* Value	Spearman ρ	*P* Value
Questionnaire Variables						
SRBD scale	**−0.28**	**.005**	−0.06	.53	**0.33**	**<.001**
Inattention/hyperactivity subscale	**−0.22**	**.03**	−0.01	.89	0.16	.12
Snoring subscale	**−0.27**	**.006**	−0.05	.66	**0.30**	**.003**
Sleepiness subscale	−0.04	.67	−0.05	.62	**0.28**	**.005**
Polysomnographic Variables						
Obstructive apnea index	−0.12	.23	0.07	.49	**0.33**	**.001**
Apnea/hypopnea index	−0.12	.22	−0.03	.77	**0.30**	**.003**
Respiratory disturbance index	0.04	.73	−0.07	.54	**0.37**	**.002**
Minimum oxygen saturation, %	0.09	.37	0.08	.43	−0.18	.08
EEG arousal index	0.06	.55	0.11	.29	**0.22**	**.03**
Percentage of sleep time with end-tidal CO_2 >50 mm Hg	0.06	.55	−0.09	.38	0.18	.09

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CO_2, carbon dioxide; EEG, electroencephalographic; OSA, obstructive sleep apnea; SRBD, Sleep-Related Breathing Disorder.

*Each correlation is adjusted for age. Change scores were calculated as follow-up value minus baseline value. Bold indicates correlations that reached statistical significance.

dren in whom the given measure was available at follow-up, $P<.02$ for each). **Table 3** shows correlations between baseline neurobehavioral measures and both the SRBD scale (upper panel) and polysomnographic measures of apnea severity (lower panel). Correlations for subscale components of the overall SRBD scale allow assessment of which portions of the SRBD scale contributed most to associations with neurobehavioral measures. The SRBD scale showed a strong correlation with the ADHD scale, mainly because of the inattention/hyperactivity subscale within the SRBD scale. However, correlations between polysomnographic measures and ADHD symptoms were comparatively low; for example, each was lower than the correlation between the snoring subscale, which contains no items about daytime behavior, and the ADHD scale. In contrast, no SRBD scale or polysomnographic variable correlated significantly with the attention quotient. Mean sleep latency on the Multiple Sleep Latency Test was correlated, to approximately equivalent degrees, with the SRBD scale, snoring subscale, sleepiness subscale, obstructive apnea index, and percentage of sleep time spent with high end-tidal carbon dioxide levels.

Table 4 compares the effectiveness of the baseline SRBD scale vs polysomnographic measures as predictors of behavioral improvement 1 year after adenotonsillectomy or other surgical care. Patterns of correlation resembled those seen at baseline. The SRBD scale, but not polysomnographic measures, predicted 1-year improvement in the ADHD scale. Neither the SRBD scale nor polysomnographic measures predicted improvement in the attention quotient. Both the SRBD scale and polysomnographic measures predicted, to similar extents, 1-year improvement in daytime sleepiness.

Overall, bivariate comparisons suggested that the best polysomnographic predictor of morbidity and 1-year im-

Table 5. Results of Logistic Regression Models in Which Baseline, Dichotomized Neurobehavioral Measures Were Regressed on the SRBD Scale and the Obstructive Apnea Index*

Explanatory Variable	β	SE	Odds Ratio (95% CI)	*P* Value
High ADHD scale† regressed on				
SRBD scale (normalized)	2.80	0.64	16.5 (4.7-58.3)	<.001
Obstructive apnea index (normalized)	–0.59	0.28	0.6 (0.3-1.0)	.04
Low attention quotient‡ regressed on				
SRBD scale (normalized)	0.15	0.23	1.2 (0.7-1.8)	.52
Obstructive apnea index (normalized)	–0.01	0.23	1.0 (0.6-1.5)	.95
Low mean sleep latency§ regressed on				
SRBD scale (normalized)	0.12	0.26	1.1 (0.7-1.9)	.64
Obstructive apnea index (normalized)	0.63	0.35	1.9 (1.0-3.7)	.07

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; SRBD, Sleep-Related Breathing Disorder.
*Each model was adjusted for age; Hosmer-Lemeshow goodness-of-fit test $P>.05$ in each case.
†Defined as a score greater than 60 (1 SD above norm).
‡Defined as a score less than 85 (1 SD below norm).
§Defined as a value less than 15 min.[24]

Table 6. Results of Logistic Regression Models in Which 1-SD Improvements in Neurobehavioral Morbidity Across 1 Year Were Regressed on Baseline SRBD Score and Obstructive Apnea Index*

Change in Morbidity	β	SE	Odds Ratio (95% CI)	*P* Value
Decreased ADHD scale† regressed on				
SRBD scale (normalized)	0.56	0.26	1.7 (1.0-2.9)	.03
Obstructive apnea index (normalized)	–0.33	0.29	0.7 (0.4-1.3)	.25
Increased attention quotient‡ regressed on				
SRBD scale (normalized)	–0.37	0.26	0.7 (0.4-1.1)	.15
Obstructive apnea index (normalized)	0.38	0.24	1.5 (0.9-2.4)	.11
Increased mean sleep latency§ regressed on				
SRBD scale (normalized)	0.49	0.29	1.6 (0.9-2.9)	.09
Obstructive apnea index (normalized)	0.50	0.32	1.7 (0.9-3.1)	.11

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; SRBD, Sleep-Related Breathing Disorder.
*Each model was adjusted for age; Hosmer-Lemeshow goodness-of-fit test $P>.05$ in each case.
†Defined as a score reduced by more than 1 SD (10 points) at follow-up.
‡Defined as a score increased by more than 1 SD (15 points).
§Defined as a value increased by more than 3 min (approximately 1 SD).

provement in morbidity was the obstructive apnea index, and the best SRBD scale predictor was the total SRBD score. **Table 5** provides the results of multiple logistic regression models of these 2 predictors, adjusted for age and each other, as predictors of high ADHD scale scores (1 SD above norms), low attention quotients (1 SD below norms), or excessive daytime sleepiness (mean sleep latency <15 minutes). Adjustment for the obstructive apnea index still left the SRBD scale strongly predictive of high ADHD scores, whereas adjustment for the SRBD scale left the obstructive apnea index with a weak inverse relationship to high ADHD scores. Adjustment for each predictor variable did not reveal any new association with the attention quotient. Similarly, neither the SRBD scale nor the obstructive apnea index independently predicted low mean sleep latency, although the polysomnographic variable showed a trend ($P=.07$).

Similar results were obtained when 1-year behavioral improvement was regressed on the 2 baseline predictor variables (**Table 6**): the SRBD scale but not the obstructive apnea index independently predicted improvement on the ADHD scale; neither variable independently predicted improvement on the attention quotient; and neither independently predicted improvement in mean sleep latency, although the SRBD scale showed a trend.

COMMENT

This study of 5- to 12-year-old children, before and 1 year after adenotonsillectomy or unrelated surgical care, confirms the validity of the SRBD scale by comparison with polysomnographic findings. Furthermore, the data suggest for the first time that if the goal is prediction of clinically relevant neurobehavioral health outcomes rather than sleep laboratory findings, the 1-page SRBD questionnaire provides as much or more clinical utility than does the more elaborate polysomnogram. This analysis was performed retrospectively in a cohort assembled primarily to study neurobehavioral effects of SRBDs, and other important health effects, such as those on the cardiovascular system, were not studied. However, if the current findings can be confirmed prospectively and with respect to other outcomes, then the impact on the diagnosis and management of OSA in children could be substantial.

The criterion validity that we demonstrate for the SRBD scale supports its usefulness in clinical research. A growing number of investigations have used the SRBD scale—at least 8 studies in 2004 and 2005 alone[25-32]—and the present data support its effectiveness as a screen to identify children at high or low risk for OSA. On the other hand, our findings also demonstrate that even a comparatively detailed questionnaire is unlikely to replicate polysomnographic data reliably enough for individual patients in clinical settings. The sensitivity and specificity of the dichotomized SRBD score were 78% and 72%, respectively, in the entire sample. These results suggest some utility as a simple adjunct assessment during otolaryngology office visits: almost all (91%) of the 78 patients who underwent adenotonsillectomy were suspected to have OSA based on their clinical evaluations, whereas only 40 (51%) in fact showed OSA on polysomnography.[2] This suggests an otolaryngologist office visit diagnostic sensitivity of 95% but a specificity of only 13%. These numbers could have been different if we had had an opportunity to study otolaryngologists' patients who were not scheduled for adenotonsillectomy in addition to those who were. However, the results raise the possibility that the SRBD scale might help otolaryngologists improve the specificity (and associated positive predictive value) of their office-based evaluations, to the extent that they seek to predict polysomnographic results.

Polysomnography, however, is an imperfect gold standard when it comes to predicting either neurobehavioral morbidity believed to arise from OSA or response to treatment. Whereas numerous studies[33-37] have shown that snoring predicts adverse neurobehavioral outcomes in children, many studies[29,36-42] also have failed to find correlations between those outcomes and polysomnographic findings. Snoring itself, or some other feature of OSA that is not well quantified on standard polysomnography, may play an important role in the pathogenesis of associated cognitive and behavioral morbidity. Examples of technical approaches under investigation, with promise that they might improve the predictive value of polysomnography, include analyses of esophageal pressure recordings,[43] respiratory cycle–related electroencephalographic changes,[11] the ratio of respiratory to nonrespiratory arousals,[44] and the cyclic alternating pattern.[25]

These observations also raise an important possibility that has not, to our knowledge, been tested previously. Apart from the unique ability of polysomnography to record and illuminate known pathophysiologic features, could a child's symptoms, determined by interview or questionnaire, provide predictive value beyond that of polysomnography in a clinical setting? The present results suggest that the answer may be yes. Conversely, these findings did not generally demonstrate added value of polysomnography after the SRBD scale was taken into account.

Part of the reason that the SRBD scale proved effective in predicting cross-sectional morbidity may be that some parents probably tend to rate their children high, in a nonspecific manner, for any pathologic finding. This could explain, in part, the correlations between the SRBD scale or its components and the ADHD scale, which is also a parent rating. In contrast, no significant correlation emerged between the SRBD scale and the attention quotient, which is derived from an objective continuous performance task. However, the SRBD scale did correlate with results on the Multiple Sleep Latency Test, which also is an objective test. Even if the predictive value of the SRBD scale derives in part from subjective parent impressions, and also from item overlap with the behavioral rating instrument, the SRBD scale likely captures the impact of disruptive behavior on affected families, information that reasonably might contribute to a treatment decision.

The present data derive from a unique, intensively studied cohort of children. The findings are limited, nonetheless, by the nonrandomized design, the retrospective nature of the analysis, and the lack of additional OSA-related outcome measures. For example, the relative extent to which the SRBD scale and polysomnography may predict children's systemic hypertension, pulmonary hypertension, growth impairment, quality of life, or responses of these morbidities to treatment remains untested. Preoperative polysomnography also may serve important purposes other than to diagnose OSA, for example, to screen for severe OSA that raises risks of perioperative adenotonsillectomy complications.[45] For these reasons, we cannot conclude that the SRBD scale is an adequate substitute for polysomnography in clinical practice. However, the present findings should stimulate new prospective studies of OSA and adenotonsillectomy outcomes in relation to both polysomnographic and simpler assessment methods. Nocturnal polysomnography is expensive, time-consuming, and sometimes unavailable in a timely manner. The diagnostic added value of polysomnography—over that provided by a simple, 1-page symptom inventory or a good history and physical examination—should be clearly demonstrated. If this added value cannot be verified, then recommendations for objective testing before adenotonsillectomy, to confirm treatable OSA and distinguish it from primary snoring,[1] may deserve reassessment. Persistence of OSA in a significant number of children after adenotonsillectomy,[46] combined at that point with reduced sensitivity of a symptom-based diagnosis, as suggested by the present data, argues that polysomnography may prove more important after adenotonsillectomy than before.

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