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Original article

Pediatric Sleep Questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems ☆

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Abstract

Objective: To develop and validate questionnaire scales that can be used in research to investigate the presence of childhood SRBDs and prominent symptom complexes, including snoring, daytime sleepiness, and related behavioral disturbances.

Background: Obstructive sleep-related breathing disorders (SRBDs) are common but usually undiagnosed among children. Methods to help identify SRBDs without the expense of polysomnography could greatly facilitate clinical and epidemiological research.

Methods: Subjects were children aged 2–18 years who had polysomnographically-confirmed SRBDs ($n = 54$) or appointments at either of two general pediatrics clinics ($n = 108$). Parents completed a Pediatric Sleep Questionnaire which contained items under consideration for inclusion in desired scales.

Results: Item reduction, based on data from a randomly selected 50% of the subjects (group A), produced a 22-item SRBD score that was strongly associated with diagnosis of an SRBD ($P < 0.0001$) in a logistic regression model that accounted for age and gender. Diagnosis was also strongly associated with subscores for snoring (four items, $P < 0.0001$), sleepiness (four items, $P = 0.0003$), and behavior (six items, $P < 0.0001$) among group A subjects. The scales performed similarly well among group B subjects, and among subjects of different ages and gender. In group A and B subjects, respectively, a selected criterion SRBD score produced a sensitivity of 0.85 and 0.81; a specificity of 0.87 and 0.87; and a correct classification for 86 and 85% of subjects. The scales showed good internal consistency and, in a separate sample ($n = 21$), good test-retest stability.

Conclusions: These scales for childhood SRBDs, snoring, sleepiness, and behavior are valid and reliable instruments that can be used to identify SRBDs or associated symptom-constructs in clinical research when polysomnography is not feasible.
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1. Introduction

Obstructive sleep apnea affects 0.7–3.0% of children and can produce excessive daytime sleepiness, behavioral problems, learning disabilities, right-sided heart failure, growth retardation, or failure to thrive

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[1–3]. With a prevalence that is not yet known, upper airway resistance syndrome affects children who do not meet diagnostic criteria for OSA but suffer from sleep fragmentation and daytime behavioral morbidity similar to that seen in children with OSA [4]. Most children who have obstructive sleep-related breathing disorders (SRBDs) of either type remain undiagnosed [4]. Recent conservative estimates suggest that more than 80% of adult men and 90% of women with obstructive sleep apnea syndrome have yet to be diagnosed [5], and children probably escape diagnosis more often than adults because they frequently have distinct signs and symptoms that are less widely recognized [6].

The gold-standard in the diagnosis of SRBDs is polysomnography, but the time, effort, and expense of laboratory studies has limited relevant research and particularly epidemiological research that requires large samples. Research in adults has profited from the existence of several validated questionnaire instruments to assess for SRBDs or related symptoms [7,8]. However, few published questionnaires have been designed to assess for SRBDs and associated symptoms as they occur in children. For example, although excessive daytime sleepiness can affect adults or children with SRBDs, inattention and hyperactivity – often sufficient to result in a diagnosis of attention-deficit/hyperactivity disorder – may be more specific to children with SRBDs [9–12].

In one previous study, a three-question-item obstructive sleep apnea score allowed reliable diagnosis for only a minority of 23 children referred for possible SRBDs [13]. A subsequent study of these and additional questions also showed that these items had potential value in epidemiological research, though test characteristics were again inadequate to obviate the need for polysomnography in most pediatric patients with sleep-related complaints [14]. Each of these two studies reported on the utility of scores that combined only the three best question-items; one publication did not include the equation for the combined score; and neither score would have been convenient to use in practice because of item-specific coefficients, unique constants, and non-uniform question-item response scales. The scores included items that focused only on observed breathing or snoring during sleep, and neither score included representative items from other symptom-complexes known to be common in childhood OSA. Neither score was tested in a sample that included children with upper airway resistance syndrome. Finally, neither study reported reliability of the questionnaire instruments.

In an ongoing effort to develop a Pediatric Sleep Questionnaire (PSQ) that can help assess children for sleep disorders, we prospectively developed and validated questionnaire scales for SRBDs and related symptoms, including 3 prominent symptom-complexes: snoring, excessive daytime sleepiness, and inattentive/hyperactive behavior. We sought to explore potential utility in clinical research rather than to devise an instrument that reduces the need for polysomnography in clinical practice.

2. Methods

2.1. Subjects

Parents of children aged 2–18 years who had polysomnography for clinical indications between April 1996 and September 1998 in the Sleep Laboratory of the University of Michigan were prospectively recruited to give written informed consent and participate in this Institutional Review Board-approved study. We excluded children who had severe medical or mental impairments that precluded parental assessment of usual childhood behaviors. However, more specific inclusion criteria were avoided to preserve external validity ('generalizability') of results. On the evening of the polysomnogram, each parent completed questionnaires about the patient's sleep and daytime behavior. Within the same period, parents who accompanied their children to two University-owned but almost entirely community-based general pediatrics clinics were also recruited to fill out the questionnaires. The questionnaires took about 20–30 min to complete. To help assess test-retest reliability, a separate small series of parents at one of the general pediatrics clinics were asked, by mail, to complete the questionnaire again 2–4 weeks after the initial responses.

Patients' data were included in the current study if polysomnography confirmed an SRBD, as defined objectively by either a rate of apneas and hypopneas (apnea/hypopnea index, or AHI) above 5 per hour of sleep or by peak negative end-inspiratory esophageal

pressures in excess of −20 cm of water. These criteria were chosen with some care, in an effort to adopt internally uniform limits reasonably applicable to our wide range of subject ages, and with the realization that better cutoffs are difficult to define at present in the absence of the necessary outcome-based, age-stratified studies [15]. Although one frequently cited study of 50 normal children found an apnea index (AI) of 1 or more to be unusual [16], this study did not define what rate of apneas causes adverse outcomes and did not address the role of hypopneas, which at least in adults appear to have outcome-related significance comparable to that of apneas [17,18]. We chose to include hypopneas in our criterion for OSA, and we used an AHI threshold of 5 instead of an AI of 1.

Although esophageal pressures in excess of −20 cm of water do not define upper airway resistance syndrome, no widely accepted alternative definition is currently available. A sentinel publication described the syndrome as a combination of excessive daytime sleepiness and gradually worsening pressures that led to frequent arousals [19], but published data have not (1) defined a minimum required rate of arousals above that seen in normal adult sleep [20], (2) established a criterion pressure that distinguishes abnormal vs. normal pressures, (3) indicated what proportion of an abnormal record must exhibit abnormal pressures, or (4) established what length of recording, prior to an arousal, should exhibit continuously worsening pressures in order to attribute the arousal to increased breathing effort. In addition, some publications [21,22] and our own clinical experience have suggested that some patients have excessively negative pressures without frequent arousals but still experience symptomatic improvement after intervention to relieve upper airway obstruction. As a criterion for inclusion in the current SRBD group when OSA was absent, we therefore adopted a simple, objective, but somewhat conservative criterion: a minimum esophageal pressure of −20 cm of water. This cut-off level is twice the limit thought to be pathological by some researchers [19].

Subjects were listed in order of recruitment at each site and consecutive pairs were then randomly divided into groups A and B. Data from group A were used to develop the scales discussed below, and data from group B were used to verify validity.

2.2. Polysomnography

Nocturnal polysomnography included four electroencephalographic leads (C3-A2, C4-A1, O1-A2, O2-A1 of the 10–20 international electrode placement system), two electro-oculographic leads (right and left outer canthi), chin and bilateral anterior tibialis surface electromyograms, two electrocardiographic leads, nasal and oral airflow (thermistors), thoracic and abdominal excursion (piezoelectric strain gauges), and finger oximetry. In a minority of cases, and at the referring physician's request, esophageal pressure was monitored with a water-filled catheter [23] which does not have significant adverse effects on children's sleep [24]. Sleep stages were scored in 30-s epochs according to standard criteria [25] by technologists who, after an extensive training program, had correctly scored at least 90% of epochs in a set of reliability records.

An apnea was defined as 10 or more seconds of complete airflow cessation during sleep, regardless of any change in oxygen saturation. An hypopnea was defined as a 10-s reduction in airflow, chest excursion, or abdominal excursion that led to either a 4% or greater oxyhemoglobin desaturation, an arousal, or an awakening. Some pediatric sleep laboratories now score apneas or hypopneas that are less than 10 s long, in part because normal respiratory rates can be considerably higher in young children than in adults. However, this justification would not apply well to the older teenagers we studied. We suspect that in the current study, esophageal pressure monitoring allowed identification of subtle SRBDs in some of the younger children for whom shorter apneic event criteria might otherwise have been important.

2.3. Development of PSQ

Items thought to be predictive of SRBDs in children were formulated based on clinical experience (see Appendix A). Questions were kept simple and concise, and a yes/no/don't know response format was chosen instead of a more finely graded Likert scale to simplify administration of individual question-items or scales, which may eventually be presented orally in some settings. Questions were phrased in ways that were sometimes only subtly different (e.g. items B2 and B3) in order to determine

which method of posing the question would be most useful. Items for inattention and hyperactivity were taken from DSM-IV category A symptoms for attention-deficit/hyperactivity disorder and paired with 4-level Likert responses in a manner well-established in previous community-based epidemiological research [26]. To reduce responses to yes/no formats equivalent to those for other items, 'does not apply' and 'applies just a little' were scored as no (0), and 'applies quite a bit' and 'definitely applies most of the time' were scored as yes (1).

Early versions of the PSQ were refined based on pilot tests and review by clinicians experienced in pediatric sleep medicine. Utility of the questionnaire was suggested by preliminary data on validity and by performance of the question-items in a study of the association between symptoms of attention-deficit/hyperactivity disorder and those of SRBDs [27].

2.4. Analyses

Scales for SRBD, snoring, sleepiness, and inattentive/hyperactive behavior were developed. We sought to produce a concise overall SRBD questionnaire of about 20 items that could be completed in about 5 min. Items were chosen for inclusion in scales based on several principles: (1) the desire to include items that represented snoring frequency, snoring quality, observed breathing problems, any of several SRBD-related problems (mouth breathing, nocturnal sweating, nocturia, enuresis, nasal congestion, nocturnal bruxism, delayed growth, obesity), problem sleepiness, inattention, hyperactivity, and impulsivity; (2) results of simple logistic regressions of SRBD presence or absence on responses to each question-item, controlling for age and gender (using data from group A); and (3) results of multiple logistic regressions that tested the independent utility of two or more similarly phrased questions.

We subjected items chosen on the basis of these criteria to factor analysis, by the principal components method with varimax rotation, to check that items loaded adequately on expected scales. Raw scale scores were then calculated as the proportion of questions answered affirmatively. Occasional missing answers or responses of 'don't know' were discounted from the denominator when calculating these proportions. Raw scale scores were then standardized by subtracting the mean score and dividing by the standard deviation. For each scale, validity was assessed with a logistic regression model of SRBD (presence or absence) on the particular scale scores, controlling for age and gender. Validity was then reassessed in the same manner using data from group B subjects. Possible differences in validity for subjects of different age or gender were assessed by tests of interaction terms within logistic regression models. For the SRBD scale, we performed receiver operator curve calculations to select an optimal cutoff among group A subjects, determined the sensitivity and specificity associated with that cutoff, and rechecked the selected criterion with group B data.

Reliability was assessed in two ways. Internal consistency was checked by calculation of Cronbach's alpha, within group A and then group B subjects. Test-retest reliability data was collected on a completely separate sample of 21 children whose parents completed the questionnaire-items twice, first at a general pediatrics clinic and then again by mail approximately one month later.

All analyses were performed with SAS®, V. 6.12 (SAS Institute Inc., Cary, NC). In tests of statistical significance, the level was set at 0.05.

3. Results

3.1. Sample characteristics

Consecutive totals of 54 subjects with SRBDs and 108 general pediatrics subjects provided data suitable for analysis. These represented about 80% of the child-parent pairs approached at the sleep laboratory and about 50% of eligible child-parent pairs approached at the general pediatrics clinics. The yield at waiting rooms of the general pediatrics clinics was lower in part because many parents declined to finish the questionnaire once they were called into their appointment. The mean ages of the SRBD and control children were 9.3 ± 4.1 (SD) and 7.0 ± 3.8 years, respectively (t-test $P = 0.0005$), and the proportion male was 0.70 and 0.54, respectively (chi-square $P = 0.04$). No significant differences in age or gender existed between groups A and B after random assignment to each.

Among the 54 children with SRBDs, 46 qualified

for inclusion because they had at least five apneas and hypopneas per hour of sleep, and eight children with lower rates of apneic events qualified because they had peak negative esophageal pressures in excess of −20 cm of water. The mean rate of apneas and hypopneas for the entire group ($n = 54$) was 13.1 ± 11.5 per hour of sleep (range 0.1–59.3), and the mean peak negative esophageal pressure ($n = 14$ patients monitored) was −34.3 ± 19.5 cm of water (range −10 to −70). Esophageal pressures had been monitored in 6 group A and 8 group B subjects. Neither the rate of apneic events nor the mean peak negative esophageal pressures showed statistically significant differences between groups.

3.2. Scale development

Logistic regression models and selection criteria described above identified the question-items shown in Table 1 as those most suitable for use in SRBD and SRBD-related scales. Items A1, A9, A11, A12, A22, C1, C2, C3, C6, C7, C9, C12, C13, and C17 (see Appendix A) were not retained because they demonstrated associations with SRBDs which, though statistically significant, were weaker than associations shown by other similar questions. For example, positive responses to item A1, '… does your child ever snore?,' were less strongly associated with SRBDs (odds ratio = 6.9, $P = 0.0079$) than were positive responses to item A2, ''… does your child snore more than half the time'' (OR = 10.8, $P = 0.0004$). Item A8 showed a strong association with SRBDs but did not do so after taking similarly worded item A6 into account. Items that demonstrated no statistically significant association with SRBDs included A15, A17, A23, A27, A29, A30, B3, and B5.

Table 1
Questionnaire items retained for use in the SRBD scale and subscales (indicated in bold); results of logistic regressions with presence of an SRBD as the outcome and each symptom as the explanatory variable (controlling for age and gender); and loading of question-items on 4 related constructs in factor analysis

Symptom category	Item[a]	Logistic regression		Factor analysis	
		Odds ratio	*P*-value	Factor	Loading
Snoring					
Frequency	A2: usually snores	10.8	0.0004	Breathing	0.85
	A3: always snores	10.5	0.0006	Breathing	0.81
Quality	A4: snores loudly	10.4	<0.0001	Breathing	0.88
	A5: heavy breathing	52.4	0.0003	Breathing	0.62
Breathing problems	A6: trouble breathing	41.8	<0.0001	Breathing	0.47
	A7: observed apneas	22.3	0.0005	Breathing	0.37
Mouth breathing	A24: mouth open during day	14.3	0.0004	Breathing	0.55
	A25: dry mouth on awakening	9.0	0.0020	Breathing	0.62
Daytime sleepiness	B1: unrefreshed in morning	7.3	0.0012	Other	0.60
	B2: problem with sleepiness	3.9	0.0316	Sleepiness	0.89
	B4: sleepy per teacher	8.9	0.0019	Sleepiness	0.85
	B6: hard to wake up	3.6	0.0139	Other	0.54
Inattention/hyperactivity	C3: does not listen	8.0	0.0023	Behavior	0.71
	C5: difficulty organizing	10.0	0.0011	Behavior	0.70
	C8: easily distracted	7.1	0.0005	Behavior	0.55
	C10: fidgets	8.0	0.0022	Behavior	0.80
	C14: on the go	6.8	0.0030	Behavior	0.74
	C18: interrupts	6.1	0.0018	Behavior	0.79
Other symptoms	A32: nocturnal enuresis	8.6	0.0016	Other	0.55
	B7: morning headache	10.2	0.0123	Breathing	0.52
	B9: delayed growth	7.9	0.0196	Other	0.72
	B22: obesity	4.9	0.0245	Other	0.49

[a] Text for each item is listed in Appendix A.

3.3. Factor analysis

For the factor analysis of the 22 retained variables, a scree plot of eigenvalues suggested that 4 or 5 factors would be optimal. Factor loadings on 4 constructs/factors are shown in the last two columns of Table 1. All question-items about snoring, breathing problems, and mouth breathing loaded well onto the first factor, labeled 'breathing'. All items that concern attention, hyperactivity, and impulsivity loaded well onto the second factor, 'behavior'. Items that reflect problem sleepiness loaded onto the third factor, 'sleepiness', while those related to difficulty getting up in the morning, nocturnal enuresis, delayed growth, and obesity showed high loading on a fourth factor, 'other'.

3.4. Scale validity

Univariate logistic regression models showed that age had a significant association with SRBD presence (odds ratio = 1.19, $P = 0.0076$) but gender did not ($P = 0.34$). In a logistic regression model that controlled for age and gender, the score on a snoring scale – constructed as the standardized mean value of question-items A2, A3, A4, A5–was associated with SRBD diagnosis ($P < 0.0001$): the odds ratio for presence of an SRBD and a one-standard-deviation increase in the raw snoring score was 3.87 and for the overall model, the area under a calculated receiver operator curve (ROC) was 0.85 (Table 2). In analogous models, the sleepiness score (B1, B2, B4, B6) and behavioral score (C3, C5, C8, C10, C14, C18) were also highly significant, and the area under the ROC for the respective models was 0.80 and 0.84. The standardized mean of all responses (each 0 or 1) on the 22-item SRBD scale showed the strongest association with SRBD diagnosis (area under the ROC = 0.95, $P < 0.0001$) (see Figs. 1 and 2). This model controlled for age and gender but neither variable showed a significant independent association with outcome ($P > 0.1$ for each). Table 3 shows that tests of the snoring, sleepiness, behavior, and SRBD scales in group B subjects showed similarly high magnitudes of association and levels of significance.

3.5. Interaction with age and gender

In logistic regression models of group A data, successive tests of interaction terms for age and (1) snore score, (2) sleepiness score, (3) behavior score, and (4) SRBD score all failed to show significance ($P > 0.1$ for each; gender was accounted for in each model). Tests of interaction terms for gender and the same scores also showed no significant interactions ($P > 0.1$, age accounted for in each model) except for gender × behavior score ($P = 0.0396$): the association between diagnosis of SRBD and the behavioral score showed a higher magnitude for $n = 33$ female children (area under the ROC = 0.92, $P = 0.0125$) than for 48 male children (area under the ROC = 0.80, $P = 0.0034$). However, the interaction of gender with behavior showed no significance ($P = 0.72$) when tested among group B subjects.

3.6. Sensitivity and specificity of SRBD scale

An ROC for the raw mean SRBD score as a test for SRBD diagnosis, among group A subjects, is shown in Fig. 2. These data suggested that the optimal SRBD scale cutoff to indicate presence of SRBD would be

Table 2
Group A subjects: Logistic regression models of SRBD diagnosis (present or absent) as explained by snoring, sleepiness, inattention/hyperactivity, and overall SRBD standardized scale scores[a]

Scale	Beta	SE	*P*-value	Odds ratio	Area under ROC
Snoring	1.35	0.33	<0.0001	3.87	0.85
Sleepiness	1.08	0.30	0.0003	2.93	0.80
Behavior	1.35	0.34	<0.0001	3.86	0.84
SRBD	2.63	0.57	<0.0001	13.83	0.95

[a] In each model, age and gender were taken into account by including them as additional explanatory variables. Odds ratios are for SRBD presence and a one-unit increase in standardized score on the indicated scale (equivalent to a one-standard-deviation increase in the raw score). SRBD = sleep-related breathing disorder; ROC = receiver operator curve for entire model.

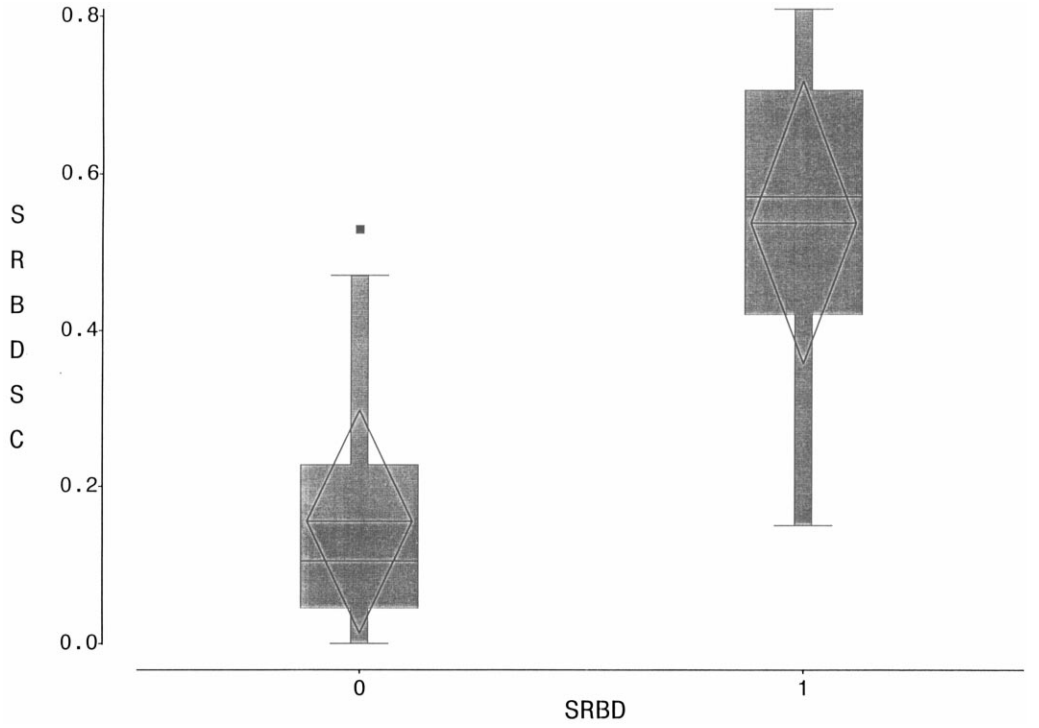

Fig. 1. Box plots of the SRBD scores (SRBDSC) among children with SRBDs (SRBD = 1) and control children (SRBD = 0). Boxes show median, 75th, and 25th percentiles. Whiskers show 90th and 10th percentiles. Diamonds show means and standard deviations.

0.33 (i.e. 33% of the 22 question-items answered positively), with greater values suggesting the diagnosis. This criterion correctly classified 86.4% of the subjects and resulted in a test sensitivity of 0.85 and a specificity of 0.87. Application of the same criterion to group B subjects correctly classified 85% of the subjects and showed a sensitivity of 0.81 and a specificity of 0.87.

The number of SRBD subjects with an AHI ≤ 5 was too small to allow comparison of these subjects to controls within each group (A and B). However, among all subjects with AHI ≤ 5 or presumed absence of SRBDs ($n = 8 + 108 = 116$), the SRBD criterion score of 0.33 correctly classified 87.1% of the subjects and resulted in a test sensitivity of 0.88 and a specificity of 0.87. Among those subjects with $AHI > 5$ or presumed absence of SRBDs ($n = 46 + 108 = 154$), the SRBD criterion score of 0.33 correctly classified 85.7% of the subjects and resulted in a test sensitivity of 0.83 and a specificity of 0.87.

3.7. Reliability: internal consistency

Among group A subjects, Cronbach's alpha for each scale was: snoring scale, 0.86; sleepiness scale, 0.66; behavior scale, 0.84; and SRBD scale, 0.89. Among group B subjects, Cronbach's alpha for each scale was: snoring scale, 0.86; sleepiness scale, 0.77; inattention/hyperactivity scale, 0.83; and SRBD scale, 0.88.

3.8. Test-retest reliability

The mean time between initial and subsequent questionnaire completion was 36.3 ± 13.6 days, and the range was 19 to 67 days. The two administrations revealed a Spearman correlation coefficient ρ of 0.92 for the snoring scale ($P < 0.0001$), 0.66 for the sleepiness scale ($P = 0.0010$), 0.83 for the behavior scale ($P < 0.0001$), and 0.75 for the SRBD scale ($P < 0.0001$). The mean differences between raw

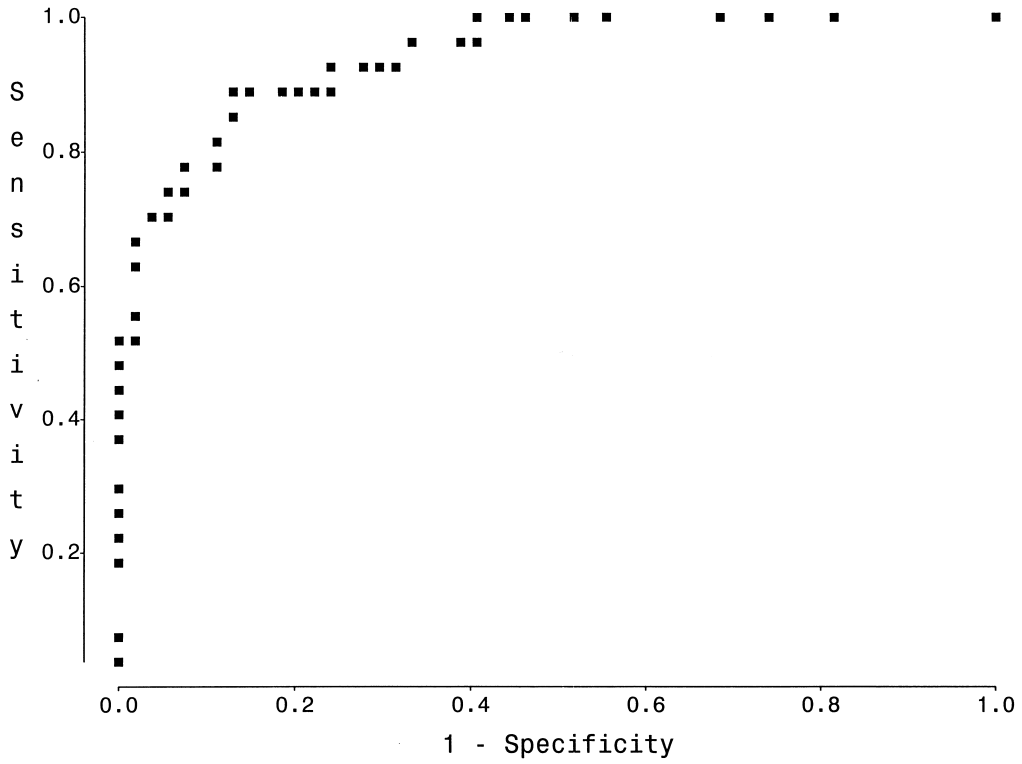

Fig. 2. Receiver operator curve for SRBD score as a test for SRBD diagnosis among group A subjects. Performance of the SRBD score can be assessed by the degree to which the curve deviates from a straight line (no relationship to diagnosis, area under the curve = 0.5) and toward the upper-left corner (perfect prediction of diagnosis, area under the curve = 1.0). In this case, area under the curve = 0.95.

scores on successive administrations (2nd minus 1st) of each scale were 0.00 ± 0.11, -0.04 ± 0.23, 0.00 ± 0.11, and -0.02 ± 0.07, respectively, none of which approached statistical significance (paired *t*-tests, $P > 0.2$ for each).

4. Discussion

This study demonstrates the validity and reliability of PSQ scales for childhood SRBD, snoring, excessive daytime sleepiness, and inattentive/hyperactive

Table 3
Group B subjects: Logistic regression models of SRBD diagnosis (present or absent) as explained by snoring, sleepiness, inattention/hyperactivity, and overall SRBD standardized scale scores[a]

Scale	Beta	SE	*P*-value	Odds ratio	Area under ROC
Snoring	1.54	0.35	<0.0001	4.65	0.85
Sleepiness	0.92	0.29	0.0016	2.52	0.77
Behavior	0.93	0.30	0.0017	2.54	0.79
SRBD	2.30	0.50	<0.0001	9.93	0.92

[a] In each model, age and gender were taken into account by including them as additional explanatory variables. Odds ratios are for SRBD presence and a one-unit increase in standardized score on the indicated scale (equivalent to a one-standard-deviation increase in the raw score). SRBD = sleep-related breathing disorder; ROC = receiver operator curve for entire model.

behavior. Validity was established by comparison to objective criteria – polysomnographically defined obstructive SRBDs – and by demonstration that the questionnaire scales had substantial ability to predict diagnostic classification. The SRBD items that were selected for inclusion in the snoring and behavioral scales segregated well on factor analysis, which suggests that they addressed respective underlying constructs. Items that addressed problem sleepiness and difficulty getting up in the morning loaded onto separate factors, but both sets of items had sufficient face validity to justify inclusion in a unified sleepiness scale. All scales proved reliable, as judged by both internal consistency and test-retest stability.

The SRBD scale produced excellent odds ratios in group A and B regressions with diagnosis as the outcome, and areas under ROCs were above 0.90. Both sensitivity and specificity were high when 8 or more positive answers to the 22 question-items were considered abnormal. This test criterion identified subjects with excessive negative intrathoracic pressures about as accurately as it identified subjects with obstructive sleep apnea. These test characteristics make the instrument a valuable potential tool in epidemiological research. For example, the SRBD scale could be used to identify variables that covary with SRBDs in a population for which screening by polysomnography would be impractical. Use of the SRBD scale in clinical practice, however, is not likely to obviate the need for polysomnography. The test can be made either more sensitive or specific by requiring fewer or more positive responses, respectively, as an indication of SRBD presence, but only at the sacrifice of the other test characteristic value (Fig. 2). Most importantly, the SRBD and other scales were validated by comparison of general pediatric patients to diagnosed sleep clinic patients: We have not tested whether the scales would correctly identify SRBDs among children referred to sleep centers for symptoms of SRBDs. Previous investigators have tested their own questionnaire items in this context and found their accuracy insufficient to reduce the need for polysomnography in clinical practice [14], and our current data do not assess whether our scales would perform differently. Another group developed a questionnaire-based OSA score with data from diagnosed patients and normal controls, but then demonstrated less clear-cut discriminant ability when they retested the instrument among 23 children referred for possible OSA [13]. A third group described a sleep breathing disorders scale, but included only three items (about difficulty breathing during the night, inability to breathe during the day, and snoring) and methodological differences prevent direct comparison of their validity data to the results we obtained [28].

Ample evidence now exists that SRBD symptoms differ between children and adults. Though we did not administer our question-items to adults, our data confirm previous reports of the importance of several childhood symptoms that may not be as prominent in adults, including mouth breathing [13,14], a history of delayed growth [29], and especially features of inattention and hyperactivity [1,9]. Our data confirm that daytime sleepiness is an important symptom of SRBDs in children, as in adults, but also suggest that this symptom may be less prominent than other daytime behaviors among children with SRBDs.

Given the different presentations of SRBDs in children and adults, we were somewhat surprised to find no evidence, within the broad range of ages we tested, that the association between diagnosis and scale scores varied with age. This finding may reflect the broad, simple wording of most question-items. The age-specific influence of some individual question-items may have been obscured when composite scale scores were calculated. Some of the originally tested items (such as A9 and A15) that failed to reach inclusion in the final scales may have proven useful in more age-specific analyses. Our ability to discern effects of age may also have been limited by an insufficient sample size and power for this analysis. Further testing in larger samples of children will be necessary to develop more age-specific instruments.

The current data support use of the reported scales in SRBD research – as question-items appear to assess the features of snoring, sleepiness, and behavior that are important in SRBDs – but use of these scales in other contexts should proceed with some caution. Use in clinical practice should probably await studies of whether these scales distinguish between referred patients with SRBDs and those without SRBDs, and between patients with SRBDs and those with other causes of excessive daytime sleepiness. The sleepiness items are straightforward and have good face validity, but future validation in comparison to results of Multiple Sleep Latency Tests would also be useful.

The current study was conservative in that all control subjects were assumed to be free of SRBDs; future studies of PSQ performance would benefit from inclusion of control polysomnographic data, which would probably reduce the false positive rates we found and thereby show improved scale performance.

We conclude that the SRBD, snoring, sleepiness, and behavioral scales are valid and reliable instruments for use in clinical research on sleep-disordered breathing in children. The SRBD scale applies to a broad age group, should provide a useful alternative to adult instruments, and may provide more comprehensive assessment than simpler pediatric instruments that have been published previously. The specific subscales for snoring, sleepiness, and behavior are valid as they relate to SRBD diagnosis and may be useful for studies that focus on these individual symptom-constructs [27].

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Appendix A. Question-items tested and retained (in bold) for final scales

While sleeping, does your child...

A1 … ever snore?
A2 … snore more than half the time?
A3 … always snore?
A4 … snore loudly?
A5 … have ''heavy'' or loud breathing?
A6 … have trouble breathing, or struggle to breathe?

Have you ever …

A7 … seen your child stop breathing during the night?
A8 … been concerned about your child's breathing during sleep?
A9 … had to shake your sleeping child to get him or her to breathe, or wake up and breathe?
A11 … seen your child wake up with a snorting sound?
A12 Does your child have restless sleep?
A15 At night, does your child usually become sweaty, or do the pajamas usually become wet with perspiration?
A17 At night, does your child usually get out of bed to urinate?
A21 Does you child usually sleep with the mouth open?
A22 Is your child's nose usually congested or ''stuffed'' at night?
A23 Do any allergies affect your child's ability to breathe through the nose?

Does your child …

A24 … tend to breathe through the mouth during the day?
A25 … have a dry mouth on waking up in the morning?
A27 … complain of an upset stomach at night?
A29 … get a burning feeling in the throat at night?
A30 … grind his or her teeth at night?
A32 … occasionally wet the bed?

Does your child …

B1 … wake up feeling *un*refreshed in the morning?
B2 … have a problem with sleepiness during the day?
B3 … complain that he or she feels sleepy during the day?
B4 Has a teacher or other supervisor commented that your child appears sleepy during the day?
B5 Does your child usually take a nap during the day?
B6 Is it hard to wake your child up in the morning?
B7 Does your child wake up with headaches in the morning?
B9 Did your child stop growing at a normal rate at any time since birth?
B22 Is your child overweight?

This child often …

C1 … fails to give close attention to details or makes careless mistakes in schoolwork, work or other activities

C2 … often has difficulty sustaining attention in tasks or play activities

C3 … does not seem to listen when spoken to directly

C4 … does not follow through on instructions and fails to finish schoolwork, chores or duties

C5 … has difficulty organizing task and activities

C6 … avoids, dislikes, or is reluctant to engage in tasks or activities that require sustained mental effort (such as homework or schoolwork)

C7 … loses things necessary for tasks or activities (e.g. toys, school assignments, pencils, books or tools)

C8 … is easily distracted by extraneous stimuli

C9 … is forgetful in daily activities

C10 … fidgets with hands or feet or squirms in seat

C11 … leaves seat in classroom or in other situations in which remaining seated is expected

C12 … runs about or climbs excessively in situations in which it is inappropriate

C13 … has difficulty playing or engaging in leisure activities quietly

C14 … is 'on the go' or often acts as if 'driven by a motor'

C15 … talks excessively

C16 … blurts out answers before questions have been completed

C17 … has difficulty awaiting his/her turn

C18 … interrupts or intrudes on others (e.g. butts into conversations or games)

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