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Original Research Article

Screening for sleep related breathing disorders and assessing the risk of obstructive sleep apnea in 2-18 years of children using paediatric sleep questionnaire: an observational study

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ABSTRACT

Background: Paediatric obstructive sleep apnea (OSA) is a prevalent yet under-recognised condition associated with significant neurocognitive, behavioural, and cardiovascular morbidity. Polysomnography, the diagnostic gold standard, remains inaccessible in many resource-limited settings. The paediatric sleep questionnaire (PSQ) offers a validated, non-invasive alternative for outpatient screening. Objectives were to screen children aged 2-18 years for sleep-related breathing disorders (SRBD) and assess the risk of OSA using the PSQ, along with associated clinical risk factors.

Methods: An observational study was conducted at a tertiary care paediatric outpatient department. Children presenting with at least one sign or symptom of SDB were enrolled using a validated structured checklist. The 22-item PSQ (Chervin et al) was administered via caregiver interview. A PSQ score≥0.33 defined high OSA risk. Associations with clinical variables were assessed by chi-square test.

Results: Of 386 children enrolled (65.5% male; majority aged 6-10 years), 235 (60.9%) had PSQ ≥0.33. Neurobehavioural daytime symptoms-hyperactivity, attention deficit, aggressive behaviour, poor school performance, and difficulty in arousing-were significantly associated with high PSQ score (all $p<0.05$). Nighttime symptoms including snoring, mouth breathing, restless sleep, frequent awakenings, enuresis, increased work of breathing, and diaphoresis showed significant associations (all $p<0.05$). Physical signs significantly associated with high PSQ score included hypertrophied nasal turbinate, tonsillar hypertrophy, adenoid facies, and obesity (all $p<0.05$). Among children with confirmed adenoid enlargement on lateral nasopharyngeal radiograph (n=112), higher grades of adenoid hypertrophy were significantly associated with higher PSQ score categories ($p=0.001$).

Conclusions: A substantial proportion (60.9%) of symptomatic children in an outpatient setting were at high OSA risk. The PSQ is a practical, validated screening tool enabling early identification of at-risk children, particularly in resource-limited settings where polysomnography is unavailable.

Keywords: Obstructive sleep apnea, Children, Paediatric sleep questionnaire, Sleep-disordered breathing, screening, Adenoid hypertrophy, Obesity

INTRODUCTION

Sleep is a fundamental physiological process essential for the growth, neurocognitive development, and overall health of children. The normal sleep cycle alternates between non-rapid eye movement (NREM) and rapid eye movement (REM) sleep, playing a critical role in physical restoration, memory consolidation, and brain maturation.[1] SRBD constitute a significant and often under-recognised cause of sleep disturbance in the paediatric population, comprising a spectrum from primary snoring to OSA.[2]

OSA in children is characterised by recurrent episodes of partial or complete upper airway obstruction during sleep, resulting in intermittent hypoxia, hypercapnia, and sleep fragmentation.[3] The prevalence of paediatric OSA is estimated at 2-5%, with habitual snoring reported in up to 10-12% of children, with peak incidence between 2 and 8 years of age corresponding to maximal adenotonsillar growth.[4] Unlike adults who predominantly present with excessive daytime sleepiness, children more often exhibit neurobehavioural manifestations-including hyperactivity, attention deficits, and poor academic performance-contributing to under-recognition and delayed diagnosis.[5]

Untreated paediatric OSA is associated with significant morbidity across multiple organ systems, including neurocognitive impairment, behavioural disturbances, systemic hypertension, metabolic dysregulation and impaired linear growth.[6] Early identification and timely intervention are therefore essential to prevent long-term complications.

Polysomnography (PSG) remains the gold standard for definitive OSA diagnosis; however, its high cost, limited availability, and requirement for specialist facilities restrict its widespread use, particularly in low- and middle-income settings.[7] This highlights the critical need for validated, non-invasive, and practically deployable screening tools.

The PSQ, developed by Chervin et al is among the most widely validated screening instruments for SRBD in children.[8] Comprising 22 items assessing snoring, breathing disturbances, daytime sleepiness, and neurobehavioural symptoms, it achieves a sensitivity of 0.85 and specificity of 0.87 at a cut-off score of $\geq$0.33. Its cross-cultural applicability has been demonstrated in Chinese, Hindi, Spanish, Turkish, and French versions.[9-13] Despite this, data from outpatient-based PSQ screening in the Indian paediatric population-particularly examining correlations with clinical risk factors remain limited.

This study was undertaken to screen children aged 2-18 years for SRBD, assess the risk of OSA using the PSQ and evaluate associated clinical risk factors in a tertiary care outpatient setting in Northern India.

METHODS

Study design and setting

An observational study was conducted in the Paediatric Outpatient Department of Sri Guru Ram Das Institute of Medical Sciences and Research, Vallah, Amritsar, India, from July 2024 to December 2025, following institutional ethics committee approval.

Participants

Children aged 2-18 years presenting with at least one symptom, sign, or constellation of features suggestive of sleep-disordered breathing, as defined by a validated structured clinical checklist, were eligible for inclusion.[14] Written informed consent was obtained from parents/guardians. Children with established neuromuscular disorders, genetic syndromes, developmental disorders, or congenital anomalies recognised causes of complex OSA were excluded.

Data collection

Detailed demographic data and anthropometric measurements (height, weight, BMI) were recorded and interpreted according to WHO and IAP Growth Charts (2015).[15] Presenting symptoms were documented using a structured SDB checklist encompassing daytime symptoms (including hyperactivity, attention deficit, nasal congestion, morning headache, and poor school performance), nighttime symptoms (including snoring, mouth breathing, restless sleep, enuresis, and bruxism), and physical signs (including tonsillar hypertrophy, adenoid facies, and hypertrophied nasal turbinate).

PSQ administration

The University of Michigan PSQ, adapted from Chervin et al was administered by the investigator through structured caregiver interviews.[8] The 22-item questionnaire covers snoring, breathing disturbances, daytime sleepiness, and neurobehavioural symptoms. Items were scored as 'Yes' (1), 'No' (0), or 'Don't Know' (excluded from calculation). The PSQ score was computed as the ratio of affirmative responses to total answered items (range 0.0-1.0). A score$\geq$0.33 (corresponding to $\geq$8 affirmative responses) was used as the threshold for high OSA risk, based on the validity study by Chervin et al.[8]

Radiological assessment

Lateral nasopharyngeal X-rays were performed in children with PSQ$\geq$0.33 to assess adenoid enlargement. Adenoid hypertrophy was graded as grade 1 (minimal), grade 2 (mild), grade 3 (moderate), or grade 4 (severe) based on standard radiological criteria.

Statistical analysis

Data were entered into Microsoft excel and analysed using IBM SPSS Statistics version 31. Descriptive statistics were expressed as frequency (n) and percentage (%). Associations between categorical variables and PSQ score were assessed using the chi-square test. A $p<0.05$ was considered statistically significant.

RESULTS

Demographic characteristics

A total of 386 children were enrolled (253 males [65.5%], 133 females [34.5%]). The majority were in the 6-10

years age group (189 children, 49.0%), followed by ≤5 years (136, 35.2%), 11-15 years (58, 15.0%), and >15 years (3, 0.8%). A history of seasonal allergy or recurrent upper respiratory tract infections was present in 194 children (50.3%). Based on BMI, obesity (>95th centile) was identified in 70 children (18.1%), and low weight for age (<10th centile) in 60 children (15.5%).

Frequency of symptoms and physical signs at enrolment (n=386)

The most prevalent daytime symptoms were nasal congestion (197 children, 51.0%), hyperactivity (150, 38.9%), difficulty in arousing from sleep (124, 32.1%), attention deficit (99, 25.6%), morning headache (90, 23.3%), and poor school performance (80, 20.7%). The most common nighttime symptoms were snoring/snorting noises (190, 49.2%), mouth breathing (142, 36.8%), restless sleep (109, 28.2%), bruxism (86, 22.3%), and frequent awakenings (85, 22.0%). The most frequent physical signs were hypertrophied nasal turbinate (312, 80.8%), tonsillar hypertrophy (114, 29.5%), adenoid facies (102, 26.4%), and infraorbital darkening (74, 19.2%).

PSQ scoring and proportion at high OSA risk

Of 386 children, 235 (60.9%) had PSQ ≥0.33, indicating high risk for OSA, while 151 (39.1%) had PSQ<0.33. By PSQ score range, 174 (45.1%) had scores in the 0.33-0.50 range, 41 (10.6%) in the 0.51-0.66 range, and 20 (5.2%) had scores >0.66. Among the 235 high-risk children, 119 (50.6%) were in the 6-10 years age group, 86 (36.6%) were ≤5 years, and males accounted for 155 (66.0%). No statistically significant associations were found between PSQ score and age group (p=0.126) or gender (p=0.827).

Association of daytime symptoms with PSQ score

Table 1 shows associations between daytime symptoms and PSQ score. Attention deficit (p=0.003), hyperactivity (p<0.001), difficulty in arousing from sleep (p=0.035), poor school performance (p=0.029), and aggressive behaviour (p<0.001) were significantly associated with PSQ ≥0.33. Nasal congestion, morning headache, moodiness and excessive daytime sleepiness did not demonstrate significant associations (Table 1).

Association of nighttime symptoms with PSQ score

Table 2 shows associations between nighttime symptoms and PSQ score. Snoring/snorting noises (p<0.001), mouth breathing (p<0.001), restless sleep (p=0.002), frequent awakenings (p<0.001), enuresis (p<0.001), increased work of breathing (p=0.046), and diaphoresis (p=0.005) showed statistically significant associations with high PSQ score. Parasomnias, hyperextended neck, witnessed apnoea, and bruxism did not reach statistical significance (Table 2).

Association of physical signs with PSQ score

Table 3 shows associations between physical signs and PSQ score. Hypertrophied nasal turbinate (p<0.001), tonsillar hypertrophy (p<0.001), adenoid facies (p<0.001), and obesity (p=0.004) showed highly significant associations with PSQ ≥0.33. Deviated nasal septum, infraorbital darkening, mouth breathing (as a sign), and low weight for age did not show significant associations (Table 3).

Adenoid hypertrophy grading and association with PSQ score

Among 235 children with PSQ ≥0.33, lateral nasopharyngeal radiographs confirmed adenoid enlargement in 112 (47.7%). Grade 3 (moderate) hypertrophy was most prevalent (60 children, 53.6%), followed by grade 2 mild (30, 26.8%), grade 1 minimal (12, 10.7%), and grade 4 severe (10, 8.9%). A statistically significant association was found between adenoid hypertrophy grade and PSQ score category (p=0.001), with higher grades corresponding to higher PSQ score ranges.

Table 1: Association of daytime symptoms with PSQ score, (n=386).

Daytime symptoms	PSQ<0.33	PSQ ≥0.33	P value
Nasal congestion	84	113	0.175
Mouth breathing	6	22	0.069
Attention deficit	26	73	0.003*
Hyperactivity	40	110	<0.001*
Difficulty in arousing from the sleep	39	85	0.035*
Morning headache	35	55	0.723
Poor school performance	20	60	0.029*
Moodiness	33	38	0.179
Aggressive behaviour	13	50	<0.001*
Excessive daytime sleepiness	18	28	1.000

*Statistically significant (p<0.05). Chi-square test applied.

Table 2: Association of nighttime symptoms with PSQ score, (n=386).

Nighttime symptoms	PSQ<0.33	PSQ ≥0.33	P value
Snoring/snorting noises	41	149	<0.001*
Mouth breathing	39	103	<0.001*
Restless sleep	29	80	0.002*
Frequent awakenings	15	70	<0.001*
Enuresis	21	37	<0.001*
Parasomnias	20	23	0.322
Increased work of breathing	6	27	0.046*
Hyperextended neck	7	11	1.000
Diaphoresis	3	21	0.005*
Witnessed apnoea	0	2	0.522
Bruxism	34	52	1.000

*Statistically significant (p<0.05). Chi-square test applied.

Table 3: Association of physical signs with PSQ score, (n=386).

Physical signs	PSQ<0.33	PSQ≥0.33	P value
Hypertrophied nasal turbinate	101	211	<0.001*
Tonsillar hypertrophy	29	85	<0.001*
Adenoid facies	12	90	<0.001*
Mouth breathing	8	22	0.175
Deviated nasal septum	5	9	1.000
Infraorbital darkening	29	45	1.000
Obesity (BMI >95th centile)	18	52	0.004*
Low weight for age (<3rd centile)	22	38	0.774

*Statistically significant (p<0.05). Chi-square test applied.

DISCUSSION

This outpatient-based observational study screened 386 symptomatic children and found that 60.9% were at high risk for OSA based on PSQ scoring ≥0.33). These findings underscore the substantial burden of sleep-disordered breathing in the paediatric outpatient setting and validate the practical utility of the PSQ as a non-invasive screening tool in resource-limited environments where polysomnography is not accessible.

Demographic variables

A male preponderance was observed both in the overall study population (65.5%) and among high-risk children (66.0%), consistent with Huang et al who found 62.3% males among 4,668 children diagnosed with OSA, with males also demonstrating higher apnea-hypopnea index (AHI) values.[16] The predominance of children in the 6-10 years age group reflects the peak period of adenotonsillar growth relative to airway size, as described by Piotto et al.[17] Neither age nor gender showed a statistically significant independent association with PSQ score, in keeping with the multifactorial nature of the disease.

Daytime symptoms

Neurobehavioural manifestations were the predominant daytime features in this study population. Hyperactivity, attention deficit, aggressive behaviour, poor school performance, and difficulty in arousing from sleep were all significantly associated with PSQ≥0.33. These findings are consistent with Csábi et al who demonstrated significantly elevated hyperactivity and externalising behavioural problem scores in children with sleep-disordered breathing compared to controls.[18] Boyajian et al and Goyal et al in school-based cohorts from Jordan and India respectively-similarly reported significant associations between OSA risk and poor academic performance.[19,20]

Excessive daytime sleepiness did not show a statistically significant association with PSQ score, which is characteristic of the paediatric OSA phenotype, wherein behavioural and arousal-related disturbances predominate over classical somnolence.[21] This distinction is clinically important: reliance on adult symptom patterns may cause paediatric OSA to be missed in routine clinical assessments.

Nighttime symptoms

Snoring/snorting noises were the most prevalent nighttime symptom and showed the strongest association with PSQ ≥0.33 (p<0.001). Kulsum and Shariff reported habitual snoring in 17.1% of paediatric outpatients, emphasising its pivotal role as an indicator of sleep-disordered breathing.[22] Mouth breathing and restless sleep also demonstrated significant associations, consistent with their established roles as markers of upper airway obstruction.[23]

Enuresis showed a highly significant association with high PSQ score, consistent with Diab et al whose systematic review and meta-analysis of 11,612 children found nocturnal enuresis in approximately 40% of children with OSA (OR=2.30), attributed to altered arousal mechanisms, autonomic dysregulation, and increased intrathoracic pressure during sleep.[24] Diaphoresis, reflecting sympathetic overactivity during obstructive events, was also significantly associated. Parasomnias and bruxism, however, did not show significant associations in this study-a finding consistent with Lundetrae et al and Orradre-Burusco et al who reported limited evidence for strong associations between these features and OSA severity in children.[25,26]

Physical signs

Hypertrophied nasal turbinate was the most prevalent physical finding, present in 80.8% of enrolled children, and was significantly associated with PSQ $\geq$0.33. This is consistent with Zalzal's review identifying inferior turbinate hypertrophy as a primary contributor to nasal obstruction and increased airway resistance in children with sleep-disordered breathing.[27]

Tonsillar hypertrophy showed a highly significant association with high PSQ score ($p<0.001$), in keeping with its established role as the predominant anatomical factor in paediatric OSA. Mitchell et al identified tonsillar size as the only clinical variable independently correlating with preoperative AHI, and Bhattacharjee et al demonstrated a significant reduction in mean AHI from 18.2 to 4.1 events/hour following adenotonsillectomy in a multicentre cohort of 578 children.[28,29]

Adenoid facies showed a highly significant association with PSQ $\geq$0.33 ($p<0.001$), reflecting the impact of chronic upper airway obstruction on craniofacial development. Zhan et al demonstrated that prolonged adenoid hypertrophy causes significant skeletal and soft tissue craniofacial changes, with oral breathing and snoring identified as key mediating factors.[30]

Obesity

Obesity was significantly associated with high PSQ score ($p=0.004$). Redline et al found obese children had 4.59 times higher odds of moderate sleep-disordered breathing (95% CI: 1.58-13.33) in a cohort of 399 children aged 2-18 years, and Verhulst et al demonstrated sleep-disordered breathing in 47% of overweight/obese children on formal polysomnography.[31,32] The NANOS study by Alonso-Álvarez et al reported OSA prevalence of 21.5-39.5% in randomly selected obese community children, confirming that a substantial proportion of obese children in the community have unrecognised sleep-disordered breathing.[33] These findings collectively reinforce the importance of routine OSA screening in obese paediatric patients.

Low weight for age did not show a statistically significant association with PSQ score in this study, though growth impairment was present in a clinically meaningful proportion of children. Esteller et al reported growth failure (weight and/or height for age $\leq 5^{th}$ centile) in 13.95% of children with confirmed OSA syndrome versus 5.81% of controls.[34] Growth impairment in OSA is attributed to disrupted growth hormone secretion, increased caloric expenditure from laboured breathing, sleep fragmentation, and chronic intermittent hypoxia. Although statistical significance was not reached in the present study, growth faltering remains a clinically relevant feature requiring monitoring in children with sleep-disordered breathing.

Adenoid hypertrophy grading

A significant association between adenoid hypertrophy grade and PSQ score category was demonstrated ($p=0.001$), with moderate (Grade 3) hypertrophy predominating. These findings are consistent with Tagaya et al who reported a significant positive correlation between adenoid grade and apnea index ($r=0.45$, $p<0.01$) in preschool children, confirming adenoid grade as an independent predictor of OSA severity.[35] Brooks et al similarly found adenoid size to be related to disease severity rather than the number of apnoeic events.[36] These observations support the use of lateral nasopharyngeal radiography as a useful adjunct in risk stratification of children with high PSQ scores.

Utility of PSQ in outpatient screening

The present findings support the PSQ as a practical, non-invasive, and caregiver-administered screening tool for outpatient use. A systematic review and meta-analysis by Parenti et al confirmed the SRBD-PSQ as the most sensitive available screening instrument for paediatric OSA at an AHI threshold $\geq$1.[37] Umano et al demonstrated excellent PSQ performance (AUC 0.88) specifically in obese children.[38] The significant associations identified in the present study between high PSQ scores and established clinical risk factors including adenotonsillar hypertrophy, obesity and neurobehavioural symptoms indicate that PSQ-based screening correlates well with clinically relevant morbidity and supports its incorporation into routine paediatric outpatient practice in accordance with the recommendations of the American Academy of Paediatrics.

Limitations

Several limitations should be acknowledged. OSA diagnosis was based solely on PSQ screening without confirmatory polysomnography, which remains the diagnostic gold standard. PSQ scoring relied on parental recall and subjective reporting, which may be subject to recall and reporting bias. Children with complex OSA secondary to genetic, neuromuscular, or developmental disorders were excluded, which may limit the

generalisability of findings. The study was conducted at a single tertiary care centre and referral bias may have influenced symptom frequency. Future studies incorporating PSG confirmation would further validate the utility of PSQ-based screening in this population.

CONCLUSION

A substantial proportion (60.9%) of children presenting with features suggestive of SRBD at a tertiary care paediatric outpatient department were identified as being at high risk for OSA using the PSQ. Neurobehavioural symptoms-hyperactivity, attention deficit, poor school performance, and aggressive behaviour-along with nighttime symptoms including snoring, mouth breathing, restless sleep, enuresis, and diaphoresis, were significantly associated with high PSQ scores. Obesity, hypertrophied nasal turbinate, tonsillar hypertrophy, adenoid facies and higher grades of adenoid hypertrophy were also significantly associated with OSA risk. The PSQ is a validated, practical, and non-invasive screening instrument suitable for early identification of at-risk children in outpatient settings, particularly in resource-limited environments where polysomnography is not readily accessible. Routine PSQ-based screening by paediatricians may facilitate early intervention and reduce the long-term morbidity associated with untreated paediatric OSA.

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