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A Study on Factors Related to Sleep Disordered Breathing in Children

Nawoon Kim, Daewoo Lee, Jaegon Kim, Changkeun Lee, Yeonmi Yang

Department of Pediatric Dentistry and Institute of Oral Bioscience, School of Dentistry, Jeonbuk National University

Abstract

The aim of this study was to investigate the risk factors associated with sleep disordered breathing (SDB) by comparing intraoral factors, body mass index (BMI), and medical history with pediatric sleep questionnaire (PSQ) findings.

Seven hundred eighty-seven subjects aged between 7 to 11 years old were included. Their caregivers were asked to complete questionnaires. Oral manifestations including Angle's classification, overjet, and Brodsky tonsil grade were examined. Children with PSQ scores of more than 0.33 points were classified into the SDB high-risk group.

Among the 787 subjects, 34 (4.3%) were classified into the SDB high-risk group. Children with allergic rhinitis, atopic dermatitis, excessive overjet, or large tonsil size had a significantly higher risk for SDB versus those without. Also, there was a significant difference in SDB risk according to BMI status. Gender, gestational age, breastfeeding, and Angle's classification were not associated with SDB.

Children at high risk for SDB were predisposed to tonsillar hypertrophy, allergic rhinitis, obesity, and atopic dermatitis. Children with these factors could be candidates for early intervention to prevent the progression of SDB.

Key words : Sleep disordered breathing, Pediatric sleep questionnaire, Risk factor

Ⅰ. Introduction

Sleep disordered breathing (SDB) encompasses a group of diseases including primary snoring, upper airway resistance syndrome (UARS), obstructive sleep apnea (OSA), and central sleep apnea (CSA). SDB is characterized by having intermittent periods of abnormal respiratory patterns such as apnea, hypopnea, or respiratory effort-related arousals (RERAs)[1]. Primary snoring is not associated with apnea or hypopnea, while UARS is characterized by increased RERAs without obvious apnea or hypopnea[2]. Separately, OSA is characterized by the repetitive reduction or cessation of airflow during sleep, because of a partial or complete obstruction of the upper airway, resulting in subcortical or cortical arousals[1-3]. Such arousals can result in sleep fragmentation and nonrestorative sleep[3]. On the other hand, CSA is less common and occurs when the brain fails to transmit signals to the respiratory muscles; it is not associated with physical obstruction of the upper airway[1].

The night symptoms of pediatric SDB are loud and frequent snoring, mouth breathing, witnessed apnea during sleep, restless sleep, night sweats, and nocturnal enuresis. The daytime symptoms of pediatric SDB include morning headache, excessive daytime sleepiness, poor concentration, and mood

Corresponding author : Yeonmi Yang
Department of Pediatric Dentistry, School of Dentistry, Jeonbuk National University, 20, Geonji-ro, Deokjin-gu, Jeonju, 54907, Korea
Tel: +82-63-250-2212 / Fax: +82-63-250-2131 / E-mail: pedo1997@jbnu.ac.kr
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problems[1,4]. Despite the various known symptoms of SDB, about 80% of people with SDB remain undiagnosed, due to the unawareness of their own condition[5]. Furthermore, polysomnography, the gold standard for diagnosing SDB, has limited accessibility, because it requires a night of sleep in a sleep laboratory, which is expensive, and requires trained examiners. Accordingly, several types of questionnaires about symptoms and complications were developed to screen patients at high risk for SDB whom may require further evaluation. Sleep questionnaires are considered as a valuable tool to evaluate in epidemiological research[6].

A pediatric sleep questionnaire (PSQ) was developed by Chervin to help identify SDBs without the expense of polysomnography. The PSQ consists of 22 questions and assesses relative symptoms of SDB including snoring, sleep behaviors, mouth breathing, daytime sleepiness, inattention, and hyperactivity. The possible responses to each question are "yes," "no," and "don't know," and the PSQ score is calculated according to the proportion of "yes" responses to the 22 questions, excluding the "don't know" responses. When 8 or more positive answers to the 22 question-items were considered abnormal, both sensitivity and specificity were high, 0.81 and 0.87, respectively. Therefore, the optimal cutoff value for screening SDB was 0.33 points[6].

The prevalence of habitual snoring in children is in the range of 5% to 12%, while that of pediatric OSA is in the range of 1% to 4%[7]. In Korea, the reported prevalence rates of primary snoring and OSA in adolescents in a study were 11.2% and 0.9%, respectively[8]. In adults, it is reported that men have a greater risk of SDB than women, but this distinction is unclear in children. Several predisposing factors for pediatric SDB have been reported including adenotonsillar hypertrophy, obesity, micrognathia, and hyperglossia[1-3,9,10]. However, there is no study conducted on the risk factors for SDB in a large number of samples on Korean children. Thus, the aim of this study was to investigate the risk factors of SDB in children by comparing intraoral factors, body mass index (BMI), and medical history findings to PSQ outcomes.

Ⅱ. Materials and Methods

The research protocol was reviewed and approved by the Institutional Review Board of Jeonbuk National University Hospital (CUH 2018-07-046).

1. Study population

Elementary school students in Jeonju City aged between 7 to 11 years were included. In total, 1,176 pairs of children and their parents were invited to participate in the study, and informed consent were obtained from 787 (67%) of them.

2. Methods

1) Medical history and sleep questionnaire

Prior to the physical examination, parents were asked to fill out the questionnaire form, which consisted of questions about medical history and sleep behaviors (Fig. 1). The information about the child's age, gender, medical history data on preterm birth, allergic rhinitis, asthma, atopic dermatitis, attention-deficit hyperactivity disorder (ADHD), and adenotonsillectomy were collected. Children with a PSQ score of 0.33 points or more were classified as the high-risk group.

2) Physical examination

Body weight and stature were measured to calculate BMI. Children were classified into four categories according to Korean age and sex specific percentiles for BMI (Korea Centers for Disease Control and Prevention, 2017). Children with BMI percentile less than the fifth percentile were classified as the underweight group. Children with BMI percentile at the fifth percentile or more but less than the 85th percentile, were classified as the normal group. Children with BMI percentile at the 85th percentile or more but less than the 95th percentile were classified as the overweight group. Finally, children whose BMI percentile was the 95th percentile or more were classified as the obese group.

Oral examinations were performed by a trained dentist. Angle's classification of the first molar, anterior overjet, and tonsil size were evaluated. Children with overjet of 4mm or less were classified as the normal group, while the others were classified as the large overjet group. Tonsil size was evaluated by direct visualization and recorded according to the Brodsky tonsil scale, as follows: 0 = surgically removed; 1 = tonsil occupies less than 25% of the visible airway; 2 = tonsil occupies 25% to 50% of the visible airway; 3 = tonsil occupies 50% to 75% of the visible airway; and 4 = tonsil occupies 75% or more of the visible airway.

◈ Pediatric Sleep Questionnaire (PSQ) ◈

Please answer on behalf of your child for the past month

While sleeping, does your child ...			
1. ... snore more than half the time?	☐ Yes	☐ No	☐ Don't know
2. ... always snore?	☐ Yes	☐ No	☐ Don't know
3. ... snore loudly?	☐ Yes	☐ No	☐ Don't know
4. ... have "heavy" or loud breathing?	☐ Yes	☐ No	☐ Don't know
5. ... have trouble breathing, or struggle to breathe?	☐ Yes	☐ No	☐ Don't know
6. Have you ever seen your child stop breathing during the night?	☐ Yes	☐ No	☐ Don't know
Does your child ...			
7. ... tend to breathe through the mouth during the day?	☐ Yes	☐ No	☐ Don't know
8. ... have a dry mouth on waking up in the morning?	☐ Yes	☐ No	☐ Don't know
9. ... occasionally wet the bed?	☐ Yes	☐ No	☐ Don't know
10. ... wake up feeling unrefreshed in the morning?	☐ Yes	☐ No	☐ Don't know
11. ... have a problem with sleepiness during the day?	☐ Yes	☐ No	☐ Don't know
12. Has a teacher or other supervisor commented that your child appears sleepy during the day?	☐ Yes	☐ No	☐ Don't know
13. Is it hard to wake your child up in the morning?	☐ Yes	☐ No	☐ Don't know
14. Does your child wake up with headaches in the morning?	☐ Yes	☐ No	☐ Don't know
15. Did your child stop growing at a normal rate at any time since birth?	☐ Yes	☐ No	☐ Don't know
16. Is your child overweight?	☐ Yes	☐ No	☐ Don't know
My child often ...			
17. ... does not seem to listen when spoken to directly	☐ Yes	☐ No	☐ Don't know
18. ... has difficulty organizing task and activities	☐ Yes	☐ No	☐ Don't know
19. ... is easily distracted by extraneous stimuli	☐ Yes	☐ No	☐ Don't know
20. ... fidgets with hands or feet or squirms in seat	☐ Yes	☐ No	☐ Don't know
21. ... is 'on the go' or often acts as if 'driven by a motor'	☐ Yes	☐ No	☐ Don't know
22. ... interrupts or intrudes on others (e.g. butts into conversations or games)	☐ Yes	☐ No	☐ Don't know

Fig. 1. The Pediatric Sleep Questionnaire.

3. Statistical analysis

Categorical variables including medical history of preterm birth, allergic rhinitis, asthma, atopic dermatitis, ADHD, adenotonsillectomy, and the results of physical examination were compared between the high-risk group and normal group using the chi-squared test or Fisher's exact test. For items showing a significant difference in the univariate analysis, binominal regression analysis was performed to study the association of the item and SDB. All statistical analyses were performed using the Statistical Package for the Social Sciences version 23.0 software program (SPSS, IBM Corp., Armonk, NY, USA).

Ⅲ. Results

1. Subject characteristics

Among 787 included children, 396 (50.3%) were boys and 391 (49.7%) were girls. The mean age of subjects was 9.06 ± 1.39 years. The children with underweight or normal weights accounted for 79.6%, while children who were overweight or obese accounted for 20.4% (Table 1).

2. High-risk group for SDB and its symptoms

The number of children who were classified into the high-risk group was 34 (4.3%). The results of the PSQ for the high-risk group are shown on Table 2. "Mouth breathing" (86.7%), "hard to wake up" (78.8%), and "fidgeting with hands" (72.7%) were the most common symptoms among the high-risk children (Table 2). Children who had allergic rhinitis, atopic dermatitis, large overjet, or enlarged tonsils showed problems in all four of the following subscales: snoring, breathing, sleepiness, and inattention/hyperactivity.

3. Risk factors of SDB

The children in the high-risk group were more likely to have allergic rhinitis (p = 0.001), atopic dermatitis (p = 0.006), large overjet (p = 0.006), enlarged tonsils (p < 0.001), and obesity (p < 0.001) compared to children in the normal group (Table 3). Logistic regression analysis of these 5 factors showed that 4 items except large overjet were significantly associated with SDB as following: enlarged tonsil [Odds ratio (OR): 6.82], allergic rhinitis (OR: 4.54), obesity (OR: 4.19), and atopic dermatitis (Table 4, OR: 2.84).

Table 1. Subject characteristics

		n (%)
Gender	Boy	396 (50.3)
	Girl	391 (49.7)
BMI category	Underweight	39 (5.0)
	Normal	587 (74.6)
	Overweight	79 (10)
	Obese	82 (10.4)
Age (years) (Mean = 9.06 ± 1.39)	7	137 (17.4)
	8	166 (21.1)
	9	164 (20.8)
	10	155 (19.7)
	11	165 (21.0)

Table 2. Frequency of positive responses to each PSQ question in the high-risk group and all subjects

Question	High-risk group (n = 34)	All subjects (n = 787)
	n (valid percent†)	
1. Snores more than half the time?	14 (46.7%)	35 (4.6%)
2. Always snores?	16 (50.0%)	37 (4.8%)
3. Snores loudly?	10 (31.3%)	31 (4.0%)
4. Heavy breathing?	15 (50.0%)	59 (7.7%)
5. Struggles to breathe?	14 (43.8%)	41 (5.3%)
6. Observed apnea	11 (34.4%)	44 (5.7%)
7. Mouth breathing	26 (86.7%)	160 (21.6%)
8. Dry mouth upon waking up	20 (74.1%)	157 (22.7%)
9. Nocturnal enuresis	9 (27.3%)	80 (10.2%)
10. Unrefreshed in the morning	21 (65.6%)	110 (14.9%)
11. Problem with sleepiness during the day	8 (27.6%)	27 (3.5%)
12. Appears sleepy during the day	5 (17.2%)	34 (4.4%)
13. Hard to wake up	26 (78.8%)	127 (16.3%)
14. Headache in the morning	5 (16.7%)	18 (2.3%)
15. Delayed growth	10 (31.3%)	86 (11.3%)
16. Obesity	15 (44.1%)	129 (16.8%)
17. Does not listen	11 (34.4%)	46 (6.0%)
18. Difficulty organizing	13 (38.2%)	39 (5.0%)
19. Easily distracted	13 (43.3%)	56 (7.3%)
20. Fidget with hands	24 (72.7%)	118 (15.4%)
21. "On the go"	14 (41.2%)	86 (11.1%)
22. Interrupts others	8 (27.6%)	46 (6.0%)

† : valid percent was calculated by excluding "don't know" responses.
PSQ = Pediatric Sleep Questionnaire

Table 3. Sample demographic and clinical characteristics

	High-risk group (n = 34)	Normal group (n = 753)	Odds ratio (95% CI)	*p*-value
Preterm birth	1 (3.3%)	51 (7.1%)	2.21 (0.30 - 16.54)	0.715[a]
Breastfeeding	27 (79.4%)	655 (87.0%)	0.58 (0.25 - 1.36)	0.199[a]
Male gender	19 (55.9%)	377 (50.1%)	1.26 (0.63 - 2.53)	0.600
Allergic rhinitis	26 (76.5%)	356 (47.3%)	3.62 (1.62 - 8.11)	0.001
Asthma	3 (8.8%)	22 (2.9%)	3.22 (0.91 - 11.32)	0.088[a]
Atopic dermatitis	11 (32.4%)	103 (13.7%)	3.02 (1.43 - 6.38)	0.006
ADHD	0 (0%)	2 (0.3%)	0.96 (0.94 - 0.97)	0.915[a]
Adenotonsillectomy	2 (5.9%)	70 (9.3%)	0.61 (0.14 - 2.60)	0.761
Class II molar key status	4 (11.8%)	69 (9.2%)	1.32 (0.45 - 3.86)	0.546[a]
Large overjet [b]	16 (47.1%)	188 (25.0%)	2.67 (1.34 - 5.34)	0.006
Enlarged tonsils [c]	11 (34.4%)	101 (14.8%)	7.57 (3.65 - 15.72)	< 0.001
Obesity [d]	15 (44.1%)	146 (19.4%)	3.28 (1.63 - 6.61)	< 0.001

CI = confidence interval
Chi-squared test
a: p-value from Fisher's exact test
b: Anterior overjet > 4 mm
c: Tonsil occupies more than 50% of visible airway (Brodsky grades 3 and 4)
d: Overweight or obese children (BMI ≥ 85th percentile)

Table 4. Risk factors for sleep disordered breathing

Factor	Odds ratio	95% confidence interval	*p*-value
Allergic rhinitis	4.54	1.84 - 11.23	0.001
Atopic dermatitis	2.84	1.19 - 6.77	0.018
Large overjet [a]	1.50	0.66 - 3.37	0.332
Enlarged tonsils [b]	6.82	3.08 - 15.13	< 0.001
Obesity [c]	4.19	1.88 - 9.32	< 0.001

Binominal logistic regression analysis
a: Anterior overjet > 4 mm
b: Tonsil occupies more than 50% of visible airway (Brodsky grades 3 and 4)
c: Overweight or obese children (BMI ≥ 85th percentile)

IV. Discussion

SDB is a disorder that interferes with normal ventilation and sleep patterns due to increased upper airway resistance during sleep. It generally evolves from primary snoring to OSA[11]. In this study, children who always snore accounted for 4.8% of subjects, and the prevalence of potential SDB was 4.3%. In a literature review, the prevalence of primary snoring was in the range of 5% to 12%, while that of OSA was in the range of 1% to 4%[7]. Snoring in Korean children in the elementary school age range (occurring more than 3 days per week) was reported to be 7.1%, and children who reported snoring almost every day were reported at 4.3%[12]. Considering that a good screening test is sensitive rather than specific, the PSQ will be useful for screening patients for OSA rather than primary snoring.

Sleep questionnaires provide clinicians with comprehensive information about individuals' habits and symptoms during sleep and daytime[13]. A number of sleep questionnaires have been developed for children, and the PSQ, has been widely studied and has shown adequate diagnostic validity[7,14]. Its optimal cutoff value for screening SDB was 0.33 points with a sensitivity of 0.81 and a specificity of 0.87[6]. The PSQ was able to discriminate 89% of the children with OSA from those

with primary snoring[15]. It showed good internal consistency and test-retest reliability[6,16,17]. Thus, it can be regarded as a reliable screening tool that can be easily applied at the clinic or epidemiologic research.

Adenotonsillar hypertrophy and obesity are well-known as major risk factors of SDB in children[2,10]. The proportional size of the adenoid and tonsils increases during childhood between 3 and 8 years of age, which can make the airway narrower. The prevalence of pediatric SDB also increases in the period[2]. Likewise, the results of this study confirmed that tonsillar hypertrophy and obesity are definite risk factors of pediatric SDB. The risk of SDB was 6.8 times and 4.2 times greater in children who have tonsillar hypertrophy and obesity, respectively. It is notable that 45% of obese children with OSA have adenotonsillar hypertrophy, but the adenotonsillar size is smaller in the obese children with OSA versus OSA children who are not obese. This suggests that obesity can narrow the airway space. Thus, obese children with OSA are more likely to have adenotonsillar hypertrophy, but they may have limited improvement in OSA symptoms through adenotonsillectomy[3,10,18]. Allergic rhinitis in children can increase nasal resistance by causing nasal mucosal edema, which may aggravate pediatric SDB[2,19,20]. The results of this study also indicate that children with allergic rhinitis have a risk of SDB that is 4.5 times greater than that of others. Previous studies reported the association between atopic dermatitis and SDB, and this study also showed the association[21,22]. The risk of SDB was 2.8 times greater in children who have atopic dermatitis. Although the exact mechanism has not yet been elucidated, atopic dermatitis, considered inflammatory skin disease, shares many risk factors with SDB such as obesity, genetics, allergic diseases, environmental exposure, and it is speculated that they may influence each other's disease expression[21].

Craniofacial factors related to narrow airway space including retruded mandible, midfacial deficiency, and high-arched palate are also associated with SDB[1,2]. Class II molar key status and excessive anterior overjet were used as methods of evaluating retrognathia. In the univariate analysis of this study, there was a significant difference of the prevalence of SDB between children with excessive anterior overjet and those without. However, no significant relationship was found in logistic regression analysis. Class II molar key status showed no significant association with SDB. Since it is caused not only by mandibular retrusion, but also by overgrowth of the maxilla, the class II molar key status does not correspond exactly with skeletal class II relationship. Therefore, additional analysis through radiographic examination is required, and early intervention with orthopedic treatment is recommended for children with craniofacial factors related to narrow airway space.

This study has significance in that, it identified the prevalence of SDB among Korean children and the characteristics of these children by including a relatively large number of subjects. Even though questionnaire has its validity, it still cannot definitely diagnose SDB alone. Nonetheless, because polysomnography for diagnosing SDB is costly and time-consuming, it is not suitable for large-scale epidemiological studies. Another limitation of the questionnaire is that the parents who completed the questionnaire may not sleep with their children, so they might not consistently notice symptoms such as an apnea during sleep. Despite this circumstance, the parent-reporting questionnaire used in this study is more objective than a self-reporting questionnaire, since it is difficult for children to recognize their own symptoms during sleep. In addition, although this study included a relatively large number of subjects, it does not represent the entire Korean children. Further research including individuals from various regions will be necessary to confirm the prevalence of SDB among Korean children.

Dentists examine the oral and maxillofacial structures of patients every day are familiar with these structures. Thus, if dentists have enough knowledge of SDB, they can play an important role in identifying risk factors to screen patients for SDB. If children who visit dental clinics are screened systematically and referred to an appropriate medical provider such as a pediatrician or otolaryngologist, the intervention will lead them to grow up healthy by receiving early treatment.

V. Conclusion

The aim of this study was to investigate the risk factors associated with SDB by comparing history taking and clinical examination with PSQ findings. Children at high risk for SDB accounted for 4.3%, and they were predisposed to tonsillar hypertrophy, allergic rhinitis, obesity, and atopic dermatitis. Children with these factors could be candidates for early intervention to prevent the progression of SDB.

Authors' Information

Nawoon Kim *https://orcid.org/0000-0002-8395-7486*
Daewoo Lee *https://orcid.org/0000-0002-9942-2400*

Jaegon Kim *https://orcid.org/0000-0002-8789-6756*
Changkeun Lee *https://orcid.org/0000-0002-1155-7846*
Yeonmi Yang *https://orcid.org/0000-0003-3359-9278*

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국문초록

어린이의 수면 호흡 장애 관련 위험인자

김나운 · 이대우 · 김재곤 · 이창근 · 양연미

전북대학교 치과대학 소아치과학교실 및 구강생체과학연구소

이 연구의 목적은 소아 수면 설문지(PSQ)를 활용하여, 구강 내 소견, 체질량 지수(BMI) 및 병력과 비교함으로써 수면 호흡 장애(SDB)와 관련된 잠재적 위험 요인을 조사하는 것이다.

만 7세에서 11세 사이의 787명의 어린이가 포함되었으며, 어린이의 보호자는 설문지를 작성하였다. Angle의 분류, 수평피개 및 Brodsky 편도 등급을 포함한 구강 증상을 조사하였다. 이중 PSQ 점수가 0.33점 이상인 대상은 SDB 고위험군으로 분류되었다.

787명 중 34명(4.3%)이 SDB 고위험군으로 분류되었다. 알레르기성 비염, 아토피성 피부염, 과도한 수평피개, 편도 비대를 가진 어린이는 그렇지 않은 어린이보다 SDB 위험이 훨씬 더 높았다. 또한 BMI 상태에 따라 SDB 위험도에 유의한 차이가 있었다. 성별, 재태 연령, 모유 수유 및 Angle의 분류는 SDB와 관련이 없었다.

이 연구에서 SDB 고위험군의 어린이는 4.3%로 나타났으며, 예측인자로는 편도 비대, 알레르기성 비염, 비만 및 아토피성 피부염이 있었다. 이러한 예측인자를 가진 어린이는 SDB가 발생할 위험이 높고 조기개입이 필요한 대상이 될 수 있다.