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Original article

Oral health in children with sleep-disordered breathing: a cross-sectional study

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Summary. Sleep-disordered breathing (SDB) is associated with a wide range of oral manifestations, including adeno-tonsillar hypertrophy, narrow dentoalveolar width, increased overjet, reduced overbite, and malocclusion. There are no studies about the relationship between SDB and poor oral health in the pediatric population. The aim of this study was to investigate oral health status and oral health-related quality of life (OHRQoL) in children at risk of SDB (SDB+), compared with a control group, not at risk for SDB (SDB). The current cross-sectional study recruited consecutive children, aged between 8 and 17 years, from a university-based dental clinic. Caregivers completed the Pediatric Sleep Questionnaire (PSQ) to stratify risk of SDB. Both children and caregivers completed the Child Oral Health Impact Profile (COHIP) to measure the OHRQoL. A dental exam was conducted to evaluate dental caries, periodontal status, oropharyngeal characteristics, and dental occlusion. DMFS (decay-missing-filled for permanent teeth), dmfs (for primary teeth), PPD (pocket probing depth), parent COHIP score, child COHIP score, and BOP (bleeding on probing) were compared between children SDB+ and SDB-. In this study, 122 children were enrolled and divided into two equal subgroups (61 each). There was a significant association between SDB and all six outcomes (all $p < 0.05$) with higher values in SDB+ children. SDB+ was associated with a poorer OHRQoL, and a greater COHIP score for both parents and children. In conclusion, the current study suggests that the impact of SDB on oral health and OHRQoL in children is relevant and far-reaching. Therefore, it is necessary to closely monitor the oral health of SDB+ children, and, if appropriate, to use gentle non-pharmacological treatments able to reduce nasal congestion. (www.actabiomedica.it)

Key words: sleep-disordered breathing, oral health, quality of life, children

Introduction

Sleep-disordered breathing (SDB) is a common breathing disorder in the paediatric population; it is characterized by the disruption of normal respiratory patterns and ventilation during sleep (1).

SDB can manifest itself in a variety of conditions from the simple snoring to the upper airway resistance syndrome until the obstructive sleep apnoea (OSA) with secondary growth impairment, neurocognitive deficits, and less often cardiovascular sequelae (2,3). The prevalence of SDB has been estimated in several studies and varies from 0.7% to 13.0%, depending on the populations studied, the methods used for assessment, and the diagnostic criteria (4). Commonly, 1-5% are diagnosed with OSA (5), with a peak prevalence at

2-5 years of age, when the lymphoid tissue of the tonsils and adenoid is largest in relation to airway size (6). SDB is associated with reduced sleep quality, resulting in behavioural issues, cognitive deficits, poor school performance, chronic respiratory diseases, and craniofacial deformation (7-9). In addition, children with SDB often show a wide range of oral manifestations, including adenoid hypertrophy, tonsillar hypertrophy, macroglossia, thick soft palate, reduced posterior airway space, reduced sagittal nasopharyngeal and oropharyngeal dimensions, narrow dentoalveolar width, increased overjet, reduced overbite, and malocclusion (10-12). Many of these oral manifestations are associated with several oral diseases, including dental caries and periodontal disease (13). Compounding this issue, many SDB children are mouth breathers, which leads to xerostomia leading to an increase in caries susceptibility (14). Therefore, it can be deduced that oral manifestations found in children with SDB likely have significant and far-reaching consequences on their oral health, but actually, there are no studies linking SDB with poor oral health in the paediatric population. Therefore, the aim of this study was to investigate both the oral health status and oral health-related quality of life (OHRQoL) in children at risk of SDB (SDB+) compared with a control group not at risk for SDB (SDB-).

Materials and Methods

The current cross-sectional study was conducted between November 2018 and March 2019 in paediatric patients who attended routine dental check-up at the dental clinic of the Catania University. Inclusion criteria were: age between 8 and 17 years at the time of enrolment, to be in good overall health, and to not have active orthodontic treatment within the last year.

The study was approved by the local Institutional Review Board and written informed consent was obtained from all parents or guardians of the participating children.

Caregivers were asked to complete the Paediatric Sleep Questionnaire (PSQ) to stratify the risk of SDB (15). PSQ is a 22-item questionnaire comprising three symptom complexes: snoring, excessive daytime sleepiness, and inattentive or hyperactive behaviour, an overall score of ≥8 indicate SDB.

In order to evaluate oral health, the measurement of OHRQoL was assessed considering the answers given by the children and their caregivers to the Child Oral Health Impact Profile (COHIP) questionnaire (16). The COHIP questionnaire consists of 35 items representing 5 conceptually distinct domains: oral health (oral symptoms such as teeth pain, sensitivity, and oral sores), functional wellbeing (child's ability to perform specific everyday activities), social/emotional wellbeing (peer interactions and mood states), school environment (assignments associated with the school environment), and self-image (positive feelings about self). Responses were scored on a scale ranging from 0 (never) to 4 (almost all the time). For some items, the scale was reversed so that higher scores consistently indicated poor oral health. A sub-score for each of the five COHIP domains and an overall total COHIP score were calculated. For the overall scores, higher scores reflect worsened OHRQoL.

The clinical examinations were carried out by a trained dental doctor, not involved in the study and blinded to results of the PSQ, using a dental mirror and a ball-ended periodontal probe. Craniofacial features and dental occlusion were recorded. Soft palate morphology was classified according to the Mallampati classification (17). Tonsil size was classified according to the Brodsky score (18). Dental occlusion was evaluated using Angle's malocclusion classification (19). The diagnosis of dental caries was based on the detection of carious lesions at the cavitation stage, as recommended by the World Health Organization (WHO). DMFS and dmfs indices (decayed, missing, and filled surfaces; lower-case letters for primary teeth, upper-case for permanent teeth) were used (20).

The periodontal examination was performed for the Ramfjord index teeth (teeth number: 3, 9/F, 12/I, 19, 25/P, 28/S), separate recordings were made for the four smooth surfaces of these teeth, and an average tooth score was then recorded (21).

Two periodontal indices were measured to assess periodontal status: 1) Bleeding on probing (BOP) recorded after stimulating the region where gingiva and teeth come to contact each other by a periodontal probe; and 2) Probing pocket depth (PPD) is defined

as the distance between the gingival margin and the bottom end of the periodontal pocket (22).

Statistical analysis

Descriptive and inferential statistics were used for analysis. Continuous variables were presented as mean ± SD, or median as appropriate, while categorical variables were expressed as frequencies and percentages. Statistical analyses were performed as follows: Descriptive and inferential statistics were used for analysis. Continuous variables were presented as mean ± SD, while categorical variables were expressed as frequencies and percentages. Statistical analyses were performed using the chi-square test of homogeneity and non-parametric Mann-Whitney's test for qualitative variables and T-Student test for quantitative variables. For all six outcomes, a regression analysis was used to adjust for confounders (gender, caregiver's education, family social class, obesity, Mallampati classification, Brodsky score, and Angle's malocclusion classification). All statistical tests were performed with the MedCalc Statistical Software, v. 9.2.1.0 (MedCalc Software, Belgium) and p values of less than 0.05 were regarded as statistically significant.

Results

A total of 122 patients was enrolled and divided into two equal subgroups (61 each) dichotomized into children at risk for SDB (SDB+ group) and children, not at risk for SDB (SDB- group).

The demographic details of the two study populations are outlined in Table 1.

There was a significant difference between the two study subgroups considering DMFS, dmfs, CO-HIP, PPD and BOP (all $p < 0.05$) with higher values among SDB+ children when compared to the other subgroup (Table 2).

A regression analysis was performed adjusting for the following confounders: gender, caregiver's education, family social class, weight, Mallampati classification, Brodsky score, and class of malocclusion. In the regression analysis, age was calculated using groups that differ in age by 1 year. Caregiver's education was

Table 1. Demographic characteristics of study participants with diagnosed AR

Characteristics	SDB+ N=61	SDB- N=61	p-value
Age (in years), mean ± SD	12.4 ± 3.1	11.9 ± 2.8	0.475
Gender, n(%)			
Male	33 (54.1)	31 (50.8)	0.254
Female	28 (45.9)	30 (49.2)	
Homes with smoking, n(%)	10 (16.4)	11 (18)	
Caregiver's education, n(%)			
Upper secondary school	12 (19.7)	9 (14.8)	0.231
Bachelor's degree	49 (80.3)	52 (85.2)	
Family social class, n(%)			
Middle class	36 (59)	37 (60.7)	0.467
Upper class	25 (41)	24 (39.3)	
Weight, n(%)			
Normal	55 (90.2)	57 (93.4)	0.766
Obese	6 (9.8)	4 (6.6)	
Pediatric Sleep Questionnaire, mean ± SD	12.7 ± 3.1	5.5 ± 2.4	0.006*

SDB: Sleep-disordered breathing; SD: standard deviation
*$p < 0.05$

Table 2. DMFS, dmfs, Parent and Child COHIP, PPD, and BOP between the two study groups

Outcomes	SDB+ N=61	SDB- N=61	p-value
DMFS index, mean ± SD	13.6 ± 4.7	3.5 ± 2.2	< 0.001
dmfs index, mean ± SD	8.5 ± 2.3	2.7 ± 1.1	< 0.001
COHIP (overall) parent, mean ± SD	24.5 ± 5.6	16.7 ± 4.3	0.003*
COHIP (overall) child, mean ± SD	23.2 ± 4.6	15.9 ± 3.8	0.004*
PPD (mm), mean ± SD	2.4 ± 0.5	0.8 ± 0.3	< 0.001
BOP proportion of bleeding ± SD	0.9 ± 0.2	0.3 ± 0.2	0.004*

SDB: Sleep-disordered breathing; SD: standard deviation; DMFS: decayed, missing, and filled surfaces (for permanent teeth); dmfs: decayed, missing, and filled surfaces (for primary teeth); COHIP: Child Oral Health Impact Profile; PPD: probing pocket depth; BOP: bleeding on probing
*$p < 0.05$

categorized as upper secondary school, and bachelor's degree, with the upper secondary school serving as the reference group. Social class was categorized as middle class, and upper class, with the middle class serving as the reference group. Weight was categorized as normal, and obese, with normal serving as the reference group. Mallampati classification was categorized as class I, class II, and class III, with class I serving as the reference group. Brodsky score was categorized as grade 0, grade I, grade II, and grade III, with grade 0 serving as the reference group. Malocclusion was categorized as normal (Class I), postnormal (Class II) and prenormal (Class III) occlusion, with Class I serving as the reference group. As for DMFS regression analysis, there was a significant association between DMFS and SDB, family social class, and malocclusion. Regarding dmfs regression analysis, it has been shown a significant association between dmfs and SDB, caregiver's education, weight, Mallampati classification, and Brodsky score. The PPD regression analysis demonstrated a significant association between PPD and SDB, gender, and Brodsky score (Table 3). Table 4 shows the results of COHIP Parent regression analysis where it was noted a significant association between parent COHIP score and SBD, weight, and Mallampati classification. Moreover, the COHIP Child regression analysis showed a significant association regarding child COHIP score and SDB, weight, Mallampati classification, and malocclusion. The BOP regression analysis highlighted a significant association between BOP and SDB and weight.

Discussion

There is evidence that SDB correlates with poor systemic health in children (23-25). Despite this, there is a lack of investigation concerning the relationship between SDB and oral health in children. This is a critical question that needs to be answered and our study is likely to provide important insights into this association. We hypothesized that SDB has a profound negative impact on oral health in children. As anticipated, SDB was associated with six outcomes: DMFS, dmfs, PPD, BOP, and a child COHIP and parent COHIP questionnaire.

The OHRQoL was measured by the child and parent COHIP scores, with the higher the score the poorer the OHRQoL. SDB was found to have a significant impact on the OHRQoL for children and adults (higher child and parent COHIP scores). Given that SDB is associated with dental caries, PPD, and BOP, this comes as no surprise and further validates the association of SDB and poor oral health. In the regression analysis, both child and parent COHIP scores were associated with weight. We found a close relationship between them, indeed obesity is likely a contributing factor for adverse health outcomes and therefore increased risk of SDB (26). Obesity and caries have been shown to coexist in children of low socioeconomic status (27). Surprisingly, there was no association between the child and parent COHIP scores and caregiver's education or family social class. We were anticipating that low education and social class

Table 3. DMFS, dmfs and PPD Regression Analysis

Predictor/Confounder	Differences in means	95%CI (Lower/Upper)	p-value
DMFS Regression Analysis			
Intercept	41.54	12.65/70.43	0.004
SDB	9.74	3.77/13.83	< 0.001
Male gender	1.24	-2.36/4.84	0.240
bachelor's degree vs. upper secondary school	-9.07	-19.68/1.55	0.082
upper class vs. middle class	-5.66	-10.65/-0.67	0.043*
Obese vs. normal	2.18	-5.39/9.74	0.064
Mallampati class II vs. class I	0.86	-4.52/6.23	0.383
Mallampati class III vs. class I	-1.33	-10.64/7.98	0.287
Brodsky grade I vs. grade 0	-11.59	-23.52/0.35	0.072
Brodsky grade II vs. grade 0	-10.85	-24.53/2.84	0.073
Brodsky grade III vs. grade 0	-8.63	-22.67/5.42	0.096
Malocclusion class II vs. class I	-27.69	-43.18/-12.21	< 0.001
Malocclusion class III vs. class I	-26.93	-42.12/-11.75	< 0.001
dmfs Regression Analysis			
Intercept	-0.23	-15.32/14.87	0.856
SDB	5.76	3.47/8.04	< 0.001
Male gender	1.57	-1.13/4.27	0.238
bachelor's degree vs. upper secondary school	7.28	-1.02/15.59	0.045*
upper class vs. middle class	0.22	-3.62/4.06	0.376
Obese vs. normal	-4.01	-7.14/-0.87	0.023*
Mallampati class II vs. class I	0.84	-2.56/4.23	0.288
Mallampati class III vs. class I	7.98	2.45/13.51	0.002*
Brodsky grade I vs. grade 0	5.07	0.88/9.25	0.018*
Brodsky grade II vs. grade 0	3.69	-0.36/7.73	0.049*
Brodsky grade III vs. grade 0	11.98	4.87/19.12	< 0.001
Malocclusion class II vs. class I	2.11	-6.32/10.54	0.097
Malocclusion class III vs. class I	5.71	-1.08/12.48	0.074
PPD Regression Analysis			
Intercept	1.95	-0.62/4.53	0.052
SDB	2.56	1.53/3.59	< 0.001
Male gender	0.83	0.67/0.98	0.010*
bachelor's degree vs. upper secondary school	-1.04	-3.15/1.07	0.075
upper class vs. middle class	-0.29	-0.78/0.21	0.188
Obese vs. normal	-0.31	-1.05/0.43	0.128
Mallampati class II vs. class I	-0.29	-0.76/0.19	0.347
Mallampati class III vs. class I	0.23	-0.29/0.74	0.322
Brodsky grade I vs. grade 0	-0.63	-1.43/0.18	0.048*
Brodsky grade II vs. grade 0	-0.76	-1.43/-0.08	0.033*
Brodsky grade III vs. grade 0	-0.40	-1.56/0.76	0.047*
Malocclusion class II vs. class I	-0.96	-2.43/0.51	0.088
Malocclusion class III vs. class I	-0.83	-2.13/0.47	0.164

SDB: Sleep-disordered breathing; SD: standard deviation; DMFS: decayed, missing, and filled surfaces (for permanent teeth); dmfs: decayed, missing, and filled surfaces (for primary teeth); PPD: probing pocket depth.
*$p < 0.05$

would be associated with higher COHIP scores, but no such relationship was noted. A possible explanation for this could be our study sample. There were limited numbers of children in each of the respective categories, insufficient to draw definitive conclusions. A final remarkable association was found between child and

Table 4. COHIP Parent, COHIP Child, and BOP Regression Analysis

Predictor/Confounder	Differences in means (or Odds Ratio)	95%CI (Lower/Upper)	p-value
COHIP Parent Regression Analysis			
Intercept	26.39	-3.56/56.33	0.073
SDB	8.34	3.87/12.92	< 0.001
Male gender	2.04	-1.56/5.64	0.265
bachelor's degree vs. upper secondary school	-9.35	-21.63/2.94	0.143
upper class vs. middle class	0.93	-4.42/6.28	0.347
Obese vs. normal	2.18	-7.16/8.03	0.029*
Mallampati class II vs. class I	0.44	-2.01/6.54	0.056
Mallampati class III vs. class I	23.08	10.54/35.62	< 0.001
Brodsky grade I vs. grade 0	-5.03	-17.34/7.28	0.423
Brodsky grade II vs. grade 0	-10.85	-11.32/15.33	0.539
Brodsky grade III vs. grade 0	2.05	-22.67/5.42	0.756
Malocclusion class II vs. class I	-13.52	-33.15/6.11	0.073
Malocclusion class III vs. class I	-16.82	-34.88/1.25	0.057
COHIP Child Regression Analysis			
Intercept	3.87	-18.42/26.15	0.642
SDB	8.72	4.17/13.27	< 0.001
Male gender	0.57	-2.33/3.47	0.536
bachelor's degree vs. upper secondary school	-7.83	-18.05/2.39	0.097
upper class vs. middle class	2.87	-2.52/8.26	0.126
Obese vs. normal	-3.04	-7.64/1.57	0.035*
Mallampati class II vs. class I	2.64	-1.46/6.73	0.047*
Mallampati class III vs. class I	16.28	6.35/26.21	< 0.001
Brodsky grade I vs. grade 0	-1.67	-8.58/5.25	0.443
Brodsky grade II vs. grade 0	-1.05	-6.32/4.23	0.412
Brodsky grade III vs. grade 0	-4.75	-13.83/4.34	0.137
Malocclusion class II vs. class I	8.45	-2.62/19.53	0.025*
Malocclusion class III vs. class I	8.11	-2.08/18.28	0.044*
BOP Regression Analysis			
Intercept	31.45	0/4238.53	0.378
SDB	246.66	12.57/8543.52	< 0.001
Male gender	7.88	0.57/76.88	0.109
bachelor's degree vs. upper secondary school	0.07	0/97.57	0.421
upper class vs. middle class	0.35	0.78/5.31	0.359
Obese vs. normal	0.02	0/0.56	0.005*
Mallampati class II vs. class I	0.07	0.06/1.19	0.077
Mallampati class III vs. class I	13.83	1.59/188.44	0.063
Brodsky grade I vs. grade 0	1.53	0/265.18	0.603
Brodsky grade II vs. grade 0	3.56	0.03/5832.79	0.735
Brodsky grade III vs. grade 0	2568.30	870.45/7834.53	0.087
Malocclusion class II vs. class I	1.93	0.47/7.43	0.327
Malocclusion class III vs. class I	0.14	0.03/5.31	0.153

SDB: Sleep-disordered breathing; SD: standard deviation; COHIP: Child Oral Health Impact Profile; BOP: bleeding on probing
*$p < 0.05$

parent COHIP scores and Mallampati classification. Higher scores (poorer OHRQoL) were associated with higher Mallampati classification. This is perhaps due to these patients being at increased risk for SDB, which in turn puts them at greater risk for oral health complications (28). Our analysis showed that there is

a significant association between SDB and dental caries in the primary and permanent dentitions. The relationship between SDB and dental caries, although not clearly understood, may be secondary to sharing common risk factors. For example, it is well established in the literature that dry mouth is associated with dental caries and OSA (29). A study showed that the incidence of dry mouth upon awakening is much higher in OSA patients versus primary snorers and increases linearly from mild, moderate, to severe OSA (30). Given the increased degree of dry mouth that accompanies the severity of OSA, the association noted between SDB and dental caries comes as no surprise. Future studies should compare the association between pediatric dental caries and mild, moderate, and severe OSA respectively. Another important finding of our study was that SDB is associated with periodontal status (BOP and PPD). As with dental caries, this relationship is likely the result of shared risk factors. In addition to dental caries, dry mouth is associated with the gingival disease. A study reported that xerostomia was related to gingival disease in young adults via the accumulation of dental plaque (31). Gingival inflammation secondary to xerostomia may explain our findings that children with SDB have greater BOP and PPD. As well, all of the SDB patients in our study were mouth-breathers, and chronic gingivitis and periodontitis are frequently found in mouth-breathers (32,33). Notably, we found only an association between low socioeconomic status and dental caries in the permanent dentition. Based on previous studies that concretely show the relationship between low socioeconomic status and dental caries in the primary dentition, we speculate our findings are related to a small study sample (34).

The present results showed strong associations between SDB and all six outcomes. However, future studies need to be properly designed and carried out to definitively determine causality. Our hope from this study is that medical and dental practitioners will be alerted to pay careful attention to the oral health of their SDB patients, understanding that they are at an increased risk for a number of oral health problems. As the oral health consequences of SDB become more commonly recognized by the medical community, diagnosis and appropriate interventions can begin earlier, minimizing social, financial, systemic, and oral health complications. In addition, it may be fruitful to use, if appropriate, gentle non-pharmacological treatments able to reduce nasal congestion and sequelae of respiratory infections that frequently may be associated with SDB. In this regard, a recent study reported a successful treatment with thermal water, hyaluronic acid, and grapefruit seed extract in reducing nasal congestion and airways hyperreactivity in children with upper respiratory infections (35).

In conclusion, SDB should be thoroughly managed in childhood to prevent chronic and potentially irreversible damage.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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