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SCIENTIFIC INVESTIGATIONS

Prevalence of sleep-disordered breathing and associations with malocclusion in children

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Study Objectives: This study aimed to determine the prevalence of sleep-disordered breathing (SDB) and its association with malocclusion among children in Recife, Brazil.

Methods: This study included 390 children aged 7 to 8 years. The data comprised the measurement of body mass, orthodontic examination, and parental information required by the Sleep Disturbance Scale for Children. The statistics tools used were Pearson's chi-square test and the Lemeshow test.

Results: Positively screened for SDB was found in 33.3% of the children, and the association with overjet was *P* = .007 (odds ratio [OR], 95%, confidence interval [CI]: 1.93). The association with anterior open bite was *P* = .008 (OR, 95% CI: 2.03), and the association with posterior crossbite was *P* = .001 (OR, 95% CI: 2.89). This report was unable to indicate an association between body mass index and SDB. The multivariate logistic regression model revealed that the anterior open bite (*P* = .002; OR, 95% CI: 2.34) and posterior crossbite (*P* = .014; OR, 95% CI: 2.79) had an association with positively screened for SDB.

Conclusions: The results of this study indicated that the prevalence of SDB was high and highly associated with malocclusion. Since posterior crossbite and anterior open bite were associated with positively screened for SDB, early diagnosis and intervention may prevent and minimize adverse effects of SDB on individuals lives.

Keywords: body weight, child, malocclusion, prevalence, sleep-disordered breathing

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Since occlusal disorders are considered risk factors for developing sleep and breathing disorder, the present study aimed to investigate the prevalence of positively screened for sleep-disordered breathing and its relation to malocclusion in Brazilian children.

Study Impact: The impact of this study in the field is related to the identification of children who need more attention in planning their care, aiming at the adoption of strategies that help them to cope with the vulnerable situation they are in and to enable a reduction of the risks and harms caused by the nontreatment of respiratory sleep disorders.

INTRODUCTION

Scientific investigation on sleep disorders has focused on insomnia and excessive daytime sleepiness in adulthood and their impacts on normal physiological functioning and quality of life. Although sleep disorders impact 20–30% of health conditions reported by children's health care providers,[1,2] few reports have been done on the prevalence of these disorders in children. Sleep disorders can lead to several comorbidities, such as abnormal growth and cardiovascular, immunological, and metabolic disorders, which can affect a child's health and quality of life over the years.[3] However, among the primary risk factors for sleep-disordered breathing (SDB), body mass index (BMI) is an important predictor of the severity of sleep disorders.[3]

SDB includes several upper airway disorders, ranging from primary snoring (PS) to obstructive sleep apnea (OSA).[4] PS is a respiratory noise in which sleep architecture, alveolar ventilation, and blood oxygen saturation are maintained at average values, whereas OSA is the partial or complete obstruction of the upper airways that impairs normal ventilation during normal sleep patterns.[5] The prevalence of SDB in children ranges from .7 to 16.9%; however, in the current literature, PS ranges from 4.3 to 16.9% and OSA ranges from .7 to 3%.[6–9]

SDB is commonly associated with orofacial and dentofacial features and may be related to malocclusion.[6] Abnormal craniofacial morphology, such as retrognathia and dental malocclusion, contributes to upper airway obstruction and increased risk of SDB.[6,10] However, SDB is an issue rarely mentioned by parents in well-child visits and by primary health care providers. Therefore, a vast number of underdiagnosed cases of this disorder may exist in primary care centers,[7] and further education may be required for both parents and providers to deal with this subject.[11,12,13] Oral screening in children and the use of a validated questionnaire could improve early diagnosis and reduce underdiagnosis of SDB.[14]

The main reason for investigating the risk factors of SDB in childhood is to prevent developing SDB across the individuals' lives.[11] Since occlusal disorders are risk factors for developing sleep and breathing disorder, the present study aimed to investigate the prevalence of positively screened for SDB and its relation to malocclusion in Brazilian children.

METHODS

This cross-sectional study was conducted on 7- and 8-year-old children attending local public schools in the city of Recife, Brazil. The sample size was calculated using the formula for cross-sectional studies in Epi Info Version 2000 (Atlanta, GA) based on Schlarb et al.[1] The calculation was as follows: 20% prevalence rate for SDB, 95% confidence interval, 5% error, a 1.5 design effect, and the addition of 20% to account for possible losses. The final sample resulted in a total of 435 children. Schools were randomly selected proportional to the number of schools in the 6 administrative districts of the city of Recife. The children were randomly selected from 18 of 233 schools using computer-generated random numbers. Parents or guardians signed a statement of informed consent to allow their children to take part in the trial.

We excluded children with developmental syndromes (2 children), cleft lip and/or palate (1 child), those who had undergone tonsil and/or adenoid surgery, and those who were under or had a history of orthodontic (19 children) or functional jaw orthopedic treatment (11 children). Children who presented soft palatal morphology grades 3 and 4 classified according to the modified Bittencourt et al.[15] as well as those who presented 1 cm or less space between the tonsils evaluated visually by one orthodontist were also excluded . The definition corresponds to grades 3 and 4 of the Brodsky[16] classification. The exclusion was performed to decrease the chance of individuals having other contributors to SDB and represent 3 and 9 children, respectively.

The physical assessment was comprised of the measurement of BMI, based on height (measured using a Tonelli stadiometer with a two meters capacity and precision of .1 cm) and weight (measured using a Camry digital scale, model EB9013, Recife, Pernambuco, Brazil with a capacity for 150 kg and a precision of 100 g). Children in the 85th to 97th percentile for age were classified as overweight, and those above the 97th percentile were classified as obese, as recommended by the World Health Organization.[17] For the orthodontic evaluation, a single previously trained and calibrated orthodontist (Intra-examiner Kappa Test: .80) examined the children as follows.[18]

Sagittal analysis

The molar relationship followed Angle's classification[19] compared with the anteroposterior diameter of the mandible and maxilla and the relationship between the permanent first molars. Overjet, the projection of the maxillary incisors beyond the lower incisors on the horizontal plane, was measured by using a Community Periodontal Index probe that was placed perpendicular to the occlusal plane on the buccal surface of the mandibular incisors.[20] The measurements were classified as follows: 0 mm, an edge-to-edge bite; 1 to 3 mm, normal; 4 to 6 mm, moderately increased; and > 6 mm, severely increased. In this report, values ≤ 3 mm were not classified as overjet; values > 3 mm were classified as overjet. When the maxillary incisors were occluded behind the mandibular incisors (negative overjet), it was recorded as anterior crossbite.[21,22]

Vertical analysis

Overbite is the overlap of the upper teeth along the lower teeth on the vertical plane.[18] The distance (in mm) between the incisal edges was measured using a Community Periodontal Index probe.[20] The measurements were classified as follows: 0 mm (incisal edges of maxillary incisors in contact with incisal edges of mandibular incisors), an edge-to-edge bite[21,22]; 1 to 3 mm, normal; 4 to 6 mm, moderately increased; and > 6 mm, severely increased. In the present study, values ≤ 3 mm did not indicate overbite; values > 3 mm indicated overbite. A lack of contact between the incisal edges of the maxillary and mandibular teeth was considered anterior open bite.[18,21,22]

Transversal analysis

Posterior crossbite, defined as a labiolingual relationship between the maxillary and mandibular teeth, inverted, out of the normal standards,[18] was recorded when involving one or more molars in the posterior region. Posterior crossbite was classified as unilateral (when involving only one side) or bilateral (when involving both sides).[23] The orthodontic chart used in this assessment also recorded Angle's classification (class I, II, or III), overjet, overbite, anterior open bite, anterior crossbite, and posterior crossbite.

The following sociodemographic data were recorded: sex, marital and employment status of the caregiver, and the Sleep Disturbance Scale for Children (SDSC) score. Those positively screened for SDB were evaluated using the SDSC (for 3 to 18 years of age), which was validated for Brazil[24] and filled out by the parents or caregivers concerning the children's sleep habits over the previous 6 months. The scale has 26 items divided among 6 subscales, as follows: disorders of initiating and maintaining sleep, sleep breathing disorders, disorders of arousal, sleep-awake transition disorders, disorders of excessive somnolence, and sleep hyperhidrosis. The SDSC items used to detect symptoms of SDB included the following: 1) ''the child has difficulty breathing at night,'' 2) ''the child gasps for breath or is unable to breathe during sleep,'' and 3) ''the child snores.'' The answers were recorded on a Likert scale of 1 to 5, as follows: 1 point for ''never,'' 2 points for ''occasionally'' (1 or 2 times per month), 3 points for ''sometimes'' (1 or 2 times per week), 4 points for ''often'' (3–5 times per week), and 5 points for ''always'' (daily). Hence, the sum score for the 3 questions was at least 3 and at most 15. According to the total score obtained for these 3 SDSC items, the participants were classified into the 3 following groups: group 1, at high risk of SDB (12 to 15 points); group 2, at moderate risk of SDB (7 to 11 points); and group 3, at low risk of SDB (3 to 6 points).

These variables were dichotomized in children without SDB (groups 1 and 2) and children with SDB (group 3).[18] This study also evaluated the BMI of the children, since this variable is an important factor for SDB according to Kaditis et al.[25]

Regarding the discriminatory validity of the SDSC scale, according to scale validation to Portuguese,[24] the patients with PSG positive for SDB were more likely to present a higher mean score for the SDB subscale than the patients with PSG negative for any sleep disorders (8.9 and 4.9, respectively; $P < .001$).Therefore, if the PSG examination is considered to be a measurement of the discrimination, this result points to the discriminatory validity for the SDB scale, indicating that the 3 questions of the scale are appropriate to screen patients for SDB.

Data analysis was performed with the Statistical Package for the Social Sciences (SPSS, version 17.0) by Pearson's chi-square test and the Lemeshow test with a 5% margin of error and 95% confidence interval.

The study was carried out following the Internal Research Board of the University of Pernambuco, number CAAE 53308915.8.0000.5207, following the Resolution 466/2012 of the National Commission of Ethics in Research.

The participants had informed consent signed by parents and guardians, as required by Helsinki Declaration, 1964.

The study followed the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) protocol for observational studies.

RESULTS

A total of 390 students out of the 435 (89.7%) had physical and orthodontic examinations and parents who returned the questionnaires. The losses included 45 students (10.3%) that did not complete the questionnaires or did not attend school on the examination days. The majority of the children were 7 years of age (n = 212; 54.4%), and boys accounted for 53.8% (n = 210) of the sample. **Table 1** shows the frequency of malocclusion, the BMI, and SDB of the children. Among the caregivers, the majority were women (n = 363; 93.1%), were married or in a stable relationship (n = 238; 61.0%), had completed high school or university education (n = 214; 54.9%), and were employed (n = 242; 62.1%).

Among the orthodontic variables, overjet, anterior, and posterior crossbite were significantly associated with SDB (**Table 2**). A logistic regression model with the variables showed a significant association of up to 20% ($P < .20$) in the bivariate study (overjet, anterior open bite, and posterior crossbite). In the multivariate logistic regression analysis, posterior crossbite and open bite were considered risk factors for SDB (**Table 3**).

DISCUSSION

SDB may impact public health throughout the world, affecting millions of individuals, mainly children.[26] This abnormality is often associated more with occlusal disorders than other sleep conditions, which may be explained by the abnormal development of malocclusions caused by the breathing pattern, facial muscle balance, and skeletal muscles.[26] SDB represents a development from PS to OSA, and this condition tends to progress from mild SDB to severe OSA over time, a period that may be surprisingly short in the case of weight gain and the lack of effective treatment.[27]

Adults presenting with SDB seem to have poor dental occlusions and abnormal craniofacial morphology, which may raise the question of whether orthodontic treatment in childhood could prevent SDB in adulthood.[27,10] Early diagnosis of SDB in childhood and the provision of appropriate treatment may not only treat or prevent medium-term complications, such as learning difficulties, but may potentially prevent long-term cardiovascular complications.[28]

Among the occlusal features shown in the present study, overjet, posterior crossbite, and open bite were significantly

Table 1—The numbers and percentages of children with dental malocclusions, SDB, and BMI.

Variable	n	%
Total	390	100.0
Occurrence of malocclusion		
Yes	253	64.9
No	137	35.1
Molar Relationship		
Class I	224	57.4
Class II	91	23.3
Class III	75	19.2
Overjet		
Present	91	23.3
Absent	299	76.7
Overbite		
Present	35	9.0
Absent	355	91.0
Anterior open bite		
Present	68	17.4
Absent	322	82.6
Posterior Crossbite		
Present	41	10.5
Absent	349	89.5
Anterior Crossbite		
Present	28	7.2
Absent	362	92.8
Sleep-disordered breathing		
Present	130	33.7
Absent	260	66.7
BMI		
Overweight/obese	144	36.9
Ideal range	246	63.1

BMI = body mass index, SDB = sleep-disordered breathing.

Table 2—Occurrence of SDB according to malocclusions and BMI status.

Variable	Sleep Breathing Disorders				Total		*P* Value	OR (95% CI)
	Present		Absent					
	n	%	n	%	n	%		
Total group	130	33.3	260	66.7	390	100.0		
Molar relationship							.559	
Class I	70	31.3	154	68.8	224	100.0		1.00
Class II	34	37.4	57	62.6	91	100.0		1.31 (.79–2.19)
Class III	26	34.7	49	65.3	75	100.0		1.17 (.67–2.03)
Overjet							.007*	
Present	41	45.1	50	54.9	91	100.0		1.93 (1.19–3.13)
Absent	89	29.8	210	70.2	299	100.0		1.00
Overbite							.616	
Present	13	37.1	22	62.9	35	100.0		1.20 (.58–2.47)
Absent	117	33.0	238	67.0	355	100.0		1.00
Anterior open bite							.008*	
Present	32	47.1	36	52.9	68	100.0		2.03 (1.19–3.46)
Absent	98	30.4	224	69.6	322	100.0		1.00
Posterior crossbite							.001*	
Present	23	56.1	18	43.9	41	100.0		2.89 (1.59–5.58)
Absent	107	30.7	242	69.3	349	100.0		1.00
Anterior crossbite							.488	
Present	11	39.3	17	60.7	28	100.0		1.32 (.60–2.91)
Absent	119	32.9	243	67.1	362	100.0		1.00
BMI							.975	
Obese	31	34.1	60	65.9	91	100.0		1.05 (.63–1.75)
Overweight	18	34.0	35	66.0	53	100.0		1.05 (.56–1.96)
Ideal range	81	32.9	165	67.1	246	100.0		1.00

*Significant association at 5% level (Pearson's chi-square test). BMI = body mass index, CI = confidence interval, OR = odds ratio, SDB = sleep-disordered breathing.

Table 3—Multivariate logistic regression analysis of the association between SDB and overjet, anterior open bite, and posterior crossbite.

Variable	Bivariate		Adjusted	
	P Value	OR and 95% CI	*P* Value	OR and 95% CI
Overjet	.007*		.402	
Present		1.93 (1.19–3.13)		1.29 (.71–2.36)
Absent		1.00		1.00
Anterior open bite	.008*		.002*	
Present		2.03 (1.19–3.46)		2.34 (1.36–4.03)
Absent		1.00		1.00
Posterior crossbite	.001*		.014*	
Present		2.89 (1.59–5.58)		2.79 (1.24–6.31)
Absent		1.00		1.00

*Significant association at 5% level (Lemeshow test). CI = confidence interval, OR = odds ratio, SDB = sleep-disordered breathing.

associated with positive screening for SDB, which agreed with data from a previous study.[29] The logistic regression analysis in the present report revealed that both posterior crossbite and open bite were risk factors for SDB. The current findings indicated the importance of the early diagnosis of posterior crossbite, which seems to be the type of malocclusion most associated with SDB,[30,27,29] followed by anterior open bite.[31,32] These may lead to abnormal breathing patterns, which may alter the oral and facial muscular balance and are likely to affect skeletal and occlusal development in children.[27]

In this group of children, 36.9% were overweight/obese. This agreed with previous studies that reported a high prevalence of overweight and obesity among children and adolescents aged 2 to 19 years.[27] Concerning SDB, no significant association was found with overweight/obesity in this study. Likewise, a previous study also found no association between overweight and SDB, and, similar to the current study's findings, individuals with craniofacial abnormalities were more susceptible to developing SDB than individuals with excess weight.[33] Previous studies suggested that obesity plays an important role in the pathophysiology of SDB in adults[34] and, to a lesser extent, in children.[35] We therefore speculate that more scientific evidence about the interactions between obesity and SDB is needed when considering the increase of obesity in childhood.[25,36]

In children, adenotonsillar hypertrophy and deviations concerning craniofacial morphology and dental occlusion are risk factors for SDB, which seems to have a complex, multifactor pathogenesis in children.[31,37] Therefore, orthodontic intervention could prevent SDB in adulthood.[11,16] Orthodontic intervention in the mixed dentition may reduce the signs and symptoms of respiratory obstruction in children and prevent severe malocclusions, thus contributing to the harmonious growth of the basal bones and the normal development of the occlusion and reducing the chances of abnormalities in the permanent dentition.[3,6,14,38]

The main limitation of the present report was the study design, which did not allow for the determination of cause-and-effect relationships between malocclusion and SDB. Therefore, longitudinal design studies are needed for more precise diagnostic purposes. Patients with certain soft palate type and tonsillar hypertrophy were disregarded, notably decreasing the generalization of this study findings. In the study population, the prevalence of those positively screened for SDB was high and associated with posterior crossbite and anterior open bite. We encourage that the orthodontic diagnosis be carried out with the assistance of complementary examinations (radiographic and cephalometric). If the presence of bad occlusions is confirmed, the correction of skeletal disharmonies should be considered, regardless of presenting SDB. Since these disharmonies demonstrate an association with SDB, the intervention could reduce the risk for SDB. It is worth emphasizing that early treatment, in the mixed dentition phase, is indicated due to greater bone elasticity, less resistance to expansion, and consequently less painful symptoms.[38]

ABBREVIATIONS

BMI, body mass index
CI, confidence interval
OR, odds ratio
OSA, obstructive sleep apnea
PS, primary snoring
SDB, sleep-disordered breathing
SDSC, Sleep Disturbance Scale for Children

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DISCLOSURE STATEMENT

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