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Associations between sleep-disordered breathing symptoms and facial and dental morphometry, assessed with screening examinations

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Introduction: Chronic snoring is considered abnormal in a pediatric population. This disorder is often attributed to enlarged tonsils and adenoids, but multiple anatomic obstructions should also be considered. Facial and dental morphometry associations with various sleep-disordered breathing symptoms were investigated at an orthodontic clinic. **Methods:** Parents or guardians were asked to complete a 4-part questionnaire on behalf of their children (n = 604; <18 years of age), including medical and dental history, bruxism and temporomandibular disorder habits, sleep and daytime behavior, and sleep duration and quality. All subjects underwent a clinical screening assessment by the same orthodontist to identify standard dental, skeletal, functional, and esthetic factors. **Results:** In contrast to sleep-disordered breathing or sleep apnea in adults, which is predominantly associated with obesity, sleep-disordered breathing symptoms in this pediatric cohort were primarily associated with adenotonsillar hypertrophy, morphologic features related to a long and narrow face (dolichofacial, high mandibular plane angle, narrow palate, and severe crowding in the maxilla and the mandible), allergies, frequent colds, and habitual mouth breathing. **Conclusions:** Because of the recognized impact of pediatric snoring on children's health, the determination of these good predictors can help in preventing and managing sleep-disordered breathing. If a health professional notices signs and symptoms of sleep-disordered breathing, the young patient should be referred to a sleep medicine specialist in conjunction with an orthodontist if there are dentoskeletal abnormalities. (Am J Orthod Dentofacial Orthop 2011;140:762-70)

Sleep-disordered breathing forms a severity continuum from primary snoring to obstructive sleep apnea—ie, cessation of breathing. Chronic snoring, albeit common in adulthood, is considered abnormal in a pediatric population.[1] Among children and adolescents, the prevalence of primary snoring has been reported at 3.2% to 12.1%,[2-4] and the prevalence for obstructive sleep apnea is estimated at 0.7% to 10.3%.[3-5] Sleep-disordered breathing in children has been associated with a wide variety of symptoms (Table 1).[6-13] Patients often report associated excessive daytime fatigue, morning headaches, loud and abnormal snoring or breathing, restless sleep, impaired intellectual function and attention, mood disturbance, aggressive behavior, and hyperactivity.[4,7,14-16] Sleep-disordered breathing is often underdiagnosed in children and teenagers because the primary complaints reported by parents are more often behavioral symptoms.[17]

Although enlarged tonsils and adenoids contribute greatly to pediatric sleep-disordered breathing, multiple anatomic obstructions should also be considered.[8] Although it is debated, cephalometry in children and adult obstructive sleep apnea patients has shown that decreased mandibular and maxillary lengths, skeletal retrusion, increased mandibular plane angle, and low hyoid position have implications in sleep-disordered breathing.[18-23] In the vertical plane, children with long faces, retropositioned mandibles, and associated lip incompetence have been shown to have increased sleep-disordered breathing and obstructive sleep apnea symptoms.[22,24-26] In the transverse plane, maxillary constriction is a sign of reduced transverse dimension of the upper airways and increased nasal resistance, which results in increased mouth breathing. Transverse

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maxillary deficiency can be clinically assessed, and a high, narrow palate, and severe crowding of the maxilla and the mandible might also be present.[27] In the anteroposterior plane, a micrognathic or retrognathic mandible will most likely cause the tongue to reduce the pharyngeal airway space and decrease airflow during sleep.

Children and adolescents seeking orthodontic treatment have some form of craniofacial disharmony. Approximately 15% to 22% of children who have not yet received orthodontic treatment have occlusal asymmetry, and nearly 30% have sagittal asymmetry.[28] In addition, nearly 18% of American children (12-17 years of age) have incisor crowding and malalignment.[29] Therefore, the craniofacial disharmony seen in the orthodontic clinic can possibly overlap with those previously identified as risk factors for sleep-disordered breathing or obstructive sleep apnea in children. Many studies have reported a positive relationship between craniofacial morphologic characteristics in children and sleep-disordered breathing symptoms. However, these studies were done on patients who were referred to either sleep clinics or ear, nose, and throat clinics for snoring or obstructive sleep apnea. The objective of our study was to evaluate the prevalence of sleep-disordered breathing symptoms and their associations with facial or dental morphometry in a more general setting, such as a general pediatric orthodontic population, where orthodontists are experienced in evaluating craniofacial morphology and growth.

MATERIAL AND METHODS

A cross-sectional investigation was conducted with 604 subjects from the general orthodontic department of a university clinic (Université de Montréal in Canada). The subjects were under 18 years of age (mean $\pm$ SD, 13.01 $\pm$ 2.28 years; range, 7-17 years). The study was conducted in accordance with the university's ethical standards.

The parents or guardians present at the clinical examination were asked to complete a 4-part questionnaire on behalf of their children, including medical and dental histories, bruxism and temporomandibular disorder habits, sleep and daytime behavior, and sleep duration and quality.

The sleep and daytime behavior questionnaire was a modified and translated version of the 22-item pediatric sleep questionnaire.[30,31] The questions were translated into French and verified for clarity in 86 children (not included in this cohort). The final portion of the questionnaire was a verified French translation of the Pittsburgh sleep quality index.[32-34]

Table I. Symptoms of sleep-disordered breathing in children and adolescents[6-8,12,13]

Nighttime	*Daytime*
• Abnormal sleeping positions	• Morning tension-type headache
• Chronic, heavy snoring	• Mouth breathing
• Confused arousal	• Excessive morning thirst
• Delayed sleep onset	• Excessive fatigue and sleepiness
• Difficulty breathing during sleep	• Abnormal shyness, withdrawn and depressive presentation
• Difficulty waking up in the morning	• Behavioral problems
• Drooling	• Pattern of attention-deficit/ hyperactivity disorder (ADHD)
• Enuresis	• Aggressiveness
• Frequent awakenings	• Irritability
• Insomnia	• Poor concentration
• Mouth breathing	• Learning difficulties
• Nocturnal migraine	• Memory impairment
• Nocturnal sweating	• Poor academic performance
• Periodic limb movement	
• Restless sleep	
• Sleep talking	
• Sleep terror	
• Sleepwalking	
• Witnessed breathing pauses during sleep	

All subjects underwent a clinical screening evaluation by the same orthodontist (A.P.), blinded to the questionnaires, using an orthodontic evaluation form covering various standard dental, skeletal, functional, and esthetic factors. Once the patient was placed in the physiologic natural head position, the general clinical facial evaluation included the following: (1) a profile analysis (convex when a line dropped from the bridge of the nose to the base of the upper lip and the second line extending from that point downward to the chin forms an acute angle, or straight or concave when the angle is obtuse), (2) frontal view for facial thirds analysis (brachyfacial if the lower third was shorter than the average, mesofacial if the lower third was slightly longer than the average, or dolicofacial if the lower third was much larger than the average), and (3) mandibular plane angle visualization with a finger along the border of the mandible (flat, normal, or steep).

Asymmetries of the dental midline to the facial midline were noted to evaluate the relationship of the dentition to the face. The following variables related to oral function were examined by the clinician: (1) respiration (mouth, nasal breathing, or both as reported by the patient), (2) tonsil size according to the Brodsky[35] scale (normal or hypertrophic, when greater than 50% obstruction), (3) tongue size (small without tongue coverage of the posterior mandibular teeth at rest, normal when the tongue slightly overlaps the lingual aspect of the posterior surface, large when the tongue covers more than half of the lingual surface, or scalloped when there are tooth indentations on the lateral border of tongue), (4) temporomandibular joint disorders (abnormal sounds, pain on a scale from 1 to 10), and (5) lateral mandibular movements (normal or abnormal; as a general guideline, if the mandible moved normally, it was assumed that its function was not severely impaired; restricted movement usually indicated a functional problem; the amount of maximum opening was also noted; the muscles of mastication and the temporomandibular joints were palpated, and any problems such as joint pain, noise, or limitation of opening were noted, along with any shifts of the mandible laterally or anteriorly on closing), and (6) the amounts of overjet and overbite.

A visual clinical evaluation of skeletal variables included (1) transverse dimension analysis to categorize the widths of the maxilla and the mandible clinically as decreased when there were black triangles in the posed smile, normal when they had appropriate widths, and increased when the maxilla and the mandible appeared broad or excessively wide; (2) vertical dimension analysis of the facial proportions in the frontal and lateral views, evaluated by dividing the face in thirds; the vertical dimension was noted as decreased when the lower third was smaller than the upper and middle thirds, equal in height for well-proportioned faces that were classified as normal, and increased when the lower third was larger than the upper and middle thirds; and (3) anteroposterior dimension analysis, categorized as decreased when the mandible was posteriorly positioned relative to the maxilla in the lateral view, normal when both jaws appeared proportionately positioned, or increased when the mandible was anteriorly positioned.

Palatal vault shape was also noted as either deep when the distance between the occlusal surface and the palatal vault appeared increased and the lateral distance appeared constricted, round when the palatal vault shape was ideal, or flat when the distance between the occlusal surface and the palatal vault was decreased and the lateral distance appeared enlarged.

Visual clinical evaluation of the dental component of the malocclusion included molar and canine Angle classifications, number and location of crossbites, and maxillary and mandibular dental arch crowding or spacing. Crowding was further subdivided into mild (1-2 mm), moderate (3-4 mm), or severe ($\geq$5 mm). The curve of Spee (natural curvature of the dentition in the anteroposterior dimension), and the curves of Monson and Wilson (natural curvatures of the posterior dentition in the lateral dimension of the maxillary and mandibular dentitions, respectively) were classified as mild (0-1 mm), moderate (1-2 mm), severe (>2 mm), or inversed (when reversed).[29] Periodontal soft-tissue problems were also noted. Dental and skeletal diagnoses (Class I, normal; Class II, retrusive; or Class III, prognathic) were evaluated and noted.[29]

Statistical analysis

Data are presented as the mean ± the standard deviation for continuous variables and as percentages for categorical variables. The Pearson chi-square test and the Fisher exact test were used to evaluate the statistical relationships between clinical examination parameters and reported sleep-disordered breathing symptoms. These variables were dichotomous, and, in selected cases with multiple variables, the data were reduced to 2 categorical groups: "never" and "sometimes" were reduced to "no," and "often" and "always" were reduced to "yes." Odds ratios (OR) associated with the presence or absence of characteristics and mean values with 95% CI values were also calculated. Student *t* tests for independent samples were used to compare continuous data between dichotomous sets. Statistical significance was assessed at $P < 0.05$. Data were analyzed with SPSS software (version 15; SPSS, Chicago, Ill).

RESULTS

The sex distribution was 55.5% female and 45.5% male. The majority of subjects were white (82.4%), with 8% of African origin, 6.8% Hispanic, and 2.8% Asian. According to the Center for Disease Control's body mass index for age growth charts, the body mass index scores indicated that 77.6% of the sample was considered at a healthy weight or underweight, and 22.4% was overweight or obese.

All subjects were considered in good general health, since no major health issues were reported in their medical and dental histories. Only 11.5% reported regular medication use, mostly psychostimulants (6.1%) and bronchodilatators (1.5%). Nevertheless, a quarter of the subjects (25.1%) reported suffering from allergies (eg, asthma, dust). From 12% to 53% of these subjects reported partial or constant mouth breathing, respectively. A previous history of thumb or finger sucking was reported by 17.1% of parents, but this was discontinued with time, with only 1% reporting a current habit.

According to the questionnaire, 16.3% of subjects were aware of clenching their teeth while awake or asleep, 12.0% ground their teeth while awake or asleep (suggesting bruxism), 4.8% had jaw soreness on awakening, and 5.1% had facial or masticatory muscle pain.

The following sleep-disordered breathing symptoms were reported by parents: habitual snoring, loud breathing, trouble breathing during sleep, observed cessation of breathing suggesting apnea (no subjects were previously diagnosed with apnea), and waking up feeling unrefreshed. Behavioral problems ranged from being agitated to being easily distracted (Table II).

The average hours of sleep during the past month were reported as 9 hours 8 minutes (SD, 59 minutes). The average amount of time before falling asleep was reported as 20 minutes 29 seconds (SD, 15 minutes). Greater time to fall asleep was described for 10.7% of subjects, who had been unable to fall asleep within 30 minutes at least 3 times per week. Poor overall sleep quality was reported for 3.9% of subjects.

Skeletal and dental morphologic traits in the vertical, transverse, and sagittal skeletal planes were examined, as well as the shape and dimensions of the dentoalveolar arches.

In the vertical plane, most subjects had mesofacial morphologies (71.4%) and convex profiles (86.4%). Dolichofacial, or long-face morphology, was observed in 15.7% of the subjects. In the transverse plane, a narrow palate was identified in 8.4% of the subjects. Posterior crossbites involving 2 or more teeth were found in 10.4% of subjects. In the sagittal or anteroposterior plane, most subjects appeared to have a regular bite (51.2%-59.2%) or an abnormal overbite or overjet (35.4%-43.7%). The rest had an underbite or underjet (5.1%-5.4%). Severe maxillary and mandibular dental crowding in the dentoalveolar arch was found in 16.1% of the subjects.

Enlarged tonsils were observed in 17.3% of the subjects. A large tongue was subjectively assessed in only 0.7%, although a fissured tongue was seen in 8.2%. Primary mouth breathing was noted by the clinician in 21.5% of the subjects; most were primarily nose breathers (46.3%), followed by mixed nose-mouth breathers (32.3%).

Four morphologic characteristics from the clinical examinations were related to larger vertical facial dimensions: dolichofacial morphology, greater facial height, high mandibular plane angle, and anterior open bite. The dolichofacial and high mandibular plane angle characteristics were significantly statistically associated with several snoring and breathing symptoms as well as daytime somnolence (Table III). A positive association was also found between long-face characteristics and longer time to fall asleep.

The palatal morphology assessment for transverse maxillary deficiency was positively associated with 10 of the 28 pediatric sleep-disordered breathing symptoms (Table I) compared with other subjects. Snoring, mouth breathing, and daytime sleepiness were significantly associated with a narrow palate and decreased maxillary width (Table IV). A narrow palate was further associated with decreased sleep duration ($P = 0.02$), poor sleep quality (12.2% of subjects with narrow palate had poor sleep; $P = 0.008$; OR, 4.4 [95% CI, 1.6-11.6]), morning headache (10.0%; $P = 0.024$; OR, 3.7 [95% CI, 1.3-10.6]), and daytime somnolence (22.0%; $P < 0.001$; OR, 4.4 [95% CI, 2.1-9.4]). Moreover, a posterior crossbite was significantly statistically associated with loud snoring (14.5%; $P = 0.003$; OR, 3.8 [95% CI, 1.6-7.1]).

Table II. Reported sleep and daytime behavior data from the patient questionnaire

Category	*Features*	*Frequency*
Snoring frequency	Usually snores	10.9%
	Always snores	2.9%
Snoring quality	Snores loudly	5.3%
	Heavy or loud breathing	17.7%
Breathing problems	Trouble breathing during sleep	5.1%
	Stops breathing during the night	1.8%
Mouth breathing	Daytime mouth breathing	34.0%
	Dry mouth on awakening	36.1%
Daytime sleepiness	Feeling unrefreshed in the morning	20.6%
	Problem with somnolence	7.3%
	Sleepy as reported by a teacher	3.3%
	Difficult to awaken in the morning	23.6%
Inattention/ hyperactivity	Does not seem to listen when spoken to	15.0%
	Difficulty organizing tasks and activities	12.5%
	Easily distracted by external stimuli	26.7%
	Fidgets with hands or feet	21.5%
	Agitated	7.7%
	Interrupts or intrudes on others	11.8%
	Poor academic results	8.2%
Other symptoms	Occasionally wets the bed	4.8%
	Morning headache	3.5%
	Delayed growth since birth	16.7%

Anteroposterior deficiencies were not highly associated with reported pediatric obstructive sleep apnea symptoms compared with other subjects. However, poor scholastic results were significantly associated with reported obstructive sleep apnea symptoms and severe overjet. Morning headaches and reported tooth grinding were also significantly associated with both retrognathia and overjet (Table V).

A retrusive mandible showed an associative trend ($P \leq 0.09$) with morning headaches (6.3% of subjects with retrusive mandible had morning headaches; OR, 2.5 [95% CI, 1.0-6.1]), reported tooth grinding (16.9%; OR, 1.7 [95% CI, 1.0-3.0]), and clenching (21.1%; OR, 1.5 [95% CI, 1.0-2.5]) compared with other subjects (Table VI). *T* tests demonstrated significant

Table III. Statistical associations between evaluated vertical facial morphology and reported pediatric obstructive sleep apnea symptoms

	Dolichofacial (15.7%)	*Mesofacial and brachyfacial (84.3%)*	*OR (95% CI)*	P value	*High MPA (15.7%)*	*Normal and low MPA (84.3%)*	*OR (95% CI)*	P value
Usually snores	19.8%	9.4%	2.4 (1.3–4.3)	0.006	19.8%	9.4%	2.4 (1.3-4.3)	0.006
Snores loudly	14.3%	3.7%	4.4 (2.1-9.3)	<0.001	14.4%	3.7%	4.4 (2.1-9.4)	<0.001
Trouble breathing	9.8%	4.1%	2.6 (1.1-5.8)	0.033	9.9%	4.1%	2.6 (1.1-5.9)	0.031
Day mouth breathing	50.0%	31.3%	2.2 (1.4-3.4)	0.001	53.2%	30.7%	2.6 (1.6-4.0)	<0.001
Dry mouth on awakening	48.4%	33.9%	1.8 (1.2-2.9)	0.010	52.7%	33.1%	2.2 (1.4-3.5)	<0.001
Sleepiness	13.8%	6.2%	2.4 (1.2-4.8)	0.016	13.8%	6.2%	2.4 (1.2-4.8)	0.016
Difficulty initiating sleep*	24:10 min (SD, 15:53)	19:54 min (SD, 15:38)	-	0.018	23:40 min (SD, 15:53)	19:59 min (SD, 15:39)	-	0.041

MPA, Mandibular plane angle.
*Sleep onset latency (minutes).

Table IV. Statistical associations between evaluated palatal morphology, evaluated maxillary width, and reported pediatric obstructive sleep apnea symptoms

	Narrow palate (8.4%)	*Round and flat palate (91.6%)*	*OR (95% CI)*	P value	*Decreased width (25.2%)*	*Normal and increased width (74.8%)*	*OR (95% CI)*	P value
Snores loudly	18.0%	4.1%	5.1 (2.2-11.9)	0.001	10.6%	3.4%	3.3 (1.6-6.9)	0.002
Trouble breathing	10.2%	4.6%	2.4 (0.9-6.4)	0.093	8.7%	3.9%	2.4 (1.1-5.0)	0.030
Day time mouth breathing	52.0%	32.4%	2.3 (1.3-4.1)	0.007	41.1%	31.6%	1.5 (1.03-2.2)	0.037
Sleepy as reported by teacher	12.0%	2.6%	5.2 (1.9-14.2)	0.004	6.0%	2.5%	2.5 (1.0-6.2)	0.062

protective associations between mandibular deficiency traits and less time to get to sleep, but not for longer sleep time. However, all patients had an adequate average of over 9 hours of sleep.

Dental arch deficiency was assessed by maxillary and mandibular dental crowding on a scale from spacing to severe crowding. Severe crowding in the maxilla and the mandible was significantly associated with increased snoring, loud snoring, dry mouth on awakening, and fewer hours of sleep compared with other subjects (Table VII). Furthermore, severe maxillary crowding was significantly associated with poor sleep quality (8.5% of subjects with severe crowding had poor sleep; $P = 0.018$; OR, 3.0 [95% CI, 1.2-7.4]), daytime somnolence reported by either teachers (8.2%; $P = 0.008$; OR, 3.7 [95% CI, 1.5-9.2]) or parents (12.4%; $P = 0.053$; OR, 2.1 [95% CI, 1.0-4.2]). Severe mandibular crowding had a statistically significant relationship with daytime mouth breathing (43.3%; $P = 0.046$; OR, 1.6 [95% CI, 1.03-2.05].

Hypertrophied tonsils were significantly associated with loud snoring (10.1% of subjects with hypertrophied tonsils had loud snoring; $P = 0.027$; OR, 2.5 [95% CI, 1.1-5.5]) and habitual snoring (16.7%; $P = 0.054$; OR, 1.8 [95% CI, 1.0-3.4]) compared with other subjects. Tonsils were also enlarged in subjects who were screened during the winter (northern hemisphere, January-April) compared with those screened at other times of the school year ($P = 0.031$; OR, 2.1 [95% CI, 1.1-4.2]).

The subjects' breathing patterns were assessed in the screening examinations and twice in the patient questionnaires. In all cases, significant associations were found between predominant mouth breathing and many pediatric obstructive sleep apnea symptoms compared with other subjects (Table VIII). Symptoms of habitual snoring, loud snoring, heavy breathing during sleep, trouble breathing during sleep, and dry mouth on awakening were significantly associated with all 3 mouth-breathing assessments.

Statistically significant associations were found between pediatric sleep-disordered breathing symptoms and reported allergies and sinus problems, frequent colds, and pulmonary problems compared with other subjects. Trouble breathing at night was significantly associated with all 3 categories.

Reports of frequent daytime headaches were significantly associated with symptoms of sleepiness (27.3% of subjects with frequent headaches had sleepiness; $P = 0.003$; OR, 5.3 [95% CI, 2.0-14.4]), felt unrefreshed in the morning (56.5%; $P < 0.001$; OR, 5.4 [95% CI,

Table V. Statistical associations between evaluated mandibular deficiency, evaluated incisor overjet, and reported pediatric obstructive sleep apnea symptoms

	Retrusive mandible (23.7%)	*Normal and prognathic mandible (76.3%)*	*OR (95% CI)*	P *value*	*Severe overjet ≥7 mm (18.4%)*	*Overjet <7 mm (81.6%)*	*OR (95% CI)*	P *value*
Poor academic results	12.1%	6.1%	2.1 (1.1-4.0)	0.026	16.1%	6.6%	2.7 (1.4-5.5)	0.008
Morning headache	5.3%	2.1%	2.6 (1.03-6.6)	0.049	6.3%	2.9%	2.3 (0.9-5.8)	0.085
Bruxism	17.5%	8.7%	2.2 (1.3-3.7)	0.003	17.1%	10.8%	1.7 (1.0-3.0)	0.075
Fewer hours of sleep*	9:19:19 h (SD, 0:55:20)	9:01:36 h (SD, 1:01:17)	-	0.001	9:20:53 h (SD, 0:58:27)	9:05:41 h (SD, 0:59:41)	-	0.018

*Total sleep time (hours).

Table VI. Statistical associations between evaluated mandibular deficiency and reported pediatric obstructive sleep apnea symptoms

	Retrusive mandible (23.7%)	*Normal and prognathic mandible (76.3%)*	*OR (95% CI)*	P *value*
Morning headache	6.3%	2.6%	2.5 (1.0-6.1)	0.062
Bruxism	16.9%	10.5%	1.7 (1.0-3.0)	0.054
Clenching teeth	21.1%	14.8%	1.5 (1.0-2.5)	0.090
Fewer hours of sleep*	9:05:03 h (SD, 1:00:37)	9:19:38 h (SD, 0:55:17)	-	0.013

*Total sleep time (hours).

2.3-12.8]), had difficulty awakening in the morning (43.5%; $P = 0.041$; OR, 2.6 [95% CI, 1.1-6.1]), were easily distracted (47.8%; $P = 0.029$; OR, 2.6 [95% CI, 1.1-6.1]), had poor sleep quality (17.4%; $P = 0.009$; OR, 6.1 [95% CI, 1.9-20.0]), and had morning headaches (43.5%; $P < 0.001$; OR, 39.7 [95% CI, 14-109]) compared with other subjects. The reported habit of tooth grinding while awake or asleep was not associated with sleep-disordered breathing symptoms compared with other subjects. A history of thumb or finger sucking was statistically associated with heavy breathing at night (27%; $P = 0.01$; OR, 2 [95% CI, 1.2-3.3]) and waking unrefreshed in the morning (28.4%; $P = 0.043$; OR, 1.7 [95% CI, 1.04-2.7]) compared with other subjects.

Total hours of sleep were also compared with symptoms of pediatric sleep-disordered breathing. The symptoms of difficulty awakening ($P = 0.001$), feeling unrefreshed in the morning ($P < 0.001$), and being sleepy during the day ($P = 0.014$) were all statistically associated with sleeping 15 to 30 minutes less than subjects who did not report these symptoms.

DISCUSSION

One objective of this study was to evaluate the associations of sleep-disordered breathing symptoms with facial and dental morphometry in a general pediatric orthodontic population. This was evaluated on 3 planes: vertical, transverse, and anteroposterior. Increased vertical dimensions, such as dolichofacial morphology and mandibular plane angle, were positively correlated to various sleep-disordered breathing symptoms. This was also seen with a transverse deficiency, such as a narrow palate, decreased maxillary width, and dental crowding. The anteroposterior deficiency, overjet and retrognathia, was not highly associated with many sleep-disordered breathing symptoms, but only with sleep bruxism and morning headaches. Thus, pediatric sleep-disordered breathing symptoms reported by this cohort were primarily associated with observed characteristics related to a long and narrow face. Furthermore, allergies, frequent colds, and habitual mouth breathing were also associated with sleep-disordered breathing, since they are all related to increased nasal resistance, leading to mouth-breathing. These findings further support the findings in the literature of the relationship of these craniofacial morphologic characteristics and sleep-disordered breathing.

Another objective of our study was to evaluate the prevalence of sleep-disordered breathing symptoms in a general pediatric orthodontic population. In our orthodontic clinical setting, the prevalence values of sleep-disordered breathing symptoms were 2.9% to 10.9% for snoring, 1.8% to 5.1% for reported breathing problems during the night, 34% to 36.1% for signs of mouth breathing, 3.3% to 23.6% for reported signs associated

Table VII. Statistical associations between evaluated maxillary and mandibullary dental crowding and reported pediatric obstructive sleep apnea symptoms

	Severe maxillary crowding (16%)	*Nonsevere maxillary crowding (84%)*	*OR (95% CI)*	P *value*	*Severe mandibular crowding (16.1%)*	*Nonsevere mandibular crowding (83.9%)*	*OR (95% CI)*	P *value*
Usually snores	22.7%	8.6%	3.1 (1.8-5.5)	<0.001	21.6%	8.8%	2.9 (1.6-5.1)	0.001
Always snores	8.5%	1.8%	5.0 (1.9-13.3)	0.002	8.5%	1.8%	5.0 (1.9-13.3)	0.002
Snores loudly	14.9%	3.4%	4.9 (2.3-10.3)	<0.001	14.9%	3.4%	4.9 (2.3-10.3)	<0.001
Dry mouth on awakening	51.5%	33.1%	2.1 (1.4-3.3)	0.001	48.5%	33.7%	1.9 (1.2-2.9)	0.008
Unrefreshed in the morning	27.8%	19.2%	1.6 (0.9-2.7)	0.074	27.8%	19.2%	1.6 (1.0-2.7)	0.074
Clenching teeth	8.2%	17.8%	0.4 (0.2-0.9)	0.017	8.2%	17.8%	0.4 (0.2-0.9)	0.017
Fewer hours of sleep*	8:43:45 h (SD, 0:59:19)	9:02:27 h (SD, 1:00:26)	-	0.006	8:48:17 h (SD, 1:01:02)	9:01:35 h (SD, 1:00:20)	-	0.049

*Total sleep time.

Table VIII. Statistical associations between observed mouth breathing by the clinician and reported pediatric obstructive sleep apnea symptoms

	Observed mouth breathing (21.5%)	*Observed mixed and nose breathing (78.6%)*	*OR (95% CI)*	P *value*
Usually snores	18.9%	8.8%	2.4 (1.4-4.2)	0.002
Always snores	5.6%	2.2%	2.7 (1.0-7.1)	0.066
Snores loudly	12.6%	3.3%	4.2 (2.0-8.9)	<0.001
Heavy breathing	30.7%	14.3%	2.7 (1.7-4.2)	<0.001
Trouble breathing	10.2%	3.7%	3.0 (1.4-6.3)	0.006
Day mouth breathing	68.0%	24.9%	6.4 (4.2-9.8)	<0.001
Dry mouth on awakening	53.1%	31.6%	2.5 (1.6-3.6)	<0.001
Unrefreshed in the morning	26.4%	19.2%	1.5 (1.0-2.4)	0.086
Sleepy as reported by teacher	8.6%	1.9%	4.8 (1.9-11.8)	0.001
Does not listen	20.9%	13.4%	1.7 (1.0-2.8)	0.051
Easily distracted	35.7%	24.5%	1.7 (1.1-2.6)	0.014
Fidgets	27.9%	19.8%	1.6 (1.0-2.4)	0.053
Poor sleep quality	7.8%	2.8%	2.9 (1.3-6.9)	0.017
Fewer hours of sleep*	9:17:45 h (SD, 0:56:12)	9:05:45 h (SD, 1:00:36)	-	0.047

*Total sleep time.

with daytime sleepiness, and 7.7% to 26.7% for reported behavioral problems. In addition, the various morphologic characteristics of a long and narrow face, which was associated with sleep-disordered breathing symptoms, were seen in 8.4% to 43.7% of these patients.

Although a large orthodontic population is an ideal setting for screening morphologic features associated with pediatric sleep-disordered breathing, few studies have screened such populations or attempted to correlate sleep-disordered breathing symptoms with craniofacial characteristics. Orthodontists are trained and experienced in evaluating and monitoring abnormal facial growth.[36] Nelson and Kulnis[37] used an orthodontic population as a healthy subject pool (n = 405) to study the prevalence and associations in pediatric snoring and sleep disturbance through sleep behavior questionnaires. Their results showed that the risk factors for snoring were mouth breathing, frequent coughs and colds, and morning headaches. No attempt was made to correlate sleep-disordered breathing symptoms with morphologic patient features. A sleep-disordered breathing study in 4-year-olds, with a 2-year follow-up, evaluated a subset of 100 snoring patients in the cohort for malocclusions.[38,39] These authors found a significantly smaller width of the maxilla and a decreased length of the mandible as measured on dental casts.[38] Ameli et al[40] orthodontically evaluated a cohort of suspected pediatric obstructive sleep apnea patients before adenotonsillectomy; 65% of them had malocclusions.

Because of the recognized impact of pediatric snoring on children's health, the determination of good predictors can help in preventing and managing sleep-disordered breathing. In adults, a recent meta-analysis[41] on clinical screening tests for obstructive sleep apnea found that, because of its reproducibility, the index of Kushida et al[42] (morphometry) was a good predictor and was deemed an excellent test in repeated studies. This index evaluates body mass index, neck circumference, and oral cavity measurements (palatal height, maxillary and mandibular widths, and overjet) in adults.

According to the American Academy of Pediatrics' clinical practice guidelines for sleep-disordered breathing, children should be routinely screened for snoring.[43] Symptomatic children (Table I) should undergo polysomnography for diagnosis. The harmful consequences in leaving sleep-disordered breathing untreated in children can be overall growth failure, restless sleep, and impaired daytime function (cognition, attention, mood, aggressive behavior, hyperactivity).[44,45]

This study relied on parents' or guardians' reports on their children in subjective surveys. Although parent questionnaires have been validated as useful tools to identify pediatric obstructive sleep apnea, other studies have demonstrated parental overreporting of some symptoms compared with our quantitative orthodontic evaluation.[46,47]

Because of its nature, the screening examination was relatively subjective. Cephalometric radiographs, dental casts, and digital photographs could be added to quantitatively evaluate facial proportions and profiles.

The subjects' sleep was not diagnosed by using the gold standard of polysomnography or ambulatory recording because of our large sample size (n = 604), a lack of universal availability, and excessive financial and manpower costs. Ambulatory monitoring could help to remedy this situation in the future.

CONCLUSIONS

Pediatric sleep-disordered breathing symptoms reported in this cohort were primarily associated with morphologic characteristics of a long and narrow face, nasal breathing resistance (allergies, frequent colds), and mouth-breathing. Sleep-disordered breathing symptoms and the associated craniofacial features were often reported in the orthodontic clinical setting. Since this epidemiologic study was conducted in a university orthodontic clinic, the conclusions should be extrapolated with caution, because they apply to a referral population, not a general population. In the last 20 years, dentists have become more involved in certain aspects of obstructive sleep apnea management, using oral appliances or oral surgery.[48] The dentist's role has also become relevant in the early detection of anatomic risk factors or sleep-disordered breathing-related symptoms. All health care providers can evaluate whether a pediatric patient has, or is at risk of developing, symptoms of sleep-disordered breathing by noting factors associated with it reported by parents or patients and performing a thorough clinical examination. However, whereas most orthodontic therapies enlarge the posterior airway, some, such as surgical mandibular setbacks and excessive headgear wear, might have the opposite effect.[49] Thus, if a health professional notices signs and symptoms of sleep-disordered breathing, the young patient should be referred to a sleep medicine specialist in conjunction with an orthodontist if there are dentoskeletal abnormalities.

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