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Article

Sleep Breathing Disorders' Screening Among Children Approaching Orthodontic Evaluation: A Preliminary Study

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Abstract: Background: The orthodontist can play an important role in the early detection of sleep-disordered breathing (SDB), aiding in the prevention of dentoskeletal complications and systemic issues. Early intervention supports proper pediatric development, emphasizing the need for SDB screening in orthodontics. SDB involves abnormal breathing during sleep, with obstructive sleep apnea (OSA) in children presenting unique diagnostic challenges compared to adults. Aim: This study aimed to identify children at risk for SDB through a validated screening questionnaire during orthodontic evaluations. Methods: This prospective study recruited children under 12 years of age between July 2023 and July 2024. The Sleep Clinical Record was used to screen for SDB indicators. Results: Among the 48 participants (31 females, 17 males) aged 5–12 years, 69% were identified as being at risk for SDB. Risk factors included oral breathing, nasal obstruction, tonsillar hypertrophy, malocclusion, high Friedman scores, narrow palates, and positive Brouillette phenotypes, all showing significant correlations ($p < 0.05$). Conclusion: The findings underline the critical importance of early SDB screening in orthodontic settings. These preliminary results encourage further research on larger cohorts to refine diagnostic tools and interventions. Early recognition and management of SDB can significantly enhance systemic health and craniofacial outcomes in pediatric patients.

Keywords: pediatric sleep breathing disorders; pediatric sleep apnea; attention deficit hyperactivity disorder; orthodontics

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1. Introduction

Sleep-disordered breathing (SDB) encompasses a spectrum of conditions characterized by abnormal breathing during sleep, with simple snoring and obstructive sleep apnea (OSA) being the most frequently identified disorders [1]. Obesity is a significant risk factor, as the prevalence of OSA among obese children ranges from 19% to 61% [2–5]. Specifically, for each increase in body mass index (BMI) above the 50th percentile, the risk of OSA rises by 10–12% [6,7]. Adenoid and tonsillar hypertrophy are also recognized risk factors due to the volumetric reduction they cause in the upper airways; accordingly, adenotonsillectomy is the recommended treatment for pediatric OSA [8]. Allergic rhinitis, by inducing nasal mucosal inflammation and congestion, increases airway resistance and contributes to SDB [9]. The most commonly encountered symptoms in children refer to frequent snoring (>3 nights/week), shortness of breath during sleep, snorting, enuresis, sleeping in a sitting position, headache upon awakening, daytime drowsiness, attention-deficit/hyperactivity disorder (ADHD), and learning problems [10]. Additionally, malocclusion and maxillofacial anomalies are associated with pediatric OSA. Transverse maxillary constriction with a high, narrow palatal vault is a significant risk factor, as are changes in jaw or tongue size, position, or geometry, which can further narrow the upper airway and increase obstruction risk [11,12].

Pediatric OSA primarily affects children aged 2 to 8 years, with recent studies reporting a prevalence of 12.8% [13,14]. SDB and OSA are even more prevalent in orthodontic populations, with reported risks ranging from 7% to 47.7% [15–17].

Although overnight polysomnography is the gold standard for diagnosing SDB [18], its cost and time requirements have led to the development of alternative screening tools, such as questionnaires [19]. Dentists, especially orthodontists, play a crucial role in the early detection of OSA by identifying high-risk patients and correcting malocclusions linked to the condition, such as narrow palates or mandibular retrusion [20]. Promoting pediatric OSA screening in dental practice, akin to general oral prophylaxis and education, is a valuable initiative [21–23].

This study hypothesizes that orthodontic evaluation, paired with a validated screening questionnaire, can effectively identify pediatric patients at risk for SDB. By employing the Sleep Clinical Record (SCR) as a rapid and cost-effective tool, this study seeks to establish a link between orthodontic factors and SDB risk, providing insights into the role of orthodontics in early detection and management.

The multifactorial nature of SDB suggests that a multidisciplinary approach is essential for effective diagnosis and intervention. This study aims to bridge the gap between dentistry and sleep medicine by exploring the association between orthodontic variables—such as malocclusion, oral breathing, and tonsillar hypertrophy—and SDB indicators. This preliminary research lays the groundwork for future studies to refine screening tools and interventions, ultimately enhancing pediatric health outcomes.

2. Materials and Methods

This preliminary prospective clinical trial was approved by the Medical Direction Board of the Surgical Sciences Department of the University of Cagliari, Italy, (PG/2021/11308) and executed in accordance with the principles of the Declaration of Helsinki [24]. All patients participated in the trial on a voluntary basis after receiving comprehensive information about the aim and design of the study and signing an informed consent form.

2.1. Study Population

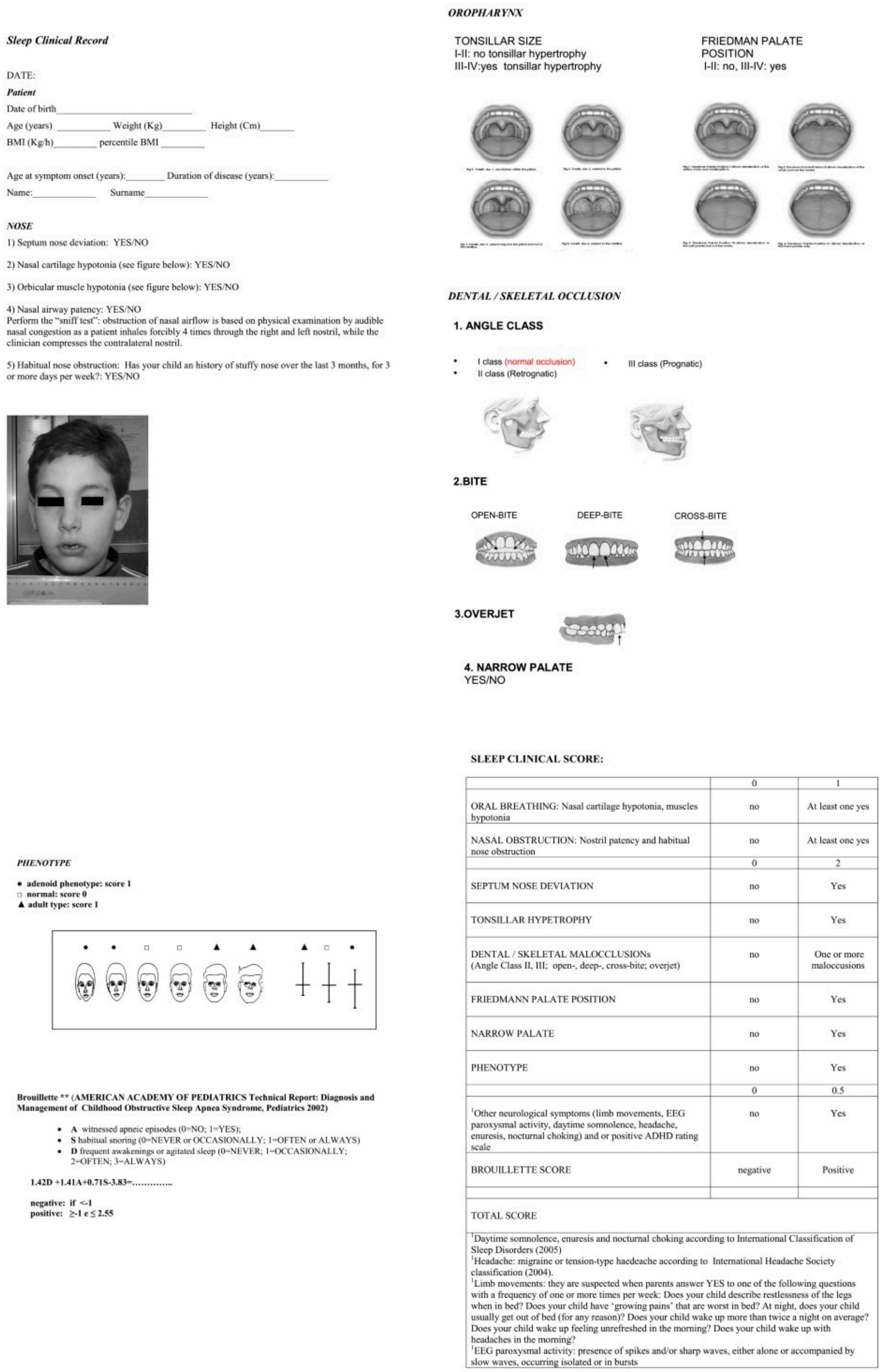
The present study was conducted at the Department of Orthodontics, San Giovanni di Dio Hospital, University of Cagliari. Patient recruitment spanned 12 months, from July 2023 to July 2024. To ensure adequate representation of the pediatric population, a minimum sample size of 30 patients was established. During the study period, 62 patients visited the orthodontic department, of whom 48 met the following inclusion criteria:

- Patients under the age of 12;
- Patients who have never undergone interceptive orthodontic therapy.

2.2. Protocol

Patients who met the inclusion criteria outlined in Section 2.1 underwent a comprehensive evaluation during their orthodontic checkup. This standard visit was conducted to diagnose dento-maxillomandibular anomalies and included a pedodontics evaluation at the Orthodontics Department of the San Giovanni di Dio Hospital. Parents or legal guardians were asked to review and sign an informed consent form prior to the dental visit.

Screening for potential sleep-disordered breathing (SDB), such as simple snoring and/or obstructive sleep apnea (OSA), was performed using a scientifically validated questionnaire, the Sleep Clinical Record (SCR) (Figure 1) [25]. The questionnaire comprises two sections: one completed by the doctor, focusing on dento-maxillofacial features indicative of SDB, and the other filled out by the accompanying parent. All visits were conducted by the same doctor, M.S., to ensure consistency and objectivity.



Sleep Clinical Record

DATE:

Patient

Date of birth____________________

Age (years) __________ Weight (Kg)________ Height (Cm)______

BMI (Kg/h)________ percentile BMI ________

Age at symptom onset (years):_______ Duration of disease (years):__________

Name:____________ Surname____________

NOSE

1) Septum nose deviation: YES/NO

2) Nasal cartilage hypotonia (see figure below): YES/NO

3) Orbicular muscle hypotonia (see figure below): YES/NO

4) Nasal airway patency: YES/NO
Perform the "sniff test": obstruction of nasal airflow is based on physical examination by audible nasal congestion as a patient inhales forcibly 4 times through the right and left nostril, while the clinician compresses the contralateral nostril.

5) Habitual nose obstruction: Has your child an history of stuffy nose over the last 3 months, for 3 or more days per week?: YES/NO

PHENOTYPE

- **adenoid phenotype: score 1**
- **normal: score 0**
- **adult type: score 1**

Brouillette ** (AMERICAN ACADEMY OF PEDIATRICS Technical Report: Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome, Pediatrics 2002)

- **A** witnessed apneic episodes (0=NO; 1=YES);
- **S** habitual snoring (0=NEVER or OCCASIONALLY; 1=OFTEN or ALWAYS)
- **D** frequent awakenings or agitated sleep (0=NEVER; 1=OCCASIONALLY; 2=OFTEN; 3=ALWAYS)

1.42D +1.41A+0.71S-3.83=…………..

negative: if <-1
positive: ≥-1 e ≤ 2.55

OROPHARYNX

TONSILLAR SIZE
I-II: no tonsillar hypertrophy
III-IV:yes tonsillar hypertrophy

FRIEDMAN PALATE POSITION
I-II: no, III-IV: yes

DENTAL / SKELETAL OCCLUSION

1. ANGLE CLASS

- I class (normal occlusion)
- II class (Retrognatic)
- III class (Prognatic)

2.BITE

OPEN-BITE DEEP-BITE CROSS-BITE

3.OVERJET

4. NARROW PALATE
YES/NO

SLEEP CLINICAL SCORE:

	0	1
ORAL BREATHING: Nasal cartilage hypotonia, muscles hypotonia	no	At least one yes
NASAL OBSTRUCTION: Nostril patency and habitual nose obstruction	no	At least one yes
	0	2
SEPTUM NOSE DEVIATION	no	Yes
TONSILLAR HYPETROPHY	no	Yes
DENTAL / SKELETAL MALOCCLUSIONs (Angle Class II, III; open-, deep-, cross-bite; overjet)	no	One or more maloccusions
FRIEDMANN PALATE POSITION	no	Yes
NARROW PALATE	no	Yes
PHENOTYPE	no	Yes
	0	0.5
[1]Other neurological symptoms (limb movements, EEG paroxysmal activity, daytime somnolence, headache, enuresis, nocturnal choking) and or positive ADHD rating scale	no	Yes
BROUILLETTE SCORE	negative	Positive
TOTAL SCORE		

[1]Daytime somnolence, enuresis and nocturnal choking according to International Classification of Sleep Disorders (2005)
[1]Headache: migraine or tension-type haedeache according to International Headache Society classification (2004).
[1]Limb movements: they are suspected when parents answer YES to one of the following questions with a frequency of one or more times per week: Does your child describe restlessness of the legs when in bed? Does your child have 'growing pains' that are worst in bed? At night, does your child usually get out of bed (for any reason)? Does your child wake up more than twice a night on average? Does your child wake up feeling unrefreshed in the morning? Does your child wake up with headaches in the morning?
[1]EEG paroxysmal activity: presence of spikes and/or sharp waves, either alone or accompanied by slow waves, occurring isolated or in bursts

Figure 1. Sleep Clinical Record, the questionnaire used in this preliminary prospective trial. The Sleep Clinical Record consists of three items: physical examination, subjective symptoms, and clinical history.

During the clinical examination, the intra- and inter-arch relationships of the maxillae, facial characteristics (facial phenotype, orbicularis muscle tone, nostril tone, nasal septum deviation, and nasal passage patency), and Mallampati and Friedman scores were assessed [26,27]. The patient's subjective symptoms and clinical history were evaluated using the Brouillette score [28], which consists of concise questions about sleep-related symptoms (mouth breathing, habitual snoring, witnessed apneic episodes, frequent awakenings, or agitated sleep) and daytime symptoms (daytime sleepiness, headaches).

The second section of the questionnaire, completed by the parent, assessed symptoms of inattention and hyperactivity using the Attention Deficit Hyperactivity Disorder (ADHD) Rating Scale (SDAI Scale) [29]. This scale is an integral part of the SCR and is necessary to calculate the final score. Each parameter in the SCR was scored as positive (+) if present or negative (−) if absent. Tonsillar hypertrophy of grade III or IV was scored as positive (+), while grades 0, I, and II were negative (−). Friedman palate positions were classified as positive (+) for classes III and IV, and negative (−) for classes I and II. A Brouillette score of −1 or higher was considered positive (+). The final SCR score was calculated for each patient based on these data.

The completed questionnaires were securely attached to the patients' medical records. This step was deemed crucial for identifying patients who might require further evaluation or treatment in the future. However, this additional phase falls outside the scope of the present study. Data collection and analysis were conducted to ensure complete anonymity for all participants.

Statistical Analysis

Descriptive analysis was used to report the scores of the total responses. The data were organized into a spreadsheet (MS Excel Office 365 MSO). Qualitative variables were presented as counts and percentages, while quantitative variables were expressed as mean ± standard deviation (SD) and range. The significance of the association between the sleep score and potential determinants was evaluated using the Kruskal–Wallis test for qualitative variables and Spearman's rho for the quantitative variable (age).

3. Results

Only 48 children, among the 62 who attended the orthodontic departments over the selected period of study, were included in the final sample. Those who were rejected did not present the whole documentation or had been previously treated. The included subjects were 8.1 years old, with a SD of ±1.6. The age of the patients ranged from a minimum of 5 years to a maximum of 12 years. Nearly two-thirds of the series were females (n = 31), while the males accounted for 35% of the total (n = 17). The demographic data about age and gender are shown in Table 1.

Table 1. The demographic data about age and gender of the recruited patients.

Demographic Data	N	Mean	SD	Min	Max
Age (years)	48	8.0625 year	1.589945 year	5 year	12 year
		Frequency	**Percentage**		
Gender	M	17	35.42%		
	F	31	64.58%		

Demographic data of sampled patients. N = number of patients; Mean = mean age of the sample, SD = standard deviation; Min = minimum value detected; Max = maximum value detected.

Physical examination of the face, nose, and oropharynx yielded the following findings: hypotonia of the orbicularis muscle was present in 58.3% of the sample (28 cases), while hypotonia of the nasal cartilage was observed in 16.67% (8 patients). Nasal obstruction affected 80% of the sample (40 children), and oral breathing was detected in 62.5% (30 patients). Reduced nasal airflow was present in 75% (36 patients), whereas nasal septum deviation was noted in only 6.25% (3 children). Tonsillar hypertrophy was identified in 22.92% (11 children). A narrow palate was observed in 72.92% of the sample (35 patients), and a Friedman palate position of grade III-IV was seen in 68.75% (33 patients). Additionally, an adenoid facial phenotype was present in 22.92% (11 children). These findings are summarized in Table 2.

Table 2. Clinical parameters.

Clinical Parameters		Frequency	Percentage
Orbicularis m. hypotonia	−	20	41.67%
	+	28	58.33%
N. cartilage hypotonia	−	40	83.33%
	+	8	16.67%
Oral breathing	−	18	37.50%
	+	30	62.50%
Reduced nasal airflow	−	12	25.00%
	+	36	75.00%
Habitual nasal obstruction	−	40	83.33%
	+	8	16.67%
Deviated nasal septum	−	45	93.75%
	+	3	6.25%
Narrow palate	−	13	27.08%
	+	35	72.92%
Tonsillary hypertrophy	−	37	41.67%
	+	11	22.92%
Friedman palate position III-IV	−	15	31.25%
	+	33	68.75%
Adenoid phenotype	−	37	77.08%
	+	1	22.92%

The clinical parameters analyzed during the visit. "+" = positivity, the related parameter was present; "−" = negativity, absence of the related parameter.

From the study of the dental arches and their relationship, we detected that nearly all children (94%) were affected by malocclusions. Regarding the angle class malocclusions, 31.25% had a class (I), 56.25% had a class (II), and 12.50% of patients had a class (III). In total, 20.83% of the subjects had normal overjet, while 50.00% had an increased OVJ, and 29.17% had a decreased OVJ. We detected a deep bite in 31.25% of the patients (15 patients), an open bite in 18.75% of the cases (9 patients), and a cross bite in 27.08% of the patients (13 children). The data obtained about dental parameters are summarized in Table 3.

The patients' subjective symptoms and their clinical history showed that the Brouillette score was positive in 22.92% of the patients (11 children). The SDAI score showed that 6.25% of the children were at risk of suffering from ADHD. The data obtained from the clinical history of the patient and from the SDAI Scale are shown in Table 4.

Sleep score ranged from 2 to 14, with a mean value of 7.4, with a SD of ± 2.1. A score of 6.5 or higher was considered positive. In total, 69% of the sample (33 children) showed a positive score, which means that the proportion of respiratory sleep disorders was extremely high. The final scores of the SCR are shown in Table 5.

Table 3. Dental occlusion parameters.

Dental Parameters		Frequency	Percentage
Overbite	Normal	11	22.92%
	Deep	15	31.25%
	Open	9	18.75%
	Cross	13	27.08%
Angle Class Malocclusion	1	15	31.25%
	2	27	56.25%
	3	6	12.50%
Overjet	Normal	10	20.83%
	Increased	24	50.00%
	Reduced	14	29.17%

Table 4. The parameters found by the clinical history of the patients.

		Frequency	Percentage
Score SDAI	−	45	93.75%
	+	3	6.25%
Brouillette score ≥ -1	−	37	77.08%
	+	11	22.92%

Table 5. Final SCR score.

Score SCR	Frequency	Percentual
2	1	2.08%
3	2	4.17%
5	5	10.42%
6	7	14.58%
6.5	1	2.08%
7	7	14.58%
7.5	1	2.08%
8 *	11 *	22.92% *
8.5	3	6.25%
9	4	8.33%
9.5	1	2.08%
10	1	2.08%
10.5	2	4.17%
11	1	2.08%
14	1	2.08%
Total	48	100.00

The SCR score and the related frequency and percentage of the total. The "*" indicates the most represented SCR.

According to the Kruskal–Wallis equality-of-populations rank test, the sleep score was significantly increased (p value < 0.05) in children with oral breathing, habitual nasal obstruction, tonsillar hypertrophy, malocclusion, positive Friedman score, narrow palate, presence of adenoid phenotype, and positive Brouillette score. If considered single and separated, none of the malocclusions emerged as statistically significant. On the other hand, sleep respiratory disorders were not affected by either gender or age, or by either class angle, overbite, or overjet. The statistical results from the Kruskal–Wallis equality-of-populations rank test are shown in Figure 2 and summarized in Table 6.

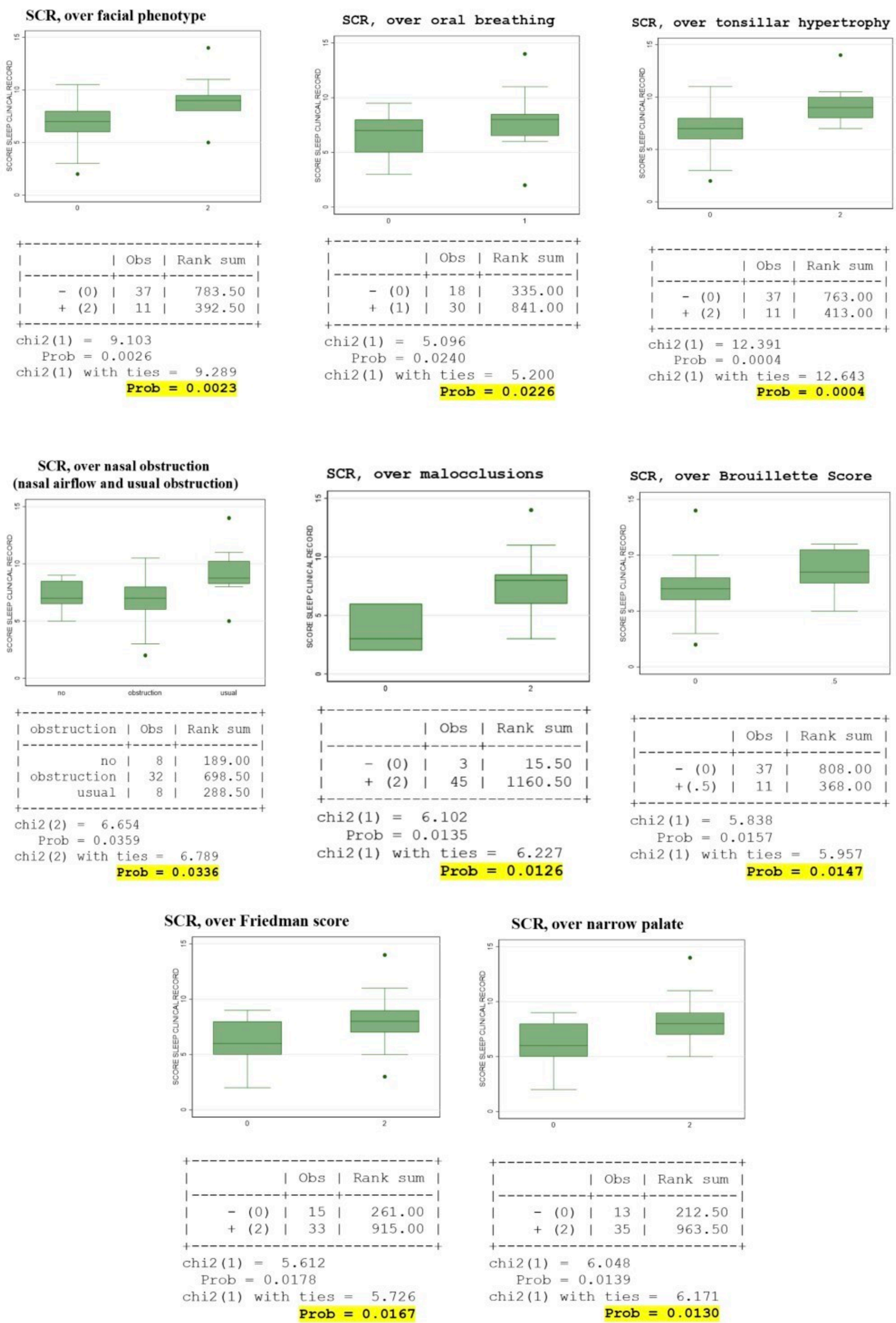


Figure 2. Kruskal–Wallis equality-of-populations rank test. Oral breathing, usual nasal obstruction, tonsillar hypertrophy, malocclusion, Friedman score, narrow palate, facial phenotype, and positive Brouillette score are statistically significant.

Table 6. The results of the Kruskal–Wallis equality-of-populations rank test.

SCR, Over	*p*-Value
Oral breathing	$p = 0.0226$ *
Habitual nasal obstruction	$p = 0.0336$ *
Tonsillar hypertrophy	$p = 0.0004$ *
Malocclusions	$p = 0.0126$ *
Narrow palate	$p = 0.0130$ *
Friedman score	$p = 0.0167$ *
Facial phenotype	$p = 0.0023$ *
Brouillette score	$p = 0.0147$ *

The *p*-value (*p*) of each SCR over the parameters calculated using the Kruskal–Wallis equality-of-populations rank test. The *p*-value (*p*) lower than 0.05 is marked by "*".

4. Discussion

The study data on the suspicion of sleep-disordered breathing (SDB) in children attending the orthodontic department for interceptive therapy were collected to identify patients at risk of suffering from SDB. The gold standard for diagnosing SDB is overnight polysomnography. However, due to its time-consuming and expensive nature, several alternative screening tools, such as questionnaires, have been proposed as more cost-effective and efficient options [19]. The Pediatric Sleep Questionnaire (PSQ), developed by Chervin et al. in 2000 [30], is the most widely used, with a sensitivity of 0.85 and specificity of 0.87 (cutoff 0.33) for identifying SDB in otherwise healthy children aged 2–18 years, as confirmed by polysomnography. The STOP-Bang questionnaire is commonly used in adults to predict obstructive sleep apnea syndrome (OSAS) risk and the need for polysomnography (PSG), with a modified version for adolescents (teen STOP-Bang) [31]. In our study, we used the more recent Sleep Clinical Record (SCR) developed by Villa et al. in 2013 [25], which has a sensitivity of 96.05% and specificity of 67%. The SCR takes 30–60 min to complete and, unlike other questionnaires, combines clinical history with physical examination findings.

The prevalence of sleep disorders in children aged 0–17 years is 2.36%, with OSA being the most common SDB in 1.17% of cases [32]. This prevalence is higher in studies from the past decade, where it ranges from 12.8% to 20.4% [14]. OSA primarily affects children aged 2 to 8 years, with a prevalence ranging from 1% to 6% [12]. However, diagnosing SDB in children remains challenging, similar to pediatric bruxism, with which there is a strong association [33]. Several risk factors are recognized as predisposing children to SDB [34], with specific anatomical conditions, such as reduced posterior airway space, playing a role in the development of OSA. It has recently been demonstrated that promoting healthier upper airway growth from birth, such as through breastfeeding, reduces the risk of developing SDB [35]. Other studies have shown significant reductions in mandibular body length, skull base, and oropharyngeal width in children with OSAS, along with changes in facial morphology, such as increased anterior facial height and reduced posterior facial height [33]. A convex facial profile due to retrognathism of the maxilla and mandible also predisposes children to SDB, a trait that can persist into adulthood in individuals with OSAS [35].

In our study, we analyzed a sample of 48 patients (17 males, 31 females) with an average age of 8 years. The main finding of our study is that nearly 70% of children undergoing orthodontic evaluations are at risk for SDB. We found a much higher prevalence of SDB in our selective sample compared to the general pediatric population, where the prevalence is about 10% [36]. Our results are notably higher than those reported by other authors, who found that approximately 7% of children seeking orthodontic evaluation were at risk for SDB [15]. However, their study enrolled older patients, predominantly adolescents, which makes direct comparison challenging. In a study of 668 pediatric patients, the PSQ was administered to assess the prevalence of SDB during the first dental visit, with 10% of children identified as at risk for SDB [37]. Another study involving 602 pediatric patients found that 12.6% of the sample was at risk for sleep-related breathing disorders [38].

In this preliminary study, we observed that the SCR score was significantly higher ($p < 0.05$) in children with oral breathing, habitual nasal obstruction, tonsillar hypertrophy, malocclusion, high Friedman score, narrow palate, adenoid phenotype, or a positive Brouillette score. It is important to emphasize that a thorough analysis of children's oral health is essential, as it enables the early detection of potential problems. A study by Paduano et al. [39] focusing on the oral health of children with an average age of 10 years found a high prevalence of oral diseases: 41.6% had active dental caries in permanent teeth, and 54.8% had periodontal disease. Regarding tonsillar hypertrophy, we observed a rate of 22.92%, slightly lower than in other studies, where the prevalence was over 30% [40]. While the prevalence of adenoid facies is not often reported, our findings align with those of Purwanegara et al. [41]. In contrast, we observed class II malocclusions in more than half of our sample, which is higher than the 4.4–44.7% range reported in a recent scoping review [42]. However, no individual malocclusion was statistically significant in our study. We also found that sleep respiratory disorders were not significantly affected by gender or age, and the ADHD Rating Scale did not show statistically significant results.

There is ample scientific evidence supporting the correlation between malocclusions and SDB in children, indicating the importance of early intervention when either disorder is present. Studies have shown that early orthodontic treatments, such as rapid palatal expansion (RPE) or mandibular advancement with functional appliances, can be effective in managing pediatric OSAS [43–46]. Correcting structural imbalances in craniofacial morphology during growth may reduce snoring and OSA in children and adolescents. Orthodontists should play a key role in managing SDB, not only by treating dental malocclusions associated with these disorders but also by screening and identifying at-risk patients. The use of a questionnaire, such as the SCR used in our study, can be an efficient, quick, and cost-effective tool for screening the pediatric population attending orthodontic clinics regularly.

4.1. Future Perspectives

Future investigations should aim to confirm these results in larger and more varied pediatric cohorts. Furthermore, extended-term studies are essential to examine the prolonged effects of the early identification and treatment of SDB on craniofacial growth, overall health, and well-being. Cutting-edge diagnostic technologies, such as three-dimensional imaging and AI-driven tools, could improve the accuracy of SDB assessment in orthodontic practices. These innovations would further embed orthodontics within multidisciplinary frameworks for addressing pediatric SDB.

4.2. Limitations

The limitations of the present preliminary study are as follows:

- the small size of the sample examined;
- comorbidity with other related conditions has not been evaluated;
- despite its sensitivity, SCR cannot replace PSG for a correct diagnosis.

5. Conclusions

The current study highlights the critical importance of early screening for SDB in children attending orthodontic departments. A notably high percentage of children undergoing orthodontic evaluations exhibited multiple morphological and functional characteristics strongly associated with an increased risk of SDB. These preliminary findings provide a solid basis for encouraging further research with larger and more representative sample sizes.

Author Contributions: Conceptualization, M.S. and E.S.; methodology, M.S.; validation, E.S.; formal analysis, F.S. and A.V. (Alessio Verdecchia); investigation, M.S.; data curation, M.L. and M.S.; writing—original draft preparation, M.S. and A.V. (Alberto Verlato); writing—review and editing, M.S.; supervision, E.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The current study has been developed in agreement with the good clinical practice guidelines provided by the Declaration of Helsinki [17] and has been approved by the Medical Direction Board of the Surgical Sciences Department of the University of Cagliari (PG/2021/11308) on 06-02-2021.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are unavailable due to the privacy of the patients.

Conflicts of Interest: The authors declare no conflicts of interest.

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