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Original Article

Assessment of Changes in Behavior and Quality of Life after Monobloc Treatment in Children with Obstructive Sleep Apnea or Primary Snoring

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Main Points

- All sleep-disordered breathing problems have harmful behavioral and neurocognitive effects on children and lower their quality of life.
- The use of a monobloc appliance in children with primary snoring and obstructive sleep apnea reduced the symptoms of sleep-breathing disorders and improved their quality of life.

ABSTRACT

Objective: The aim of this study was to examine the quality of life and behavioral disorders in children with obstructive sleep apnea (OSA) or primary snoring, as well as how these problems changed after monobloc treatment.

Methods: Fourteen children with primary snoring and 16 children with OSA who had skeletal class II malocclusion due to mandibular retrognathia were treated with monobloc appliances. To investigate the relationship between behavioral disorders and quality of life, parents were asked to complete four questionnaires: attention deficit and hyperactivity disorder (ADHD) scale, strength and difficulties questionnaire (SDQ), pediatric sleep questionnaire (PSQ), and Pittsburgh sleep quality scale (PSQS). Mann-Whitney U and Wilcoxon signed-rank tests were used to evaluate the data.

Results: According to the results of the PSQ and PSQS, an increase in sleep quality was observed after monobloc treatment. The decrease in the total ADHD score at the end of the treatment was found to be statistically significant in both the OSA ($p<0.01$) and snoring ($p<0.01$) groups. According to the SDQ scores, the increase in the social behavior score and the decrease in the peer bullying score in the snoring group were statistically significant ($p<0.05$).

Conclusion: The use of a monobloc appliance in pediatric patients exhibiting primary snoring and OSA resulted in a notable reduction in sleep-breathing disorder symptoms and a notable enhancement in their overall quality of life. Based on the analyses of the questionnaires, it was concluded that the increase in sleep quality improved the pediatric patients' quality of life after orthodontic treatment with orthodontic monobloc appliances.

Keywords: Pediatric OSA, questionnaire, monobloc, polysomnography, quality of life

INTRODUCTION

The sleep-disordered respiratory spectrum includes primary snoring, upper airway resistance syndrome, obstructive hypoventilation, and obstructive apnea. Obstructive sleep apnea (OSA) is considered the most serious form on the spectrum.[1] Worldwide, 9-38% of the adult population and 2-5% of the pediatric population suffer from OSA.[2]

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Untreated OSA in children can lead to enuresis, abnormal growth, learning disabilities, behavioral problems, cardiovascular complications, and even death.[3,4] In addition to nighttime symptoms such as snoring, sleeping in abnormal postures, night sweats, and bedwetting, children with OSA may also exhibit daytime symptoms like aggression, hyperactivity, attention deficit, learning difficulties, a morning headache, and anxiety.[5,6] Snoring, the mildest form of sleep disorder, is no longer considered harmless. Numerous investigations have demonstrated a correlation between snoring and behavioral daytime and nighttime symptoms.[1,7,8] All sleep-disordered breathing problems, including primary snoring, have harmful behavioral and neurocognitive effects on children and lower their quality of life.[7,9] Several questionnaires, such as the Strength and Difficulties Questionnaire (SDQ) and the Attention Deficit and Hyperactivity Disorder (ADHD) scale, are also used to measure the changes in behavior and brain function caused by treating sleep disorders, as well as the changes in sleep quality that affect the quality of life.[10,11]

Presently, polysomnography (PSG) is the gold standard diagnostic tool for identifying OSA in pediatric patients.[12] PSG is the recording of neurophysiological, respiratory, cardiovascular, and other physical and physiological data during sleep in a sleep laboratory, usually for the whole night, at specific times, simultaneously, and continuously. With PSG, in addition to sleep stages, several physiological characteristics, organ functioning, and interactions throughout sleep and wakefulness can be analyzed in detail.[13] Despite its effectiveness, PSG has a variety of disadvantages that restrict its overall utility. PSG has limited efficacy for diagnosing pediatric OSA due to its high cost, inconvenient nature, and lack of availability in underprivileged locations.[12] These constraints have prompted clinicians to use affordable and accessible diagnostic questionnaires an aid to PSG.[12,14]

The primary cause of sleep disorders is a narrowed upper airway. Several procedures, such as adenoidectomy and tonsillectomy, continuous positive airway pressure, rapid maxillary expansion (RPE), mandibular distraction or advancement, anti-inflammatory therapy, and weight loss, are used individually or in combination as treatments for sleep disorders. Several studies have demonstrated that RPE and monobloc appliances, two orthodontic treatment methods, are effective for treating sleep-disordered breathing in children.[15-17] The aim of this study was to examine the effects of orthodontic treatment with a monobloc appliance on the quality of life and behavioral disorders in children diagnosed with OSA or primary snoring with skeletal class II malocclusion due to mandibular retrognathia.

METHODS

This research was conducted in compliance with the Declaration of Helsinki, and the protocol was authorized by the İstanbul University, İstanbul Faculty of Medicine Clinical Research Ethics Committee, İstanbul, Turkey (approval no.: 2012/516-1010, date: March 09, 2012). All patients and their parents provided written consent to participate.

Patient Selection and Profile Determination

The anamnesis form for children with OSA may include questions related to the symptoms and risk factors associated with OSA. The pediatric sleep questionnaire (PSQ) is a commonly used tool to identify children at increased risk of OSA. It assesses symptoms such as snoring, observed apnea, daytime sleepiness, and inattentiveness.[18] Other relevant questions may include inquiries about the presence of craniofacial disorders, cerebral palsy, epilepsy, and other developmental disabilities, as these conditions are associated with a higher risk of OSA in children.[18,19] In addition, questions about the severity of OSA, such as the frequency and duration of apnea events during sleep, may be included.[20] The anamnesis form should also consider the potential impact of OSA on cardiovascular, neurocognitive, and metabolic systems. The anamnesis form gathers information that helps in the identification, assessment, and management of OSA in children.[21] The anamnesis form used in the present study was developed with consideration for this information. In addition to the questions presented in the anamnesis form, an assessment of risk factors for sleep and breathing disorders was conducted. The parents' snoring, smoking, asthma, hay fever, bruxism, and mouth or nose breathing were evaluated.

A cohort of 50 individuals, ranging in age from 8 to 14 years, who needed treatment at the department of orthodontics and presented with complaints of snoring, were subsequently directed to the sleep laboratory. Thirteen patients were excluded from the study following a polysomnographic examination because of the absence of a diagnosis of OSA or primary snoring. Four participants were excluded from the study due to having body mass index (BMI) measurements exceeding 85%. Cephalometric radiographs were assessed, and three patients who did not exhibit skeletal Class II anomalies (ANB<4°) were excluded from the study. Finally, 16 patients (mean age 11.25±1.23), 9 girls and 7 boys, with an apnea-hypopnea index (AHI) of 1 or greater constituted the OSA group, and 14 patients (mean age 10.97±1.51), 4 girls and 10 boys, with an AHI less than 1 constituted the primary snoring group.

BMI is a metric used to assess obesity on a personal level, considering an individual's height (kg/m^2). The BMI is classified as exceeding 19 within the age range of 1-2, exceeding 18 within the age range of 2-6, exceeding 21 within the age range of 6-10, and exceeding 26, indicating probable obesity within the age range of 10-18. The assessment of BMI in children can be conducted using BMI percentile curves that have been developed based on age and gender. Based on the provided information, children whose BMI falls within the range of >85% are categorized as overweight, while those whose BMI falls within the range of >90% are classified as obese. Obesity has been identified as a significant risk factor for the development

of OSA. An increase of 1 kg/m^2 in BMI is associated with a 12% increase in the likelihood of developing OSA.[22]

Brodsky, Friedman, and adenoid scoring were performed by examining all the cases to be included in the study in the otolaryngology department. In the physical examination, the presence and degree of tonsillar hypertrophy were determined between grades I and IV using the Brodsky classification. According to the Friedman Tongue Position Scoring System, the patient's mouth was opened without protruding his tongue, and the tongue, soft palate, uvula, and tonsils were evaluated. According to the appearance of the soft palate, the patient was given a score of 1-4.

The assessment of adenoid size was performed using nasal endoscopy, with scores ranging from 0 to 4 based on the degree of adenoidal obstruction in the airway. The scoring system assigns a value of 0 when there is no obstruction of the airway, a value of 1 when the closure is less than 25%, a value of 2 when the closure falls within the range of 25-50%, a value of 3 when the closure falls within the range of 50-75%, and a value of 4 when the closure exceeds 75%.

These scorings were evaluated alongside the clinical examination, and the patients who required tonsillectomy and/or adenoidectomy were identified. Adenotonsillectomy was performed on a patient with OSA, which was deemed necessary. The patient, who was re-evaluated 8 weeks after the operation, was found to have an AHI below 1 according to PSG, but habitual snoring continued. Therefore, she was included in the study in the primary snoring group.

The inclusion criteria were as follows:

• Patients who presented to the orthodontic department with complaints of snoring,

• Patients with skeletal Cl II anomalies due to mandibular retrognathia (SNB<78°, ANB>4°),

• Patients with primary snoring or OSA confirmed by PSG,

• Patients with no systemic diseases,

The exclusion criteria were as follows:

• Patients with congenital or dental abnormalities (e.g., cleft lip & palate),

• Patients with systemic disorders (e.g., chronic cardiorespiratory or neuromuscular disease, chromosomal syndrome),

• Overweight patients (BMI>85%).

Treatment Procedure

Lateral cephalometric radiographs were obtained using a digital X-ray device (Sirona Orthophos XG Plus DS/Ceph, Bensheim, Germany) and were analyzed with NemoCeph Software (Nemotec, NemoCeph Software, Madrid, Spain). Although upper airway surgeries are the primary treatment method and option for OSA, the efficacy exhibits considerable variability, and their impact on loop gain may vary depending on the initial severity of OSA. Therefore, orthodontic treatment was prompted by a comprehensive assessment of the patients' scores and their specific orthodontic treatment requirements.

The design and construction of a monobloc appliance may vary depending on the individual patient's needs and the orthodontist's treatment plan. In the present study, all the appliances were custom-made using dental impressions and acrylic material, which is biocompatible and safe for intraoral use, by the same orthodontic technician. During the occlusion recording process for the monobloc appliance, participants were instructed to advance their mandible forward until the overjet reached an approximate measurement of 2 mm through the vertical opening and, subsequently, to gradually bite into the recording wax by increasing 3-4 mm vertically on the freeway space. Efforts were made to establish a Class I relationship between the canines and molars in the sagittal plane and to achieve proper alignment of the upper and lower dental midlines to prevent midline discrepancy.

In cases where a lateral crossbite occurs upon the advancement of the mandible, the necessary degree of expansion is achieved through the use of an expansion screw. Therefore, a transversal Hyrax expansion screw (Leone Orthodontics, Firenze, Italy) was added to the monobloc appliance. The patients were instructed to turn the screw twice a week by applying the slow expansion protocol (0.25 mm per turn). The participants were instructed to wear the appliance for a minimum of 17 hours per day. To correct the high angle and dolichocephalic structure determined by clinical examination and cephalometric analysis, the patients were given an occipital headgear for nighttime use only with a monobloc appliance (Figure 1). The mean duration of treatment was 7.86±1.17 months for the primary snoring group and 8.06±1.29 months for the OSA group.

For all patients, PSG records, anamnesis forms, orthodontic materials, otolaryngological examinations, and scoring adenoids and tonsils with the Brodsky and Friedman scales, and BMI measurements were performed. Their parents were asked to fill out four questionnaires that assessed children's sleep quality and behaviors. After dental Class I relationships were established in all patients, questionnaires and PSG records were repeated (Figure 2).

Polysomnographic Assessment

This study included performing PSG studies in the sleep laboratory of İstanbul University, İstanbul Faculty of Medicine, Department of Chest Diseases, under the guidance of a skilled sleep specialist. The PSG studies were conducted during the patients' natural sleep. The participants were transported to the designated room 90 minutes before their habitual sleep period, affording them an opportunity to acclimate to their surroundings. Following the provision of information to the patient and their parents regarding the procedure and the subsequent connection of electrodes, electrode bonding was initiated.

The ALICE 5 (Pennsylvania, US) device was used to perform PSG. PSG used two-channel EEG (C3-A2, O1-A2, Electroencephalogram), a two-channel electrooculogram, a two-channel submental electromyogram (EMG), an oronasal flow meter, a finger pulse oximeter, a tracheal microphone, a body condition detector, a two-channel thoraco-abdominal motion belt, two-channel tibial EMGs, and one electrocardiogram. The device collects data on brain activity, eye movements, muscle tone, respiratory patterns, and other relevant parameters. The American Academy of Sleep Medicine's updated guideline was used to define diagnostic criteria and staging for sleep disorders in children. According to this:

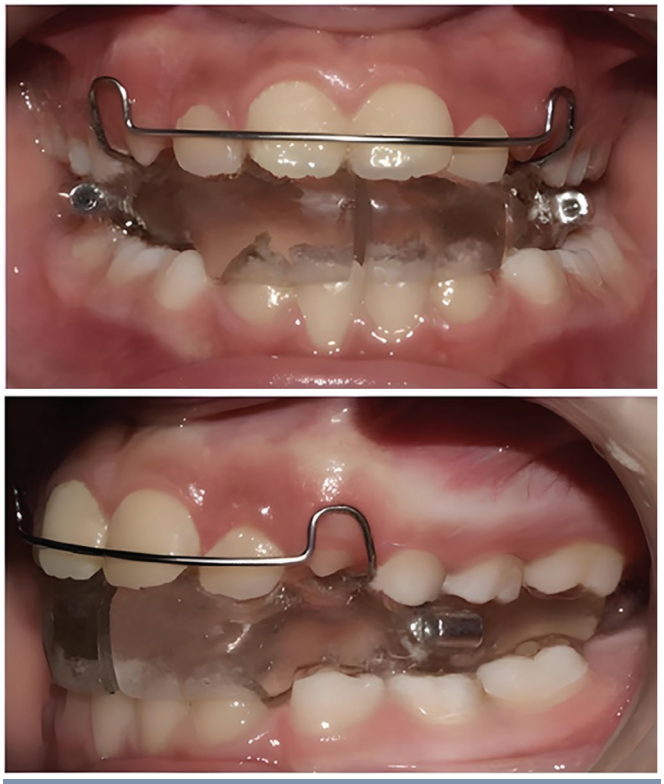

Figure 1. The monobloc appliance used in the orthodontic treatment

Obstructive apnea: A 90% or greater reduction in airflow or signal detected by an oro-nasal thermistor, non-invasive ventilation device, and other types of sensors while continuing respiratory effort as determined by chest and abdominal movements during at least two respiratory cycles.

Central apnea: The presence of one of the three criteria listed below in a patient with a decrease of more than 90% in airflow determined by sensors and no respiratory effort detected.

1. The occurrence lasted at least 20 s.

2. Persistent for at least two respiratory cycles and accompanied by awakening or ≥3% oxygen desaturation.

3. Continuation of at least two respiratory cycles in children younger than one year of age, heart rate below 50 beats/min for more than five seconds, and heart rate below 60 beats/min for more than 15 seconds.

Hypopnea: A decrease in airflow of at least 30%, persisting for at least two respiratory cycles, and accompanied by awakening or ≥3% oxygen desaturation.

Hypoventilation: The pCO_2 level, measured by arterial or other methods, is above 50 mmHg, which is more than 25% of the total sleep time.

Awakening associated with respiratory effort: Situations where increased respiratory effort during at least two respiratory cycles, flattening of the inspiratory part on nasal pressure measurement or non-invasive ventilation device, snoring, pCO_2 elevation, or awakening is observed, but the event does not meet the criteria for apnea and hypopnea.[2]

A calculation was performed to determine the index of obstructive events, specifically obstructive apnea and

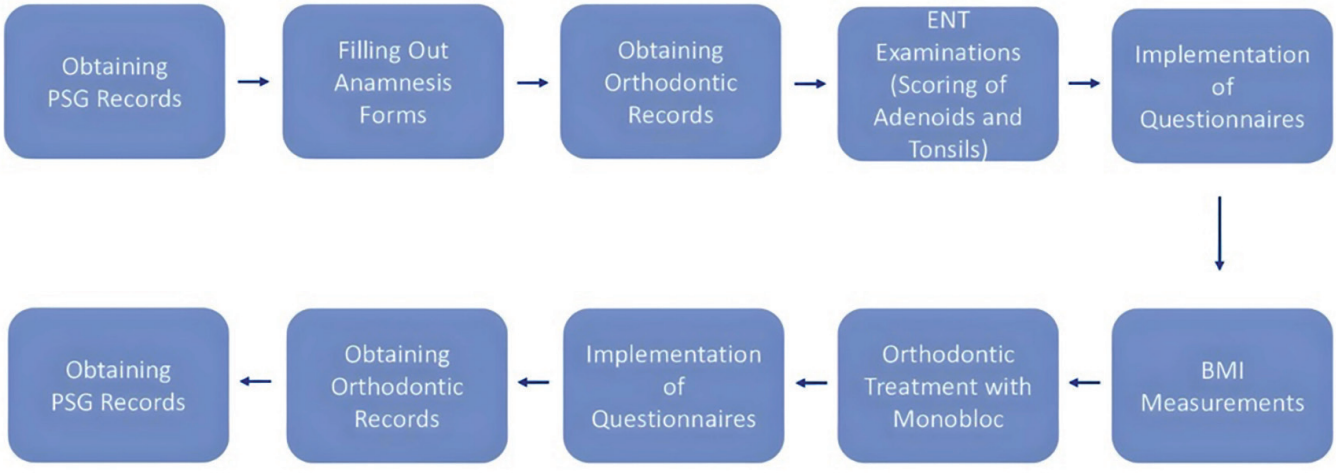

Figure 2. Flow-chart of the study
PSG, polysomnography; BMI, body mass index; ENT,

obstructive hypopnea, per hour. A positive PSG result was obtained when the AHI exceeded one per hour, leading to a diagnosis of sleep-disordered breathing. Mixed apneas were classified and recorded as obstructive. The evaluation excluded records with a duration of 5 hours.

Administration of Surveys

The 0-3 ADHD scale score is determined by evaluating the child's focus on schoolwork and activities, movements in their social environment, and the frequency and manner of speaking with other people. The SDQ is a descriptive tool that evaluates a child's social behavior, attention deficit and hyperactivity, emotional and behavioral problems, and exposure to peer bullying. The PSQ is a diagnostic and follow-up instrument used to detect the child's breathing difficulty, frequency of snoring, mouth breathing during sleep, growth stagnation, and daytime social environment distraction. The Pittsburgh Sleep Quality Scale (PSQS) evaluates a person's sleep pattern over the past month by asking, "What time did you go to bed?", "How long have you been sleeping?", "When did you awaken in the morning?", "Did you wake up during sleep?", "Have you had trouble breathing?".

Statistical Analysis

The IBM SPSS Statistics 22 program was used for statistical analysis. To determine the sample size, a power analysis was performed assuming 80% power and α=0.05 using a two-tailed t-test. While evaluating the study data, in addition to descriptive statistics (mean, standard deviation), one-way analysis of variance was used for intergroup comparisons of normally distributed parameters. The Mann-Whitney U test was used to compare parameters between two groups, and the paired sample t-test was used for within-group comparisons of normally distributed parameters. The Wilcoxon test was used to compare non-normally distributed parameters within groups. The significance level was set at $p<0.05$. The chi-square test was used for comparison of qualitative data, and Cronbach's alpha coefficient was used to determine the reliability of the surveys.

RESULTS

The evaluation of the qualitative and quantitative characteristics of the groups revealed the following findings: The mean treatment duration for the OSA group was 8.06±1.29 months, while for the primary snoring group, it was 7.86±1.17 months, with a p-value of 0.752. The mean age at T1 was 11.25±1.23 years for the OSA group and 10.97±1.51 years for the primary snoring group, resulting in a p-value of 0.587. At T2, the mean age for the OSA group was 11.64±1.49 years, compared to 11.91±1.20 years for the primary snoring group, with a p-value of 0.629. Regarding gender distribution, 43.80% of the OSA group were male, and 56.20% were female, whereas in the primary snoring group, 71.40% were male, and 28.60% were female. The gender distribution analysis yielded a p-value of 0.135, based on the chi-square distribution. There was no statistically significant difference between the groups in terms of treatment duration, age at T1 and T2, and gender ($p>0.05$).

When the hand-wrist developmental periods of the patients included in the study were examined, it was observed that 6 children in the OSA group were in the PP2, 5 children in the MP3=period, and 5 children in the MP3cap period. In the snoring group, 6 children were in the PP2 period, 5 children in the MP3=period, 2 children in the MP3cap period, and 1 child in the DP3u period (Table 1).

The prevalence of the risk factors for sleep breathing disorders is presented in Table 1. The prevalence of snoring among mothers in the OSA group was 43.75%, whereas fathers exhibited a snoring prevalence of 62.5%. In addition, 31.25% of

Table 1. Hand-wrist development periods of the patients at T1 and prevalence of the risk factors for sleep breathing disorders

	OSA (n=16)			Primary snoring (n=14)		
	Female		Male	Female	Male	
PP2=	2		4	0	6	
MP3=	4		1	0	5	
MP3cap	3		2	2	0	
DP3u	0		0	1	0	
Mother's snoring	43.75%			35.71%		
Father's snoring	62.50%			71.42%		
Mother's smoking	31.25 %			21.42%		
Father's smoking	62.50%			50%		
Smoking individuals except parents	12.50%			0%		
Asthma	0%			0%		
Hay fever	0%			0%		
Bruxism	68.75%			35.71%		
Respiration	Nose	Mouth	Both	Nose	Mouth	Both
	0%	12.5%	87.5%	0%	14.28%	85.72%

OSA, obstructive sleep apnea

the mothers and whereas 62.5% of the fathers were smokers, and 12.5% of the parents smoked within their household. Neither asthma nor hay fever was present in any child. The prevalence of bruxism among children was 68.75%, with 12.5% of the children exclusively relying on mouth breathing, and the remaining 87.5% engaged in both nasal and mouth respiration.

In the snoring group, the prevalence of snoring was observed to be 35.71% in mothers and 71.42% in fathers. Snoring was reported to be present in 21.42% of mothers and 50% of fathers. Neither asthma nor hay fever was present in any child. The prevalence rate of bruxism was 35.71% in children. According to the data, 14.28% of the children exclusively engaged in mouth breathing, whereas the remaining 85.72% engaged in both nasal and mouth breathing.

The evaluation of the PSG findings is presented in Table 2. The decrease in stage 1 at the end of the treatment was found to be statistically significant during the T1-T2 period (p=0.034, p<0.05). A statistically significant decrease in the AHI was observed (p=0.020, p<0.05). The ADHD scale reliability analysis is presented in Table 3, and the evaluation of scores is presented in Table 4. The mean attention deficit scores of the snoring group at the beginning (T1) and at the end of the treatment (T2) were significantly higher than those of the OSA group (p_1=0.030; p_2=0.007; p<0.05; p<0.01). Furthermore, the decrease in attention deficit score at the end of the treatment was found to be statistically significant in both the OSA (p=0.002, p<0.01) and snoring (p=0.001, p<0.01) groups. The decrease in the hyperactivity score at the end of the treatment was found to be statistically significant in both the OSA (p=0.008, p<0.01) and snoring (p=0.011, p<0.05) groups. However, the decrease in the impulsivity score at the end of the treatment was found to be statistically significant only in the OSA group (p=0.004, p<0.01).

The mean total ADHD score at the end of the treatment (T2) for the snoring group was found to be significantly higher than that for the OSA group (p_2=0.035; p<0.05). The decrease in the total ADHD score at the end of the treatment was found to be statistically significant in both the OSA (p=0.001, p<0.01) and snoring (p=0.004, p<0.01) groups.

The Strengths and Difficulties Score's reliability analysis is presented in Table 3, and the evaluation of scores is presented in Table 5. In the intragroup evaluations, the increase in the social behavior score (p=0.027, p<0.05) and the decrease in the peer bullying score (p=0.042, p<0.05) in the snoring group were statistically significant.

Evaluations of the PSQ score's reliability analysis are presented in Table 3. The evaluation of the PSQ scores and PSQS scores are presented in Table 6.

The decrease in the snoring, sleepiness, behavior problems, and total score at the end of the treatment was statistically significant in the OSA (p=0.001, p=0.042, p=0.050, p=0.001 respectively) and snoring groups (p=0.001, p=0.024, p=0.032, p=0.001, respectively) within the groups.

A statistically significant decrease was observed in the PSQS score at the end of the treatment in the OSA (p=0.005, p<0.01) and snoring groups (p=0.006, p<0.01).

DISCUSSION

Inadequate sleep quality negatively affects emotional stability, cognitive performance, and physical growth. PSG is the gold standard for diagnosing OSA; however, due to the lack of sleep laboratories, other assessment tools are necessary. Questionnaire applications are one of the most prevalent approaches for assessing sleep and breathing disorders.[12]

In reliability calculations, a value between 0.00 and 0.25 represents little or no reliability, between 0.025 and 0.50 represents acceptable reliability, between 0.50 and 0.75

Table 2. Evaluation of the PSG findings

PSG	T1	T2	
	Mean±SD	Mean±SD	p-value
Stage 1 (%)	0.71±0.46	0.44±0.41	**0.034***
Stage 2 (%)	60.63±14.60	56.05±15.10	0.435
Stage 3-4 (%)	33.45±15.24	34.04±16.25	0.925
REM (%)	5.21±4.87	5.09±3.88	0.912
AHI	3.03±3.77	0.54±0.46	**0.020***
Mean saturation (%)	97.44±0.89	97.50±0.89	0.751
Minimum saturation (%)	85.88±16.37	91.56±3.35	0.142
Sleep activity (%)	85.7±8.37	88.8±8.4	0.133
Arousal index	10.8±7.16	13.34±5.49	0.386
ODI	2.26±1.58	1.38±0.89	0.116

[1]Paired samples t-test, *p<0.05
T1, beginning of the treatment; T2, end of the treatment; PSG, polysomnography; SD, standard deviation; REM, rapid eye movement; ODI, oxygen desaturation index; AHI, apnea-hypopnea index

Table 3. Attention deficit and hyperactivity disorder (ADHD) scale, strengths and difficulties questionnaire, and pediatric sleep questionnaire score's reliability analysis

	T1	T2
Total ADHD	0.936	0.912
Attention deficit	0.927	0.889
Hyperactivity	0.848	0.836
Impulsivity	0.881	0.832
Total difficulty points	0.653	0.752
Social behavior	0.473	0.673
Attention deficit /hyperactivity	0.733	0.732
Emotional issues	0.593	0.715
Behavior issues	0.416	0.197
Peer bullying	0.368	0.278
Snoring	0.543	0.435
Sleepiness	0.682	0.632
Behavior problems	0.845	0.741
Total	0.691	0.720

Table 4. Evaluations of attention deficit and hyperactivity disorder (ADHD) scale scores

		OSA	Snoring	
		Mean±SD (median)	Mean±SD (median)	p-value
Attention deficit	[1]T1	0.83±0.56 (0.80)	1.47±0.80 (1.40)	**0.030***
	[1]T2	0.47±0.41 (0.40)	0.96±0.59 (0.80)	**0.007****
	[1]T1-T2	-0.37±0.43 (-0.30)	-0.51±0.53 (-0.30)	0.502
	[2]p	**0.002****	**0.001****	
Hyperactivity	[1]T1	1.07±0.74 (1.10)	1.35±0.81 (1.40)	0.297
	[1]T2	0.72±0.60 (0.80)	1.02±0.74 (0.80)	0.276
	[1]T1-T2	-0.35±0.45 (-0.30)	-0.32±0.38 (-0.20)	0.866
	[2]p	**0.008****	**0.011***	
Impulsivity	[1]T1	1.36±0.90 (1.10)	1.49±0.90 (1.60)	0.629
	[1]T2	0.93±0.70 (0.60)	1.17±0.69 (1.20)	0.268
	[1]T1-T2	-0.44±0.50 (-0.40)	-0.31±0.55 (-0.30)	0.628
	[2]p	**0.004****	0.059	
Total ADHD	[1]T1	1.04±0.58 (0.90)	1.44±0.70 (1.60)	0.124
	[1]T2	0.66±0.46 (0.50)	1.03±0.50 (0.90)	**0.035***
	[1]T1-T2	-0.38±0.36 (-0.30)	-0.40±0.39 (-0.40)	0.917
	[2]p	**0.001****	**0.004****	

[1]Mann-Whitney U test, [2]Wilcoxon signed-rank test, *p<0.05 **p<0.01
T1, beginning of the treatment; T2, end of the treatment; OSA, obstructive sleep apnea; SD, standard deviation

Table 5. Evaluation of strengths and difficulties questionnaire scores

		OSA	Snoring	
		Mean±SD (median)	Mean±SD (median)	p-value
Social behavior	[1]T1	7.81±1.80 (8)	7.29±1.98 (7.50)	0.447
	[1]T2	8.25±1.84 (8)	8.43±1.60 (9)	0.715
	[1]T1-T2	0.44±1.46 (0)	1.14±1.70 (0.50)	0.275
	[2]p	0.226	**0.027***	
Attention deficit/ hyperactivity	[1]T1	5.25±2.79 (5)	6.36±2.71 (6.50)	0.257
	[1]T2	4.75±2.59 (4.50)	5.64±2.27 (6.50)	0.240
	[1]T1-T2	-0.50±2.03 (-1)	-0.71±2.13 (-1)	0.801
	[2]p	0.340	0.210	
Emotional issues	[1]T1	4.69±2.52 (5)	4.93±2.20 (5)	0.900
	[1]T2	3.50±2.73 (3.50)	4.21±2.64 (4.50)	0.463
	[1]T1-T2	-1.19±2.34 (-1.50)	-0.71±1.68 (-1)	0.459
	[2]p	0.063	0.154	
Behavior issues	[1]T1	3.25±2.08 (3)	3.14±1.41 (3)	0.800
	[1]T2	3.13±1.67 (3)	3.07±1.49 (3)	0.882
	[1]T1-T2	-0.13±1.20 (0)	-0.07±1.82 (0.50)	0.593
	[2]p	0.658	0.964	
Peer bullying	[1]T1	2.13±2.16 (2)	3±1.52 (2)	0.091
	[1]T2	1.88±1.82 (1.50)	1.93±1.49 (2)	0.749
	[1]T1-T2	-0.25±2.32 (0)	-1.07±1.69 (-1)	0.408
	[2]p	0.715	**0.042***	
Total difficulty points	[1]T1	23.13±6.91 (25)	24.71±4.51 (25.50)	0.723
	[1]T2	21.50±7.02 (21.50)	23.29±5.47 (23)	0.439
	[1]T1-T2	-1.63±5.07 (-1)	-1.43±3.78 (-1.50)	0.933
	[2]p	0.221	0.247	

[1]Mann-Whitney U test, [2]Wilcoxon signed-rank test, *p<0.05
T1, beginning of the treatment; T2, end of the treatment; OSA, obstructive sleep apnea; SD, standard deviation

Table 6. Evaluations of pediatric sleep questionnaire scores and Pittsburgh sleep quality scale scores

		OSA	Snoring	
		Mean±SD (median)	Mean±SD (median)	p-value
Snoring	[1]T1	0.58±0.34 (0.60)	0.73±0.26 (0.70)	0.230
	[1]T2	0.05±0.14 (0)	0.07±0.15 (0)	0.543
	[1]T1-T2	-0.53±0.32 (-0.50)	-0.66±0.30 (-0.60)	0.316
	[2]p	**0.001****	**0.001****	
Sleepiness	[1]T1	0.48±0.35 (0.60)	0.31±0.27 (0.30)	0.155
	[1]T2	0.27±0.31 (0.30)	0.11±0.16 (0)	0.122
	[1]T1-T2	-0.21±0.35 (-0.30)	-0.20±0.31 (-0.10)	0.966
	[2]p	**0.042****	**0.024***	
Behavior problems	[1]T1	0.54±0.34 (0.50)	0.67±0.34 (0.80)	0.264
	[1]T2	0.43±0.34 (0.40)	0.51±0.34 (0.50)	0.516
	[1]T1-T2	-0.11±0.20 (-0.10)	-0.16±0.32 (-0.20)	0.474
	[2]p	**0.050****	**0.032***	
Total	[1]T1	0.48±0.18 (0.50)	0.52±0.16 (0.50)	0.868
	[1]T2	0.25±0.16 (0.20)	0.24±0.12 (0.30)	0.868
	[1]T1-T2	-0.23±0.11 (-0.30)	-0.27±0.15 (-0.30)	0.262
	[2]p	**0.001****	**0.001****	
PSQS	[1]T1	5.88±3.01 (6)	4.57±2.47 (4.50)	0.233
	[1]T2	3.69±2.36 (3.50)	2.57±1.74 (20)	0.151
	[1]T1-T2	-2.19±2.40 (-1.50)	-2±1.80 (-2.50)	0.916
	[2]p	**0.005****	**0.006****	

[1]Mann-Whitney U test, [2]Wilcoxon signed-rank test, *p<0.05 **p<0.01
T1, beginning of the treatment; T2, end of the treatment; OSA, obstructive sleep apnea; SD, standard deviation; PSQS, Pittsburgh sleep quality scale

represents moderate-good reliability, and above 0.75 represents excellent reliability.[23-25] In the present study, the total scores of all questionnaires were above 0.65. Considering the total scores, the highest value was found in the ADHD questionnaire (T1: 0.936, T2: 0.912), whereas the lowest value was found in the SDQ (T1: 0.653, T2: 0.752).

The PSQ can be used to determine the risk of OSA and to detect and monitor daytime symptoms that may result from a sleep breathing disorder. A value above 0.33 in the total score indicates that the patient is in the risk group.[26] We believe that the reason for the high total score in both groups is that the questionnaire evaluates not only nighttime symptoms like PSG but also daytime symptoms like sleepiness and behavioral disorder. In this study, the decrease in all scores indicates a significant improvement in nighttime and daytime symptoms caused by sleep-disordered breathing.

If the overall PSQS score is 5 or below, it indicates good sleep quality, whereas a score of 6 or more indicates poor sleep quality.[25] In the present study, it was observed that the sleep quality at the beginning of treatment in both treatment groups was not particularly poor but improved with treatment.

Even though the severity of OSA makes it likely that the results of the ADHD questionnaire will show more severe subjective findings, the results of the present study show that primary snoring and OSA have the same effects on sleep and daily life. Wise et al.[27] reported that current PSQs are not sufficient to differentiate primary snoring from OSA. According to Kaemingk et al.,[28] issues with learning and memory are more prevalent when the AHI is greater than 5. We also believe that the low AHI may have contributed to the observed similarities between the OSA and snoring groups.

Urschitz et al.[29] examined hyperactivity and academic achievement in school-aged children with primary snoring, upper airway resistance syndrome, and OSA. They found that primary snoring is a complex condition with neurocognitive disorders similar to upper airway resistance syndrome and OSA.[29]

Arman et al.[30] found that the prevalence of snoring was 7% and that it was more prevalent in boys. Children who snore are more likely to experience nocturnal symptoms such as restless sleep, breathing difficulties during sleep, increased parental anxiety, nightmares, and bedwetting, as well as daytime symptoms such as daytime sleepiness and hyperactivity.[30] Mitchell and Kelly[7] found that sleep-related respiratory disorders severely impact the quality of life by producing behavioral and neurocognitive problems through a systematic review of 33 studies using different questionnaires. They noted that after having an adenotonsillectomy, patients experienced improvements in their problems and quality of life.[31]

In the Villa et al.[32] study, the parents of nine children in the control group and 14 children with OSA were asked to fill out a modified version of the Brouillette questionnaire before monobloc therapy and again six months later. Cozza et al.[33] applied the Italian version of the Epworth Sleepiness Scale, which is used to detect excessive daytime sleepiness, to 20 patients with OSA treated with a modified monobloc. In both studies, it was determined that there was an improvement in the daytime and nighttime symptoms.

With OSA, sleep quality deteriorates due to 200-300 microarousals every night, which significantly impacts drowsiness, increased body movements during night sleep, and alertness and attention functions the following day.[34] Nieminen et al.[34] suggested that the aforementioned micro-awakening attacks may adversely affect insulin-like growth factor-I (IGF-I) levels and the distribution of IGF-binding protein 3, which plays an important role in the cellular development of the prefrontal cortex. Hypoxia, which can be observed intermittently at night during sleep, can have a negative effect on executive functions, especially in the prefrontal cortex.[35,36]

In the chronic snoring group, Arman et al.[30] observed that learning difficulties and decreases in academic performance occurred more frequently. In addition to difficulties in regulating behaviors, emotions, and attention, it has been reported by their families that children had difficulty with executive functions such as decreasing their capacity to adapt to changing situations during the day, starting, maintaining, and planning their homework.[6]

It is recommended that clinicians be careful and initiate an appropriate consultation network in cases where complaints of sleep-disordered breathing and behavioral, cognitive, and academic impairments coexist. Improvement after adenotonsillectomy or orthodontic treatment can positively affect not only sleep and respiratory functions but also behavior and quality of life.

CONCLUSION

This research resulted in the following conclusions:

• Behavioral and emotional problems such as hyperactivity, agitation, and lack of attention, as well as the connection between cognitive skills and sleep-breathing disorders, are increasingly recognized.

• Parameters showed improvement in children's social behavior, peer relations, and sleep quality at the end of the treatment.

• The use of a monobloc appliance in children with primary snoring and OSA reduced the symptoms of sleep-breathing disorders and improved their quality of life.

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Ethics

Ethics Committee Approval: This research was conducted in compliance with the Declaration of Helsinki, and the protocol was authorized by the İstanbul University, İstanbul Faculty of Medicine Clinical Research Ethics Committee, İstanbul, Turkey (approval no.: 2012/516-1010, date: March 09, 2012).

Informed Consent: All patients and their parents provided written consent to participate.

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