Sleep Science

ORIGINAL ARTICLE

Phonoaudiological assessment of patients with obstructive sleep apnea

Avaliação fonoaudiológica em pacientes com síndrome da apneia obstrutiva do sono

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ABSTRACT

Introduction: Studies relating otorhinolaryngological with phonoaudiological and polysomnographic assessments in patients with the obstructive sleep apnea syndrome (OSAS) are rare, and the paucity of information on this topic is apparent when outlining treatments for the OSAS. Objectives: The purpose of this investigation was to thoroughly describe possible alterations in orofacial motricity structure and function in the OSAS patients by means of a phonoaudiological evaluation model. **Methods:** Orofacial structures and functions were examined in male OSAS patients with respect to anthropometric, otorhinolaryngological, and phonoaudiological parameters. **Results:** A total of 22 patients was recruited, with an average age of 47±11 years old, body mass index of 26.2±4.9 kg/m^2, and cervical circumference of 43.9±3.4 cm. The otorhinolaryngological and phonoaudiological assessments revealed that 73% of patients had reductions related to tongue tension; 64% of them showed an elevated genioglossus with the tip of the tongue laying behind the inferior central incisive teeth; 55% showed failed teething; 27% exhibited normal occlusion; 18% had class II occlusions; 100% had facial asymmetry; 36% had a narrow, deep, hard palate; 55% had nasal obstruction; 100% presented with oropharynx alterations; 72% showed unilateral chewing; 63% had ineffective chewing, and 83% exhibited advanced tongue projection during swallowing. **Conclusions:** The phonoaudiological model adopted in this study produced relevant findings about modifications in orofacial motricity in the treatment of OSAS patients.

Keywords: sleep apnea, obstructive; polysomnography; myofunctional therapy; speech, language and hearing sciences.

RESUMO

Introdução: São raros os estudos correlacionando a avaliação otorrinolaringológica, fonoaudiológica e polissonográfica em pacientes com Síndrome da Apneia Obstrutiva do Sono (SAOS). **Objetivos:** O objetivo deste estudo foi descrever as possíveis alterações na estrutura e função de motricidade orofacial em pacientes com SAOS, por meio de um modelo de avaliação fonoaudiológica. **Métodos:** Foram incluídos pacientes do sexo masculino com SAOS para avaliação antropométrica, otorrinolaringológica e polissonográfica em associação a um modelo de investigação fonoaudiológica das estruturas e funções orofaciais. **Resultados:** Foram avaliados 22 pacientes com idade média de 47±11 anos, índice de massa corporal de 26,2±4,9 kg/m^2 e circunferência cervical de 43,9±3,4 cm. Na avaliação fonoaudiológica e otorrinolaringológica, observou-se: 73% dos pacientes apresentaram diminuição de tensão da língua, base de língua elevada e ponta de língua atrás dos dentes incisivos centrais inferiores em 64% dos pacientes, falhas dentárias em 55%, oclusão normal em 27%, oclusão Classe II em 18%, assimetria facial em 100%, palato duro profundo e estreito em 36%, alterações nasais em 55%, alteração orofaríngea em 100%, mastigação unilateral em 72%, mastigação ineficiente em 63% e 82% com projeção anterior de língua durante a deglutição. **Conclusões:** O modelo de avaliação fonoaudiológica adotado mostrou importantes alterações da motricidade orofacial em pacientes com SAOS.

Descritores: apnéia do sono tipo obstrutiva; polissonografia; terapia miofuncional; fonoaudiologia.

INTRODUCTION

Obstructive Sleep Apnea Syndrome (OSAS) is considered a serious public health issue[1]. It is characterized by recurrent episodes of either partial (hypopnea) or total (apnea) obstruction of the upper airway during sleep. Such events take place despite breathing efforts, which generally result in decreased saturation of oxyhemoglobin (SpO_2) and cause frequent arousals throughout the night.

Several theories have been put forward to explain the pathophysiology of the OSAS. If compared to normal individuals, these patients possess a smaller and altered pharynx[2,3]. In addition, a decrease in the muscle motor ef-

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ficiency may also cause dilatation of the pharynx, due to an increase in blood volume within this tissue, and increased adherence between surfaces of the mucosa, which in turn facilitates the collapse of the upper airway[4].

OSAS is a multifactorial disease that has been managed with a host of different strategies with the most prevalent option of choice being the continuous positive airway pressure (CPAP) device for moderate to serious cases[5]. Other treatment alternatives include behavioral changes, which result in weight loss, pharmacological treatment, use of intraoral devices, or even surgery[6,7]. In addition to its inherent academic interest, investigation of the altered neuromuscular pharynx structure in those afflicted with the OSAS, using phonoaudiological assessments, could be instrumental in the diagnosis and determination of the optimal form of treatment. However, there is no comprehensive description of the structures related to orofacial functioning in patients with primary snoring and/or the OSAS. Furthermore, there is some controversy surrounding what there is in the literature regarding this issue[8-10]. The purpose of this investigation was to thoroughly describe possible alterations in orofacial motricity structure and function in OSAS patients, by means of a phonoaudiological evaluation model.

METHODS

Subjects

Patients admitted to the Sleep Disordered Breathing Ambulatory of the Sleep Institute at Universidade Federal de Sao Paulo were selected through medical records analysis. Adult males between 30 and 65 years old were recruited over one-year period, between January 2007 to January 2008. Patients who had complained of habitual snoring (every night or almost every night) were diagnosed with OSAS based on clinical (the Epworth somnolence scale with scores over 9)[11] and polysomnographic criteria[12]. Patients were excluded from the investigation if they had body mass index (BMI) over 35 kg/m^2, previously diagnosed chronic diseases or sleep disorders that could influence on the sleep parameters, previous phonoaudiologic intervention and/or treatment for the OSAS, alcohol, abuse drugs, and sedative use. All patients provided written consent and signed a waiver, and the study had the approval of the Ethics Research Board of Universidade Federal de São Paulo – Hospital São Paulo, under application # 1,664/07.

Study design

Patients underwent an assessment protocol that consisted of a physical and anthropometric exam, an otorhinolaryngological and a phonoaudiological assessment, and polysomnography. The anthropometric assessment included measures of cervical circumference, weight, height, and BMI, which was calculated from the formula weight (kg)/height^2 (m^2).

Otorhinolaryngologic assessment

Upper airway and facial skeletal evaluations were performed by facial inspection, anterior rhinoscopy, oroscopy, dental occlusion evaluation, and flexible nasofibrolaryngoscopy.

In the facial skeletal evaluation, we looked for signs of mandibular retrognathism[13], presence of class II dental occlusions[14], and an ogival palate (narrow hard palate).

With regard to the soft tissues in the oral cavity and oropharynx, we evaluated the volume of the tongue by marking the lateral edge by the teeth, as well as the soft palate, the uvula, the size of the palatine tonsils and the modified Mallampati index (MMI) were also used. The soft palate was classified according to whether it was posteriorized (in relation to the oropharynx), in a web formation (membrane formed through the low insertion of posterior pillar in the uvula), had a voluminous lateral wall (medialized tonsillar pillars), and/or was thick.

The MMI was performed as previously described[15], whereby the patients were seated with their mouths wide open and tongues relaxed inside the oral cavity. According to the MMI, patients were distributed into the four following classes: class I, clear visualization of the entire oropharynx, including the soft palate, the tonsillar pillars, the palatine tonsils, and the tip of the uvula was possible; class II, the upper pole of the palatine tonsils and the uvula could be seen; class III, part of the soft palate and uvula were visible; or class IV, only the hard palate and soft palate part were visible.

As proposed by Friedmann et al.[15] and Zonato et al.[16], the palatine tonsils size was also classified into the four following categories: first degree (intravelic), second degree (extending beyond the anterior tonsillar Pillar), third degree (extending up to 3/4 of the mean line), and fourth degree (complete obstruction of the oropharynx). The third and fourth degrees were considered to have obstructive hypertrophy.

We have also evaluated the presence of possible deviations of the nasal septum and hypertrophy of the inferior nasal turbinates using anterior rhinoscopy and flexible nasofibrolaryngoscopy.

Phonoaudiological assessment

A phonoaudiological assessment was developed for the purpose of this study, which was based on previously determined orofacial motricity evaluations[17]. It was performed with the patient sitting upright, and consisted on a thorough observation of the face for symmetry, posture of the lips in relation to the teeth (open and closed), relation of the maxilla to mandible, nose/lip angle, and mentolabial sulcus,

lip frenum (either short or normal), and size of the lowest third of the face. The upper and lower lips were examined for symmetry, diversions, height of the commissures, and hue of the lips. Tension and muscular mobility were classified as increased or decreased. The cheeks were externally scrutinized for possible asymmetry, tension, and ability to keep them inflated and contracted. The interior of the mouth was examined for tooth marks and thickness of the internal walls. Attention was given to the resting position of the mandible, protrusion, and sideward movement with and without dental contact, closing of the mouth with respect to teeth tightening, symmetry of the masseter and temporal muscles in response to the touch.

The tongue was examined for its tension, size in relation to the inner mouth (increased or decreased), symmetry, and presence of tooth marks on the surface or inner sides of the mouth. The flaccid tongue was considered if it was had not muscle tension, it was elongated, unable to keep the twitch for the solicited time, showed tremor, fibrillation or alteration of the muscle tonus[18]. As for dental occlusion, the mean line, the presence of cavities, diastema, oral hygiene, and gum conditions were assessed. Dental occlusions were classified as class I, II or III[14]. We also analyzed the predominance of nasal, oral or oronasal noisy breathing and whether the airflow was constant or if there was deep inhalation due to the lack of air.

Mastication of 5g of bread was observed along with swallowing, as both functions occur in sequence. We observed whether the bite was lateral or anterior, and if the food quantity affected its movement within the mouth. We also paid attention to whether the lips remained sealed or opened during mastication, if food was being ground, and if there was a side of preference or if both sides were simultaneously used for chewing. We also examined whether the participation of the perioral muscle during mastication was exaggerated, as well as the direction and amplitude of mandible movement, the length of time for a mouthful to be chewed and swallowed, noise, snapping and alterations in head posture, and coordinated breathing.

Swallowing was observed for the tongue projection, contraction of the periorbicular muscle, contraction of the mentum muscle, noise and head movements, interposition of the lower lip, food remaining in the mouth after swallowing, pain, choking, and coughing.

To assess the swallowing fluids, water was used. A transparent glass was used, and the patient was asked to swallow, while the movement of the tongue was observed through the bottom of the glass.

Speech was assessed by a phonoaudiologist, by means of a spontaneous conversation to verify the existence of any changes, omissions, or phonetic distortions.

Polysomnography

Polysomnography was performed on a computerized system (EMBLA® S7000, Embla Systems, Inc., Broomfield, CO, USA), which consisted on a full-night regimen in a quiet and dark room built for this purpose. During sleep, an electroencephalogram (EEG), electrooculogram, tibial and submentonian electromiograms, electrocardiogram, air flow through the nasal cannula and oral termistor, respiratory effort by means of inductance plethismography, SpO_2, snoring and body position were recorded.

Sleep scoring was done in accordance with Rechtschtaffen and Kales method[19], and the EEG arousals were conducted according to the criteria set forth by the American Sleep Disorders Association[20]. Scoring of the respiratory events followed the criteria established by the American Academy of Sleep Medicine[21].

RESULTS

In total, 22 male patients were assessed. Their mean age was 47±11.3 years old (minimum 31, maximum 64 years old), the BMI was 26.2±4.9 kg/m^2 (minimum 24.1, maximum 32.2 kg/m^2), and cervical circumference was 43.9±3.2 cm (minimum 42, maximum 50 cm).

The objective assessment of sleep performed by polysomnography (Table 1) showed that the apnea-hypopnea index (AHI) average was 30.3±24.9 of events per hour of sleep, and the minimum SpO_2 during sleep was 83.8±9.8%, with a consequent reduction in sleep efficiency (80±10.4%), increase in superficial sleep (stage 1=8.6±9.5%), and reduction of slow wave sleep (stages 3 + 4 = 16.1±8.6%). A total of 28% of the patients had mild AHI (AHI=6.8±5.9), 36% were moderate (AHI=20.8±3.8), and 36% were severe (AHI=57.4±20.0). Polysomnographic characteristics according to the AHI severity are described in Table 1.

Table 1. Polysomnographic findings according to severity of the apnea-hypopnea index

Severity of AHI	Mild (n=6)	Moderate (n=8)	Severe (n=8)	Total (n=22)
AHI	6.8±5.9	20.8±3.8	57.4±20	30.3±24.9
Sleep efficiency (%)	86.6±7.8	77.7±10.4	77.9±11.5	80±10.4
S1 (%)	3.9±2.8	8.1±4.3	12.4±14.6	8.6±9.5
S2 (%)	54.9±7.5	53.4±18.9	59.3±9.5	56.7±13.1
S3+4 (%)	17.6±10.6	10.6±5.3	14.3±9.5	16.1±8.6
REM sleep (%)	23.3±11.5	21.0±7.8	19.4±7.7	18±5.7
Minimal SpO_2 (%)	92.5±4.6	84.4±4.7	75.3±8.8	83.8±9.8

AHI: apnea-hypopnea index; S: non REM sleep stages; SpO_2: oxyhemoglobin saturation.

The otorhinolaryngological assessment (Table 2) showed that 59% of the subjects presented with an ogival and hard palate and 50% had a soft web palate. Most had normotrophic palatine tonsils and were present as MMI classes III and IV. Nasal septum deviation was observed in 54% of the patients and class I dental occlusion was seen in 95% of the subjects.

The phonoaudiologic assessment included the examination of orofacial structures including the lips, tongue, cheeks, and dentition (Table 3). Considering the positioning of the lips, 81% of the subjects showed them closed at rest. Adequate muscular tension was observed in 68% and normal lip mobility in all of the subjects. Fifty percent of the patients kept their tongues at rest in the upper position, 41% had widened tongue, and 77% had a flaccid one; although, normal tongue mobility was seen in 100% of the subjects. All subjects had asymmetrical cheeks with adequate mobility, while 77% had cheeks with diminished muscular tension. Assessment of protrusion, retraction and right or left side movement of the mandible showed that mobility was adequate in 100% of the subjects. As for dentition, 32% of the subjects had some form of dental failure.

The phonoaudiological assessment focused on orofacial function related to breathing, mastication, swallowing, and speech (Table 4). The most significant breathing mode was the nasal one, which was observed in 68% of the subjects, while 27% and 5% adopted the oral and oronasal modes, respectively. The upper costal breathing type was found in 100% of the subjects. During swallowing of solid food and liquid, 59% of the subjects presented with forward projection of the tongue, 9% of them used the perioral muscles, and 5% showed interpositioning of the lowest lip. The evaluation of mastication showed that 50% of the subjects had unilateral right mastication and 36% did so rapidly. Regarding speech articulatory sounds, there was an anterior distortion on the alveolar fricative phoneme /s/ in 23% of evaluated subjects.

Table 2. Otorhinolaryngological assessment of the 22 subjects

Frequency	n	%
Retrognathia	1	5
Ogival hard palate	13	59
Web soft palate	11	50
Soft, posterior palate	9	41
Thick soft palate	8	36
Palatine tonsils		
Degree 0	13	59
Degree I	7	32
Degree II	2	9
Degree III e IV	0	0
Modified Mallampati Index		
Class I	1	5
Class II	4	18
Class III	7	32
Class IV	10	45
Nasal septum deviation	12	54
Hypertrophic turbinates	4	18
Dental occlusion		
Class 1	21	95
Class 2	0	0
Class 3	1	5

Table 3. Phonoaudiologic assessment of the orofacial structures of 22 subjects

Frequency	n	%
LIPS		
Posture		
Closed	18	81
Mid-open	3	14
Open	1	5
Tension		
Normal	15	68
Flaccid lower lip	6	27
Flaccid upper lip	5	23
Increased tension	0	0
Mobility		
Normal	22	100
TONGUE		
Posture		
Superior	11	50
Interdental	7	32
Inferior	4	18
Widened tongue	9	41
Muscular tension		
Normal	5	23
Flaccid	17	77
Increased tension	0	0
Mobility		
Normal	22	100
CHEEKS		
Asymmetry	22	100
Muscular tension		
Flaccid	17	77
Normal	5	23
Mobility		
Normal	22	100
Tooth marks/thickness of the internal walls	4	18
MANDIBLE		
Mobility		
Normal	22	100
DENTITION		
Dental occlusion		
Class 1	21	95
Class 2	0	0
Class 3	1	5
Good order	15	68
Improper oral hygiene	13	59
Mean line deviation	20	91
Dental failure	7	32
Diastema	0	0

Table 4. Phonoaudiological assessment of the orofacial functions of 22 subjects

	n	%
BREATHING		
Nasal	15	68
Oronasal	6	27
Oral	1	5
Over inhalation	22	100
Deep inhalation	0	0
MASTICATION		
Rotational movement of the mandible	22	100
Closed lips	12	55
Unilateral right	11	50
Fast	8	36
Slow	4	18
Noisy	4	18
Exaggerated participation of the perioral muscles	2	9
Vertical movement of the mandible	2	9
SWALLOWING		
Anterior projection of the tongue	13	59
Contraction of the periorbicular muscle	2	9
Interposition of the lower lip	1	5
SPEECH		
Lips		
Anterior	5	23
Lateral	0	0
Omissions/distortions/substitutions	0	0

DISCUSSION

This study found several alterations in orofacial motricity, structure and function in the evaluated group of OSAS patients, which shows the importance of speech evaluation in these patients.

Some authors[22] have stated that the OSAS pathophysiology remains obscure, and most alternative treatments are mechanical, thereby making it difficult to maintain compliance among patients. In addition, the elevated costs derived from complications due to untreated OSAS justify a precise assessment of high-risk patients. Better comprehension of OSAS will yield more effective treatments and prevention measures against its comorbidities and complications.

The analysis of these results contributes to our understanding of orofacial structures in treating OSAS, and whether they can be conditioned, adapted or modified with phonotherapy, which may be useful as an adjunct in the OSAS treatment in selected cases. This may be achieved with isometric and isotonic exercises that target the affected sites, thereby providing a safe, noninvasive, and low-cost alternative for OSAS patients.

The present results from the general physical examination demonstrated that the subjects were predominantly overweight (26.2±4.9 kg/m^2) and, thus, they were more prone to developing OSAS[2,3,22]. The average cervical circumference was 43.9 cm. Notably, values over 43 cm are predictive of OSA even in the absence of obesity[23].

The otorhinolaryngological assessment verified the MMI proposed by Friedmann et al.[15], which was characterized by a greater percentage of patients with degree III and IV obstructions. Accordingly, these results are consistent with the literature and indicate the existence of a disproportion between the base of the tongue and the oropharynx cavity[15,16]. In addition, the present results showed that a significant number of the subjects with OSAS (91%) had normotrophic palatine tonsils, which was also in agreement with previous studies[3,16,22,23].

The present results were also consistent with other studies that showed frequent skeletal alterations (deep and hard palate) in those patients with malformations other than the upper airway (soft and/or thick, and posterior web palate, septum deviation and MMI classes III or IV)[9,15,16].

Regarding the evaluation of orofacial structures, reductions in the tension of the tongue, lips, and cheeks were observed, but mobility was preserved in all subjects. However, inadequate posture of the tongue, due to an elevated base between the teeth (interdental) and the floor of the mouth (lower), may have caused a widened tongue with teeth marks along the sides. With respect to orofacial function, we found alterations in swallowing. The main signs were: forward projection of the tongue with the participation of perioral muscles, unilateral mastication, fast mastication with the participation of the perioral muscles, noisy mastication with sealed lips and nasal mode breathing of the upper costal type. These findings showed decompensation of the orofacial musculature, which likely worsens during sleep and aggravates the OSAS condition.

A recent investigation[24] has shown that subjects treated with myofunctional therapy presented significant improvement in cervical circumference, daytime somnolence, quality of sleep, as well as infrequent and decreased intensity of snoring, as determined by the AHI. In another study[9], a portion of the snoring individuals was found to have some hypertonic orofacial structures (lips, tongue, and cheeks), suggesting that the collapse of the upper airway was responsible for the swift change in mode of breathing from nasal to oral, during the night in 80% of the subjects. A 60% improvement in snoring was achieved by a patient without any obstructive breathing alterations after performing myotherapeutic, isometric, and isotonic exercises for the posterior muscles of the tongue and the velopharynx sphincter, in addition to adequate neurovegetative functions (respiration, suction, mastication, and swallowing). Prior to treatment, he/she experienced hypotonia of the base of the tongue and soft palate. Those authors concluded that the alleviation of muscular tension, mobility, mastication, and swallowing functions de-

rived from the phonotherapy led to increased muscular tension and reduced snoring[10].

During normal sleep, alveolar hypoventilation occurs because of a drastic decrease in metabolism[3,22] and CO_2 production. It is during sleep that an alteration in the mechanics of breathing occurs with the partial collapse and narrowing of the pharynx, which leads to a heightened resistance within the upper airway during inhalation. In subjects with OSAS, the overall architecture of the airway was modified. There has also been a report of the pharynx collapse, which affected the muscles responsible for dilatation, thereby resulting in abnormal constriction of the airway[4]. The lower boundary of upper airway obstruction was predominantly found within the nasopharynx and oropharynx, and the highest occlusion levels were generally observed during REM sleep[25].

During wakefulness, the predominant abnormality of the upper airway in patients with OSAS is a significant alteration in the lateral dimensions of the airway. Also, the pharynx becomes small and oddly shaped with increased fat on the side walls and/or bone-maxilla-mandible tissue[2]. One factor that influences snoring and OSAS by acting on constriction mechanisms of the pharynx is the delay, or even absence, of muscular contraction of the dilatation muscles during inhalation[26,27]. As a result, muscular relaxation of the upper airway causes an imbalance between dilatation and constriction, and a subsequent reduction in gauge and recurrent obstruction episodes. However, other authors[26,28] have reported hypotonia of the pharynx dilatation muscles and maximum muscular relaxation during REM.

Our findings demonstrate that a clinical phonoaudiologic assessment of orofacial motricity in patients with OSAS is an easy, low-cost, non-invasive procedure that should be considered as an alternative or adjunct treatment.

Currently, there are no standardized methods or consistent measures in the scientific literature for the purpose of phonoaudiological evaluation in OSAS patients. One limitation of this study is that we sought to create a new protocol, in which some of the previously reported evaluations[29,30] were associated with other parameters and that we considered to be important, based on experience from our clinical practice. The lack of a standardized protocol imparts considerable limitations for research and clinical applications, including the inability to compare results obtained among different studies. Therefore, the present study supports the refinement of a phonoaudiological evaluation protocol to assess orofacial motricity in OSAS patients, which seeks to increase reproducibility and ease of execution. However, controlled studies designed with careful attention to the potential confounders are needed to complement the findings of this study.

In agreement with the literature, OSAS patients examined in this study possessed BMI and cervical circumference values over the normal thresholds. The phonoaudiologic assessment showed that there were alterations in orofacial motricity, such as decreased muscular tension of the tongue and cheeks, inadequate positioning of the tongue at rest, inefficient and unilateral mastication, and forward projection of the tongue with the participation of perioral muscles, and interpositioning of the lower lip during swallowing. Such findings contribute to our understanding of orofacial structures with regard to function and are instrumental in the assessment of this group of patients.

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