REVISTA CEFAC
SPEECH, LANGUAGE, HEARING SCIENCES AND EDUCATION JOURNAL
Rev. CEFAC. 2019;21(6):e10719 http://dx.doi.org/10.1590/1982-0216/201921610719

Original articles

Comparison of nasal geometry among adults with obstructive sleep apnea: a preliminary study

Jackson Ítalo Tavares da Rocha[1]
https://orcid.org/0000-0002-5852-4486

Anna Myrna Jaguaribe de Lima[2]
https://orcid.org/0000-0002-4224-4009

Hilton Justino da Silva[1]
https://orcid.org/0000-0002-6852-3233

Adriana de Oliveira Camargo Gomes[1]
https://orcid.org/0000-0002-1871-9502

Paulo Augusto Vitorino[1]
https://orcid.org/0000-0001-5362-4157

Danielle Cristina Silva Clímaco[3]
https://orcid.org/0000-0003-1935-1540

Daniele Andrade da Cunha[1]
https://orcid.org/0000-0002-3987-9740

[1] Universidade Federal de Pernambuco, Centro de Ciências da Saúde, Programa de Pós-Graduação (Mestrado) em Saúde da Comunicação Humana, Recife, Pernambuco, Brasil.

[2] Universidade Federal Rural de Pernambuco, Recife Pernambuco, Brasil.

[3] Hospital Otávio de Freitas, Ambulatório de Pneumologia, Recife, Pernambuco, Brasil.

This work was carried out at the Department of Speech Therapy of the Center for Health Sciences, Universidade Federal de Pernambuco – UFPE, Recife, Pernambuco, Brazil.

Research support sources: Universal Edital /CNPQ/Universal 14/2014 - Process 457261/2014-5-APQ; Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

Conflict of interests: Nonexistent

Received on: July 5, 2019
Accept on: November 13, 2019

Corresponding addres:
Adriana de Oliveira Camargo Gomes
Departamento de Fonoaudiologia – UFPE
Rua Professor Artur de Sá, s/n. Cidade Universitária
CEP: 50740-520 – Recife, Pernambuco, Brasil
E-mail: acamargogomes@gmail.com

ABSTRACT

Purpose: to compare nasal geometry between two groups of patients with different degrees of obstructive sleep apnea and to correlate apnea-hypopnea index, apnea severity and degree of daytime sleepiness with nasal areas and volume.

Methods: a total of 20 adults (15 women and 5 men, mean age of 52.0±11.4 years old) without nasal obstruction were submitted to polysomnography. The subjects were divided into two groups: a) 10 individuals without apnea or with mild-grade apnea; b) 10 with moderate or severe apnea. Nasal geometry was evaluated by acoustic rhinometry. The volume, comprising the distance from the nasal valve to the posterior part of the middle nasal turbinate, and the three sectional areas corresponding to nasal valve, anterior part of the inferior nasal turbinate and posterior part of the inferior nasal turbinate, were considered. The Shapiro-Wilk, Mann-Whitney, Student's t tests for independent samples and Spearman's correlation coefficient were used for the analysis, with a significance level lower than 5%.

Results: group 2 presented lower values in the area corresponding to the nasal valve (on the right), and higher values in the nasal turbinate areas. There was no correlation between the drowsiness scale and nasal areas and volumes.

Conclusion: the area of the nasal valve was unilaterally smaller in the group with moderate and severe apnea. There was no correlation between volumes and nasal areas and excessive daytime sleepiness.

Keywords: Obstructive Sleep Apnea; Acoustic Rhinometry; Diagnosis; Nasal Obstruction; Nasal Cavity

INTRODUCTION

Obstructive sleep apnea (OSA) is a chronic, developmental disorder characterized by respiratory dysfunction during the sleep period, secondary to anatomic-structural and neuromuscular factors. The main symptoms are: daytime hypersomnia, frequent awakening, snoring, airflow interruptions, restless sleep, neurocognitive deficits, headache, cardiovascular problems, and behavioral changes[1-5].

It is known that the etiology of OSA is multifactorial and that morphometric and functional changes in oropharyngeal and nasal structures are among the cause and effect processes of OSA[6,7]. These changes promote upper airways (UAW) narrowing, one of the main factors for the emergence of this disorder[6-8].

Although the influence of nasal obstruction on OSA[9] has not been proven, one study indicated a high incidence of nasal structural alterations in patients with this sleep disorder[10], which justifies further research on the subject.

The gold-standard method for OSA diagnosis is polysomnography[11]. However, other screening procedures may be useful for combining different risk factors[12], such as airway abnormalities, including examinations that assess nasal cavity geometry[8,13].

Acoustic rhinometry (AR) is characterized by a procedure to measure nasal geometry, which means the volumes, areas and distances of the nasal cavity cross-sections, enabling identification of possible obstructions[8,13]. In this context, AR can to identify risk factors for developing and aggravating OSA related to nasal cavity obstructions, and may be adopted as an auxiliary method in order to detect anatomical changes which accompany the onset and evolution of the disease[8,13].

Thus, the use of AR may be an important ally in the complementary diagnosis of obstructive sleep apnea (OSA), since anatomical alterations of the airways are associated with this disease[14-16].

Therefore, in order to verify the association of nasal measurements with obstructive sleep apnea, the objective of this study was to compare the rhinometric measurements of sectional areas and nasal volumes between two groups with different degrees of apnea, namely, individuals without OSA or with mild-grade OSA, and individuals with moderate or severe OSA undergoing polysomnography for diagnosis, and then, correlating apnea and hypopnea index, apnea severity, and degree of daytime sleepiness with nasal areas and volume.

METHODS

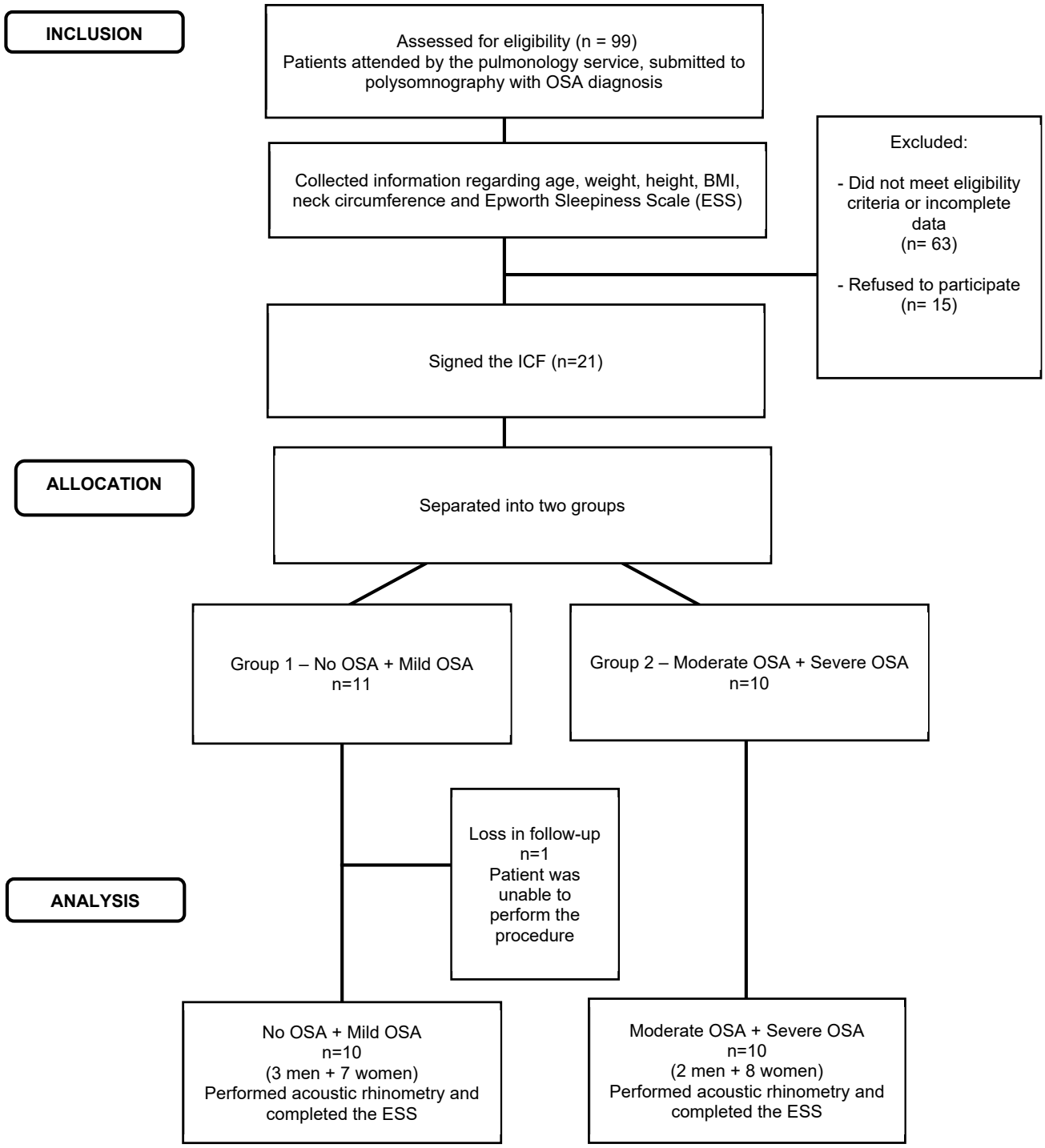
This is a primary, observational, cross-sectional, descriptive-analytic, quantitative study conducted at the Orofacial Motricity Laboratory of the Universidade Federal de Pernambuco and at the Pneumology outpatient clinic of Otávio de Freitas Hospital.

The study was approved under opinion no. 865,491 by the Human Research Ethics Committee of the Health Sciences Center of the Universidade Federal de Pernambuco, Brazil. All the subjects signed the free and informed consent form before data collection was initiated.

Adults of both genders, aged above 18 years, without complaint of nasal obstruction or previous nasal surgeries, submitted to polysomnography (PSG) attended at the Ambulatory of Pulmonology for OSA diagnosis, between January 2013 and December 2015 were recruited. Patients who presented other sleep disorders, who were potentially using sedatives or chemical dependents, who showed craniofacial and upper airway anatomical changes, and those in therapy using spiromics devices or CPAP were excluded from the study.

All the patients attended the service for apnea complaints, and therefore were submitted to polysomnography for diagnosis. The recruited subjects had already undergone medical evaluation, in which nasal anatomical changes that could influence the examination result were ruled out. The inclusion and exclusion criteria were applied according to the medical examination results.

Thus, 20 patients (15 women and 5 men) were analyzed, with a mean age of 52.0 ± 11.4 years and BMI = 31.9 ± 9.0 kg/m^2, with no complaint of nasal obstruction. After polysomnographic analysis, subjects were divided into two groups: a) group 1 - individuals without OSA and patients with mild-grade OSA; b) group 2 - patients with moderate or severe OSA (Figure 1).



Legends: OSA - obstructive sleep apnea; ESS – Epworth Sleepiness Scale; ICF - Informed Consent Form; BMI - body mass index; n - number of subjects

Figure 1. Flowchart of the research data collection procedure

The anthropometric evaluation consisted of a weight and height measurement performed on a digital scale (Welmy, with a capacity of 200 kg, divisions of 100 g) with a stadiometer; the weight was measured in kilograms (kg) and the height in meters (m). Data on body weight and height were used to calculate BMI (Weight (kg)/Height^2 (m)). A flexible tape measure with a capacity of up to 150 cm and increments of 1 mm was used at the level of the thyroid cartilage to evaluate neck circumference, with the individual in standing posture and anatomical position.

The Epworth Sleepiness Scale (ESE) [17,18] was applied to quantify the daytime sleepiness degree of the individual. The scale is composed of simple

questions on the presence of sleep in some daily situations. A score of up to 10 is considered within normal, and above 10 as excessive drowsiness[17].

The PSG examination was conducted over a complete night on the Hospital's premises, during spontaneous sleep and without any sedation. Monitoring and follow-up of the examination were performed by trained professionals, and a portable respiratory monitor (ApneaLink™) was applied. The device remained switched on between bedtime and when the patient woke up in the morning.

The ApneaLink™ monitor is able to continuously monitor pulse oximetry, detect respiratory effort (via chest-abdominal tape applied to the patient's body), measure airflow (through a pressure sensor in the nasal pressure cannula, also applied to the patient's face), record snoring and locate body position. In addition, the heart rate is continuously measured by reading the pulse wave by oximetry. All the data are recorded in the device software, and then recorded in the ambulatory itself, according to international standards.

During data analysis from the examination, detection of respiratory events (apnea or hypopnea) were performed by a specialized physician responsible for the diagnostic opinion. As previously described, the presence of apnea was characterized with a reduction of more than 90% in the baseline airflow, while the presence of an airflow reduction greater than 30% of the baseline associated with a decrease in O_2 saturation ≥ 4% characterized hypopnea. After analyzing the entire sleep period at night, the sum of all the presented events resulted in the apnea and hypopnea index (AHI), whose value when equal to or greater than 5 events/hour was the reference for the OSA diagnosis[12].

In order to perform the nasal cavity geometry evaluation procedure, acoustic rhinometry (AR) was implemented by the Eccovision Acoustic Rhinometer (Sleep Group Solution, North Miami Beach, Florida, USA). The AR enables measuring areas and volume of the nasal cavities, as well as the distance of the different constrictions from the nostrils.

The two nasal cavities were evaluated separately by volume (V) values measured in cm^3, which comprised the nasal cavity volume from the nasal valve to the posterior part of the middle nasal turbinate, comprising a distance of 10mm to 64mm, as well as the cross-sectional area (CSA) values measured in cm^2, with these being: CSA1 = corresponding to the nasal valve; CSA2 = corresponding to the anterior part of the lower nasal turbinate; and CSA3 = corresponding to the posterior part of the inferior nasal turbinate or average[19-21]. The values obtained in each nostril were also summed so that the volumes and CSA values of the nasal cavities could be analyzed together.

The cross-sectional areas are calculated by the intensity of the reflected wave and captured by the microphone. The distances to the nostril are calculated based on the speed of the reflected sound wave and the time captured by the microphone. The data is converted and displayed in an area-distance function graph represented on the computer screen, called the rhinogram, and the system calculates the values for the volumes by the graph area from these values[19,20].

Care was taken in relation to the ambient temperature, external noises, rhinotube tube placement during examinations and sealing between the nasal adapter and the nasal cavity to ensure the accuracy of the rhinometric measurements, as described in other studies[19,20].

Therefore, the ambient temperature was controlled and maintained at approximately 25 °C. After the patient was placed in the examination room for about 30 minutes, individual calibration of the instrument was performed at the beginning of the procedure, and care was taken regarding the correct positioning of the rhinometer tube in order to avoid recording losses of the patients' sound waves. The participant was instructed to sit in an upright position, with their feet well placed in contact with the ground, in addition to keeping their head always stable. At the examination time, the patient was always asked to keep their eyes fixed at a point ahead at eye level in order to maintain the head position.

In order to certify the reproducibility of the examination[21], the rhinometric measurements were performed by two examiners, and the measurements of each nostril were repeated twice by each of the examiners to confirm the measured values, which could not to defer more than 10% between them, and to prevent analysis errors due to problems in the collection procedure. The values considered in the result correspond to the second measure obtained by the second evaluator.

The patient was instructed to inhale and exhale three times through their mouth, and the third breath should be held for a few seconds while beeping indicated that measurements were being taken.

The data adherence to normality by the Shapiro-Wilk test was initially tested to analyze the results. The variables which presented normal distribution had their results expressed by mean (± standard deviation), and those which did not present adherence were shown in

median (minimum-maximum value). The Mann-Whitney test (comparing variables whose values did not present normal distribution) and the Student's *t* test for independent samples (in the comparison between variables whose values had normal distribution) were used to compare the groups, while the Spearman correlation coefficient was used to test the correlation between the variables. The significance level assumed was lower than 5% in all situations. The SPSS version 17.0 program was used.

RESULTS

The values of the variables which characterize the sample were stratified by groups 1 (no OSA and mild OSA) and 2 (moderate and severe OSA). It was observed that the groups only differed in height and (as expected) in apnea and hypopnea index (AHI), which was higher in group 2 (Table 1).

Table 1. Characterization of the sample stratified by the groups (n=20)

Variables	GROUP 1 n=10	GROUP 2 n=10	p value
Age (years) - Mean (±SD)	49.90 (±9.48)	54.1(±13.17)	0.151
Weight (kg) - Mean (±SD)	72.20 (±9.32)	85.87 (±18.95)	0.073
Height (m) - Mean (±SD)	1.62(±0.13)	1.61(±0.08)	**0.034***
BMI (kg/m^2) - Mean (±SD)	30.07 (±8.22)	33.81 (±9.84)	0.778
Neck circumference (cm) - Mean (±SD)	37.10 (±3.90)	40.50 (±5.84)	0.651
ESS (score) - Mean (±SD)	10.50 (±6.55)	16.00 (±7.30)	0.915
AHI (events/h) - Median (Min-Max)	5.20 (2.0-11.30)	36.40 (15.3-94.40)	**0.000****

* Student's t test for independent samples - level of significance p<0.05
** Mann-Whitney Test – level of significance p<0.05
Legend: Group 1 – No OSA/Mild OSA; Group 2 –Moderate OSA/Severe OSA; AHI – Apnea and Hypopnea Index; BMI – Body Mass Index; ESS – Epworth Sleepiness Scale; SD – Standard deviation; Min-Max – minimum and maximum values.

The mean values found in AR for the CSA and of the nasal cavity volumes (V) of both groups were calculated (Table 2). When comparing the left and right nasal cavities separately, it was observed that group 2 presented a lower value in CSA1 (corresponding to the nasal valve) in the right nasal cavity compared to group 1, and a higher value in the left CSA2 and total CSA3, meaning in the analysis of the sum of the two cavities.

Thus, there was a difference between the groups regarding the values of three variables in the sectional areas, but there was no difference in six area variables or in volumes.

The mean values calculated by gender did not differ, except between the left CSA1 measurements (p = 0.013), in which the male group had an average value of 1.04cm^2 and the female group presented 0.67cm^2.

Regarding the correlation test results between the variables related to OSA and nasal measurements, the values indicate that there was a positive correlation between the AHI and the severity of OSA and total CSA3. However, there was no correlation between the Epworth sleepiness scale and the rhinometric variables (Table 3).

Table 2. Values of areas and volumes assessed by acoustic rhinometry stratified by gender and by group

Variables	M n=5	F n=10	p	GROUP 1 n=10	GROUP 2 n=10	p value
CSA1 D (cm^2) - Mean (±SD)	1.15 (±0.27)	0.75 (±0.24)	0.926	0.94 (±0.36)	0.77 (±0.20)	**0.045 ***
CSA1 E (cm^2) - Median (Min-Max)	1.04 (±0.43)	0.67 (±0.18)	0.013*	0.70 (0.41-1.26)	0.72 (0.35-1.70)	0.821
CSA1 total (cm^2) - Mean (±SD)	2.20 (±0.51)	1.42 (±0.37)	0.262	1.67 (±0.61)	1.56 (±0.45)	0.152
CSA2 R (cm^2) - Mean (±SD)	3.01 (±1.02)	2.02 (±1.09)	0.954	1.99 (±0.97)	2.55 (±1.26)	0.333
CSA2 L (cm^2) - Mean (±SD)	3.08 (±1.01)	2.07 (±0.91)	0.759	1.93 (±0.61)	2.71 (±1.21)	**0.035 ***
CSA2 total (cm^2) - Mean (±SD)	6.09 (±1.74)	4.09 (±1.84)	0.802	3.92 (±1.51)	5.26 (±2.23)	0.172
CSA3 R (cm^2) - Median (Min-Max)	3.66 (±2.01)	3.01 (±1.92)	0.822	2.27 (1.27-5.89)	3.20 (1.16-7.20)	0.290
CSA3 L (cm^2) - Median (Min-Max)	4.21 (±2.53)	2.98 (±1.66)	0.338	2.44 (1.67-4.16)	3.58 (0.47-8.10)	0.212
CSA3 total (cm^2) - Mean (±SD)	7.87 (±4.27)	5.99 (±3.40)	0.467	5.21 (±2.23)	7.71 (±4.37)	**0.025 ***
V R (cm^3) - Mean (±SD)	14.54 (±4.14)	9.81 (±3.81)	0.779	10.55 (±4.22)	11.43 (±4.62)	0.502
V L (cm^3) - Mean (±SD)	14.88 (±3.78)	9.99 (±3.55)	0.894	10.58 (±3.44)	11.84 (±4.81)	0.337
V total (cm^3) - Mean (±SD)	29.42 (±6.62)	19.79 (±6.71)	0.770	21.126 (±7.22)	23.27 (±8.57)	0.370

* Student's t test for independent samples - level of significance $p<0.05$

** Mann-Whitney Test – level of significance $p<0.05$

Legend: M – male; F – female; Group 1 – No OSA/Mild OSA; Group 2 –Moderate OSA/Severe OSA; CSA – Cross-sectional Area; V – Volume, corresponding to the distance of 10mm to 64mm from the nostril; R – Right nasal cavity; L – Left nasal cavity; SD – standard deviation; Min-Max – minimum and maximum values

Table 3. Correlation between the Apnea and Hypopnea Index, OSA severity and Epworth Sleepiness Scale variables with total areas and volume

Variables	Correlation	CSA1 Total	CSA2 Total	CSA3 Total	Total Volume
AHI (events/h)	rho	0.042	0.370	0.475	0.297
	p value	0.860	0.108	**0.034 ***	0.203
ESS	rho	-0.064	-0.054	-0.046	-0.115
	p value	0.788	0.820	0.847	0.628
Severity of OSA	rho	0.023	0.389	0.459	0.280
	p value	0.922	0.090	**0.042 ***	0.231

*Spearman's correlation coefficient test – level of significance $p<0.05$

Legend: AHI – Apnea and Hypopnea Index; CSA – Cross-sectional Area; ESS – Epworth Sleepiness Scale; rho – Spearman's correlation coefficient

DISCUSSION

The structural alterations of the nasal cavity have been related to the presence of OSA, but there is still some clarification regarding its association with the etiology of this disease[10,22,23], despite the relationship between nasal obstruction and morphological alterations which generate diseases such as mouth-breathing substitution, snoring, and consequently OSA[10].

The present investigation aimed to verify factors which could be predictive of OSA in a group without nasal complaints by evaluating nasal geometry measurements, comparing one group without OSA or having mild-degree OSA with another group diagnosed with moderate or severe OSA in order to illustrate the possible relationship of nasal morphology with the presence and degree of OSA.

Regarding the studied sample, it can be noted that the two groups were composed mostly of women: 70% in group 1 and 80% in group 2 (Figure 1). When testing the difference of all the measures evaluated between the genders, and despite the fact that the male sample was much smaller, there was no significance except between the left CSA1 measurements ($p = 0.013$), in which the male group had a higher average value than the female group (1.04cm^2 vs. 0.67cm^2, respectively).

Considering that men and women did not differ in the total area and volume measurements, it was decided to not exclude men from the sample.

It is worth noting that the two studied groups did not differ in age and body measurements, except for the height measure which was lower in the group with moderate and severe OSA (Table 1). This presupposes a certain homogeneity between the groups, which favors the analysis regarding the isolation of the variables to be analyzed, i.e. nasal geometry and OSA degree. The groups differed in relation to AHI, as was already clearly predicted, as it was the factor used to stratify the groups. It should also be noted that there was no difference between the mean ESE scores, which does not corroborate the literature[17].

AR is pointed as an objective examination of the nasal cavity, highlighting its usefulness in clinical practice in specific groups[9,20,24,25]. A study comparing the means of CSA1 and CSA2 of 108 individuals with and without OSA found a difference of 10-22% in CSA1 and CSA2 between groups [26]. These findings partially corroborate the present study; it is noted that group 2 presented lower values in the right CSA1 in relation to group 1, however group 2 presented higher values in left CSA2, as well as total CSA3 (Table 2).

This result seems to contradict the initial hypothesis at first, since the measures corresponding to the nasal turbinate region (CSA2 and CSA3)[19-21] were higher in the group with moderate and severe OSA. However, considering that CSA1 corresponds to the nasal valve area[21] and that it offers greater resistance to airflow, a smaller CSA1 area in group 2 points to possible interference of this measure in OSA[27], although the later areas have larger dimensions.

Moreover, it is important to note that the group of patients evaluated in the aforementioned study consisted of almost 70% of individuals with severe OSA[8], which may also explain the difference in results in relation to the present study which refer to CSA2.

In another study[27], AR findings in 87 individuals who presented OSA complaints and signs prior to PSG diagnosis also showed lower values for the minimum CSA, characterizing larger nasal obstructions, corroborating the results obtained in this study in which the CSA1 for all the studied subjects corresponded to the smaller cross-sectional area, thus corresponding to the minimum CSA.

A positive correlation was found between CSA3 measurements with AHI and the OSA severity in the present sample (Table 3). However, these findings are in agreement with the hypothesis that nasal obstruction can be considered in the OSA etiology, considering that being positive indicates that the larger the area, the greater the AHI and the OSA severity found. Therefore, the idea that the nasal valve had a greater influence on the OSA in this group without nasal complaints than the posterior areas and the volume.

No correlation was found between the total areas of the first two segments of the nasal cavity or the total volume with AHI and the apnea severity (Table 3), thus corroborating other studies[16,23]. One possible justification for the finding is that nasal resistance is an important factor for the onset of the disease, which is not evaluated by AR[23] .

Likewise, no correlation was observed when analyzing the nasal cavity geometry and the daytime sleepiness level (the main symptom of OSA), which is different from another study which despite indicating an evaluation of daytime hypersomnia, does not mention whether the patients had an OSA diagnosis or its degree [28]. Another important factor to be analyzed is that the population of this study had a nasal obstruction complaint, which also differs from the present study.

Excessive daytime sleepiness (EDS), which is obtained subjectively through the Epworth Sleepiness Scale (ESS) score, can be defined as the inability to stay awake and alert during the day[18]. This inability may be due to sleep disorders in general and not exclusively to obstructive sleep apnea (OSA). Both groups in the present study presented EDS (ESS > 10), and there was no difference between them. The diagnosis through polysomnography in our sample was specifically done for OSA, and the presence of other sleep disorders which could also be responsible for the presence of EDS were not verified.

It should be emphasized that the subjects of the present study did not present any complaint or evidence of nasal obstruction, which may explain the absence of correlation between the majority of the rhinometric variables and the apnea indicators. This can be explained by the pathophysiology of OSA, in which the UAW collapse in turn causes respiratory obstruction, which arises from a series of factors, more specifically a reduction in soft tissue motility during the respiratory cycle, with the tongue, pharyngeal walls and the soft palate structures being essential in this process[29]. Therefore, rhinometry enables us to observe obstructions in the nasal cavity, which are not always present in all individuals with OSA.

However, considering the difference found in this sample without nasal complaints and with this being a preliminary study, a study with a sample involving a greater number of subjects and stratifying them into individuals without apnea and into the three different degrees of OSA is necessary in order to confirm the importance of acoustic rhinometry as a complementary instrument for evaluating individuals with signs or symptoms of apnea.

Therefore, longitudinal studies evaluating the nasal geometry of these patients starting from diagnosis to treatment for OSA are suggested in order to verify the influence of the most diverse procedures used to treat the pathology of the nasal structures.

CONCLUSION

As determined from the measured rhinometric measurements, the sectional area corresponding to the nasal valve was unilaterally lower in the group with moderate and severe apnea, in relation to the individuals without OSA or mild OSA. However, no correlation was observed between the volumes and nasal areas and excessive daytime sleepiness, one of the main symptoms directly related to obstructive sleep apnea in the group studied.

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