https://doi.org/10.29309/TPMJ/2024.31.01.7743

The Professional Medical Journal
www.theprofesional.com
2024, Volume, 31 Issue, 01

ORIGINAL ARTICLE

Examining the anatomy of the upper airways and soft tissues in healthy people and patients with sleep disorders.

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Article Citation: Javed M, Adnan A, Afridi MKK, Mumtaz S, Nisar S, Khan Z. Examining the anatomy of the upper airways and soft tissues in healthy people and patients with sleep disorders. Professional Med J 2024; 31(01):113-119. https://doi.org/10.29309/TPMJ/2024.31.01.7743

ABSTRACT… Objective: To assessed upper airway differences between individuals with and without obstructive sleep apnea (OSA). The study Investigated upper airway differences in OSA. **Study Design:** Comparative cross sectional study. **Setting:** Hayatabad Medical Complex, Khyber Girls Medical College. **Period:** January, 2022 to October, 2022. **Material & Methods:** 68 participants examined with results: “Anterior-posterior (AP) respiratory tract dimension” consistent across groups. Mandible rami dimension uniform, indicating no bony contribution to lateral narrowing. OSA patients displayed narrower lateral respiratory tracts due to enlarged lateral pharyngeal walls. OSA patients didn’t exhibit larger fat pads in the minimal respiratory tract compared to healthy individuals. **Results:** Our findings reveal that the upper airways of apneic patients exhibit distinct characteristics compared to those of individuals without apnea. Specifically, these differences manifest in the lateral and narrow constriction of the apneic airway. The study’s results underscore the significance of examining delicate tissue elements surrounding the upper respiratory tract to comprehend these variations in apneic respiratory tract dimensions. **Conclusion:** This study highlights OSA-related upper airway differences, primarily attributed to enlarged lateral pharyngeal walls. Understanding these distinctions may aid OSA diagnosis and management.

Key words: EOG (Electro-oculogram), ECG (Electro-encephalohram), OSA (Obstructive Sleep Apnea).

INTRODUCTION

A significant public health issue is obstructive sleep apnea. Obstructive sleep apnea has an unidentified precise etiology, which is unfortunate. But by examining the anatomy and functionality of the upper respiratory tract[1] modern imaging tools may be used to comprehend the factors that cause sleep apnea. Upper respiratory tract cross-sectional area and volume may be precisely measured using MRI and computed tomography (CT) studies.[2] Studies show that even while patients are awake, their upper respiratory tracts are narrower than those of healthy participants. Using cine CT, We have confirmed that apneic people have smaller upper respiratory tracts. These investigations raise a crucial query: Why is the respiratory tract narrower in apneic people while they are awake? The apneic respiratory tract differs geometrically from the normal respiratory tract in addition to being smaller.[3,4] When an individual remains awake, the apneic respiratory tract has the main alignment concerned with in the “anterior-posterior direction (lateral narrowing)”, unlike the regular respiratory tract, It has a straight main axis and a sectional form. Using cine CT, we have verified that the apneic respiratory tract has changed form.[5]

The current study set out to pinpoint the changes in soft tissue components that cause the apneic upper respiratory tract to shrink laterally when a person is awake.[6] The upper respiratory tract’s soft tissue features were properly defined using, the axial direction and the sagittal dimension of an MRI. It may be able to gauge the relative significance of the aforementioned structures in contributing to the tightness and “lateral insufficiency of the apneic respiratory tract” by measuring the size of the side parapharyngeal fat pads and the sides of the pharyngeal sidewalls.[6]

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Article received on: 07/08/2023
Accepted for publication: 10/10/2023

However, our findings underline the significance of the "lateral pharyngeal walls' thickness" as the main cause of the apneic respiratory tract's constriction. not the concept that body fat leads the respiratory tract walls to shrink.

MATERIAL & METHODS

Commercials were employed to enlist snoring participants as well as healthy people were conducted following the conclusion of the diagnostic sleep study, but before the patient began using nightly nasal CPAP. Due to the possibility that persistent CPAP therapy may change the qualities of the upper respiratory tract tissue, we opted not to scan patients once they started receiving it. Study was conducted in Hayatabad Medical Complex, Khyber Girls Medical College from Jan, 2022 to Oct, 2022. Institutional Review Board (IRB) number is 13-012. Inclusion criteria for this study involved the recruitment of both snoring participants and healthy individuals through commercials, following the completion of diagnostic sleep studies but before the initiation of nightly nasal CPAP therapy. To prevent potential alterations in upper respiratory tract tissue characteristics caused by persistent CPAP therapy, patients undergoing CPAP treatment were not included in the scanning process.

All subjects (both snoring and non-snoring) underwent one-night polysomnography utilizing a "Nihon Kohden Model EEG 4418A/K polygraph" in accordance with a prescribed procedure with a 7–8 hour window for sleep. Two nights of sleep were studied in apneic individuals. The first night, the same techniques used to identify obstructive sleep apnea in healthy patients were used to identify the condition. On the following night, the ideal CPAP pressure that prevented respiratory episodes and kept the oxygen saturation level over 90070 was identified. A number of common variables were closely monitored during the sleep tests. They consisted of the electroencephalographic recordings (EEG) of the frontally, central, and occipital lobes, the electrooculograms (EOG) of the right as well as left eyes, the electrical muscle stimulation of the chin, the EMG of the right as well as left frontal tibialis, figures of nose as well as oral air circulation via single-port nose heaters (in particular, the ones created by Irvine, CAD), monitoring of chest cavity as well as wall of the abdomen motion.

On a 1.5T scanner, magnetic resonance imaging examinations were carried out. During awake nasal breathing, sagittal and axial images were collected using traditional spin echo MRI. Participants were placed horizontally with their heads in a neutral anatomical position since prior research from our lab has shown that neck flexion as well as extension impacts upper respiratory tract size. The Frankfurt plane, which runs upright toward the skimming table, from the superior part of the tragus of the ear to the indulgent tissue orbit of the eye, was used to establish this neutral location.

There were two methods used to analyze the data. In the first technique, groups of participants classified as typical, snorer/mild apneic, & apneic were compared. The complete sample in the ensuing method was made up of people chosen based on the variety of their trachea length. A multifactorial study was done to look at the connection between baseline trachea length and soft tissue structures. The purpose of this research was to pinpoint the precise soft tissue elements that have the most impact on the top respiratory tract's length.

RESULTS

The average age with standard deviation (SO) aimed at the typical, snorer/mild apneic, and apneic categories, respectively, remained 34.3 7.7 years. These mean age differences are significantly different ($F = 4.1$, degrees of freedom, $OF = 2.54$, $p = 0.01$) from one another. Pair-wise analyses revealed a substantially distinct variation in the age distribution among the average and apneic individuals ($p = 0.005$). Insignificant age alterations were observed among the snorer/mild apneic and apneic groups ($p = 0.12$) and between the snorer/mild apneic & regular categories ($p = 0.21$). For the snorer/mild apneic, apneic, and control populations, the average neck size (cm) was, accordingly, 36.6 3.5, 40.3 3.8, and 44.5 3.8. The statistical difference between these neck sizes is illustrated in Table-I at F = 25.8, DF = 2.59, and p 0.0002.

The group of apneic people includes me. Pairwise analyses involving the control and apneic categories, the regular and snorer/mild apneic categories, all revealed significant neck size differences. The average BMI (kg/m) of the categories were "23.1 ± 3.4, 27.3 ± 4.6, and 32.5 ± 5.3.". There were statistically significant variations among these body mass indexes. Pairwise compares among the normal and apneic groups, The snorer/mild apneic and apneic groups, as well as the total body mass index results, showed significant variations.

Group	Mean Age (yr)	Standard Deviation (yr)	Mean Neck Size (cm)	Mean BMI (kg/m²)
Normal	34.3	7.7	36.6	23.1
Snorer/ Mild Apneic	38.4	11.4	40.3	27.3
Apneic	43.2	11.8	44.5	32.5

Table-I. Demographic characteristics

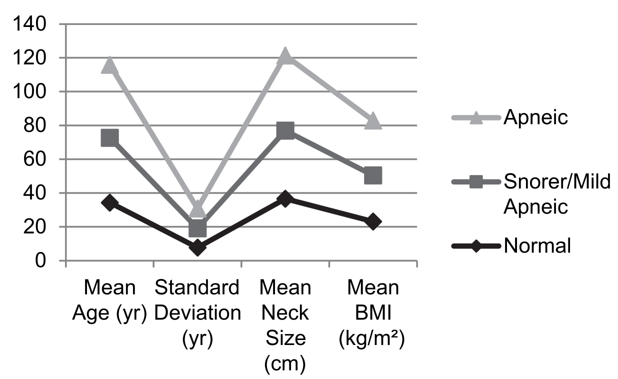

Figure-1. Demographic characteristics

Volumetric Fat Calculations

Previous investigation has demonstrated that apneic individuals have a higher overall quantity of the Para pharynx fatty padding all over the retro palatal and retro glossal areas. However, the dimension of the fat padding at the very bottom of the narrowest respiratory tract was not different between apneic and normal patients. Our statistics corroborate this conclusion. Measurements of all of the parapharyngeal fat in all subjects were accurate enough for analysis. The average total para-pharyngeal fatty measurements (mm^3) for the different categories mentioned varied from "8,300.4, 3,358.4, 9,870.3, 3,054.9, and 14,091.6, 4,831.9" (Table-II). The sum of the Para-pharyngeal fat measurements varied in a statistically significant manner. There were notable variations among the snorer/mild apneic & apneic categories, along with among the average and apneic groups, were shown by pairwise contrasts. Total Para pharyngeal fat measurements varied but not significantly between normal and snorer/mild groups.

Group	Mean Total Parapharyngeal Fat (mm³)	Standard Deviation (mm³)
Normal	8,300.4	3,358.4
Snorer/Mild Apneic	9,870.3	3,054.9
Apneic	14,091.6	4,831.9

Table-II. Total para pharyngeal fat measurements

Respiratory tract size and axial soft tissue measures are analyzed using regression. We conducted a multivariable analysis to directly analyze the associations between axial measures and respiratory tract size. Examination of the soft tissue features connected to respiratory tract dimensions. On a number of participants with complete data, Utilizing the axial measures and the overall fat pad volume, a forward-looking step-by-step regression analysis was done to determine the minimal respiratory tract area. The lateral pharyngeal border thickness was introduced in Step 1 and was responsible for 31.5110 of the variance in air-canal area. In the next stage, fatty padding breadth was included into the equation, resulting in a 43.3% total R2 value. "p = 0.001" and "p = 0.0002" indicated statistical significance for the side of pharynx border and the breadth of the lipid padding, respectively.

This analysis was conducted again, this time forcing in factors, Considerations such as age, body mass index, and cervical length must precede an evaluation of the impact of longitudinal measures. The prototype's ability to explain variance in the respiratory tract areas utilising just the aforementioned demographic variables was only 22.0%. In the aforementioned simulation, neck circumference was the only important variable. The breadth of the fat pad and the lateral pharyngeal wall both considerably improved the model's explanatory power (p = 0.004).

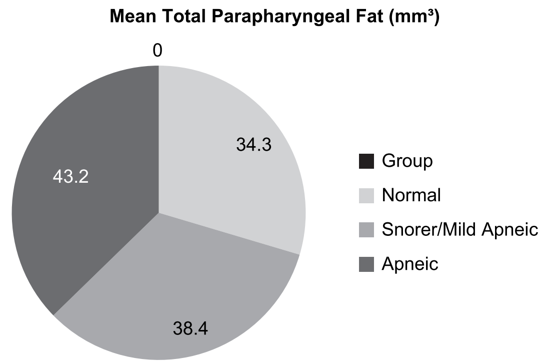

Figure-2. Total para pharyngeal fat measurements (mean in mm³)

These axial measures and the demographic factors, Together, they accounted for 49.7% of the total tracheal variance. Axial measures describe more variance in respiratory tract regions than age, body mass index, or neck circumference combined, increasing the degree of description by 23.0 to 49.7 percent.

Sagittal soft tissue assessment and regression analysis of respiratory tract size. We performed a multivariate study of the connective tissue elements linked to small trachea size to investigate the correlations among sagittal indicates and trachea size. Sagittal values of the tongues and palate's soft tissue were employed in a forwards step-wise regression study for the minimal respiratory tract area on a number of people with full data. Step I introduced the soft palate vertical length into the model, which accounted for 27.611/0 of the variation in the respiratory tract area. A significant correlation between any other sagittal soft tissue measurement and respiratory tract size was not found.

Since the "snorer/mild apnea and apneic groups" both had more females than those with normal breathing, we reanalyzed the information via just men participants' readings. In General, the results obtained with solely male respondents were comparable to those obtained with all subjects. The degree of the differences across subject groups varied in several instances, but the outcomes were equivalent. In the group made up exclusively of males, the results of the "multivariable regression analysis" of soft tissue structures in relation to respiratory tract size were similar. All patients had the same result: lateral pharynx border width was a soft-tissue feature most strongly correlated to airflow area & airflow side breadth.

DISCUSSION

The purpose of this study is to better comprehend the structural changes in the upper airflow's connective tissue that cause respiratory tract narrowing. Nair et al. (2016) suggest that comparing the various layers of connective tissue that surround the roof of the respiratory tract in individuals who are not apneic persons might provide light on the underlying anatomic alterations that propensity the respiratory tract to shut throughout sleeping.[7] Our research shows that a lesser than normal intermandibular gap and an approximation of the para-pharyngeal fatty deposits cannot account for the constriction of the respiratory tract in apneic patients. Instead, the bigger lateral pharyngeal walls in apneic people are the primary anatomical basis for respiratory tract restriction.[8] Multiple regression analyses and evaluations of differences in soft tissue structure across groups corroborated this finding.

Due to the superior soft tissue resolution and lack of ionizing radiation for the participants, MRI scanning was employed while the individuals were awake. MRI scanning has previously been used by researchers to assess the respiratory tract in individuals with sleep apnea.[9] However, the focus of these investigations has been on analyzing changes in respiratory tract size. On the other hand, we focused on using this technique to evaluate the structures of soft tissue within the top of the respiratory tract (Shah et al., 2016). It is important to examine the connection among the respiratory tract & the structures of soft tissues during awake and how these correlations differ between apneic and healthy people, in order to start understanding the anatomic mechanisms causing respiratory tract closure during apneic occurrences.

There are numerous possible drawbacks to our research design. Each of the axial and sagittal MRI scans took around 3 minutes to complete while the subject was awake and nasally breathing. We have previously shown that breathing causes considerable changes in the soft tissue and upper respiratory tract caliber. Multiple breathing cycles were place throughout the three minutes of MR scanning, and the patients may have swallowed despite being told not to. As a result, the measurements we took from the photos we received indicate average values for the upper respiratory tract's size and the soft tissue structures nearby.[10] All individuals underwent the same procedures, thus we don't think that the temporal averaging was the cause of the subject group discrepancies. Our study's objective was to determine the respiratory tract's static features and any alterations in the pertinent soft tissue structure's dimensions.

Our investigation's findings might have also been impacted by variations in the three subject groups' racial and ethnic compositions. The normal group's participants were marginally younger, Women were somewhat overrepresented compared to the apneic population. Since there was only a marginal change in the proportion of males to females among categories, we reviewed the findings with just men taking part and found the same results. As a result, the presence of female individuals did not throw off the results of our investigation. Patients with sleep apnea had bigger neck diameters and body mass indices than healthy people.[11] Weight matching has been cited as a crucial factor in comparing investigations between apneic and normal patients.

Dimensions of Soft Tissue and Bony Structures

Speaking, swallowing, and breathing are just a few of the many physiological processes that the upper respiratory tract is engaged in. The upper respiratory tract's complex musculature enables it to carry out these tasks, but its biomechanical interactions with other muscles are poorly understood.[12] The pharynx is made up of the nasopharynx, the oropharynx, and the hypopharynx. Between the turbinates of the nose and the roof of the mouth lies the nasopharynx. Two more subdivisions of the oropharynx are the retroglossal and retropalatal areas. From the floor of the mouth to the top of the larynx is the hypopharynx.

A muscular wall, situated in front of the cervical spine, surrounds the posterior wall of the oropharynx and hypopharynx. The superior, middle, and inferior constrictor muscles make up the bulk of this muscular wall; the lateral wall also benefits from their presence.[13] The palatine tonsils are a kind of lymphoid tissue found in the lateral walls of the pharynx. The muscles that make up the lateral wall of the pharynx include the superior, middle, and inferior pharyngeal constrictor muscles, as well as the stylopharyngeus, palatoglossus, and stylohyoid muscles. All three of these muscles—the styloglossus, the stylohyoid, and the stylopharyngeus—begin at the styloid process. In contrast, the hypoglossus, middle constrictor, and stylohyoid muscles all enter into the hyoid bone.[14] Our results demonstrate that apneic individuals have thicker lateral pharyngeal walls than do normal subjects, When looking at all the data, it becomes clear that changes in the dimension of the aforementioned soft tissue architecture are most strongly associated to a narrow respiratory tract diameter. The side pharynx wall is thicker and bigger in apneic people. may also help to explain structural changes in the apneic respiratory tract. Contrary to the typical respiratory tract's more horizontal form, lateral constriction causes the respiratory tract to have an anterior-posterior elliptical configuration.[15] These alterations in respiratory tract position may put the apneic patient at risk for respiratory tract closure while they are sleeping.

The layers of fat on both sides of the respiratory tract in apneic individuals are expected to be more closely spaced than in normal individuals, their area to be bigger, and their width for be bigger at the narrowest area of the respiratory tract, all in comparison with typical subjects.[16] But the pathophysiology of obstructive insomnia is significantly influenced by the accumulation of fat in the neck. Overweight is a proven risk factor for apnea, and neck dimensions are the most consistent prediction of apnea occurrence according to population research. Losing weight is related with less severe breathing problems when sleeping. So, it stands to reason that excess fat around the neck plays a role in the onset of OSA. Though, the notion that fat predisposes to the start of apnea by compressing the respiratory tract walls is called into doubt in light of our results and the discovery that apneic individuals have more flexible respiratory tracts.[17]

Tongue & the velum

Obstructive breathing while sleeping is caused by the velum, tongue, and side pharynx border. People with obstructive breathing have bigger soft palates and tongues, according to studies utilising cephalometrics and computed tomography (CT). Our findings corroborate those of Tsuiki et al. (2008), who found that obstructive breathing people had considerably bigger soft palates and tongues compared to healthy patients.[18] Most apneic individuals have expanded soft palates not because of an increase in AP width, but rather a vertical lengthening associated with this soft tissue structure. No rise in AP breadth can be attributed to the bigger tongue size in apneic people.

Bony structure

Soft tissue abnormalities and craniofacial deformities may also worsen obstructive sleep apnea. “Cephalometric techniques have been used to determine whether bony abnormalities (retrognathia and micrognathia)” contribute to obstructive breathing in sleep by measuring The dimensions of both the mouth’s soft palate & tongue, the location of the jawbone and hyoid[19], and the length of the respiratory tract (posterior respiratory tract gap). Because lateral structures are not included in phalometries, which only provide information on anterior-posterior structures, their value is rather limited”. In our study[20], we measured the axial and midsagittal distances among the lower border of the jawbone plus the velum as well as the posterior respiratory tract wall.

CONCLUSION

In our study using magnetic resonance imaging, we observed substantial differences in upper respiratory tract dimensions and soft tissue structures among snoring, apneic, and normal individuals. The primary factor influencing respiratory tract caliber was the lateral pharynx wall depth, notably greater in apneic patients. Contrary to expectations, no evidence of increased fat at mild constriction sites was found. This highlights the significance of lateral pharyngeal borders in shaping respiratory tract characteristics, necessitating further investigation into their determinants and interactions within the upper respiratory system

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