Published in final edited form as:

Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008 October ; 106(4): 563–570. doi:10.1016/j.tripleo.2008.03.032.

Gender and age-based differences in computed-tomography measurements of the oropharynx

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Abstract

Objective—To examine the influence of aging and body-mass-index (BMI) on the oropharynx configuration in male and female Japanese patients.

Study design—This study examined the computed tomography (CT) images of 19 male and 19 females, group matched for age and BMI. The airway and the soft tissue volumes between the posterior nasal spine and top of the epiglottis were compared.

Results—The patient's height, total oropharynx length (TOL), and lower oropharynx lengths and volume measurements (soft tissue and airway) demonstrated statistically significant gender differences. Men consistently had larger TOL and volumes than women. In men, TOL changed with age, and age was a significant predictor of lower oropharynx length. In males, the upper oropharynx soft tissue volume decreased significantly with age and lower oropharynx soft tissue volume increased significantly with age. In females no significant relationship was identified.

Conclusion—The airway lengthens with aging in males and we speculate that it becomes more collapsible, which in turn could contribute to obstructive sleep apnea.

Keywords

Aging; Body mass index; Oropharynx length; Obstructive sleep apnea

1. Introduction

Obstructive Sleep Apnea (OSA) develops mainly in overweight men over the age of 30, and has been associated in prior studies with a small, retroposed mandible, enlarged tongue, and soft palate, inferiorly positioned hyoid bone, and retroposition of the maxilla,^{1 2 3} narrowing

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of the airway due to fat tissue accumulation in the parapharyngeal walls⁴ and/or a decreased in response of genioglossus muscle to hypoxia with aging.⁵ One clear association that has consistently been observed is the high correlation between OSA and **obesity** as measured by the body mass index (BMI).^{6,7} Hoffstein et al. described that OSA patients had significantly higher BMI, neck, and abdominal circumferences than controls.⁸ However, BMI only cannot explain the difference in prevalence between genders or the increase in prevalence with age. OSA **gender- and age-related** differences need further explanation. First, male to female ratio for OSA is in the range of at least 2:1^{9,10,11,12} maybe more. Malhotra et al. investigate the pharyngeal length for gender differences and find that it is longer in men (76.1mm) than in women (58.2mm)($p<.00001$)¹³. They speculate that pharyngeal collapse during inspiration would be greater in men, simply on the basis of these anatomic differences. Second, OSA is a common disorder of the middle aged and elderly and snoring increases in prevalence with age up to age 70.^{14,15} One possible explanation is that there is a progressive descent of the larynx and epiglottis with aging and with obesity, which lengthens the upper airway and possibly makes it more likely to collapse. Schwartz and Keller describe the maturational descent of the epiglottis from infancy to childhood in asymptomatic children aged 1 day to 18 years.¹⁶ They report that the epiglottis, relative to the cervical vertebrae starts descending from birth and continues into adolescence. A second similar study reports a marked descent of the tip of the epiglottis during the first two years of life, but then it would remain fairly static until puberty¹⁷. These authors speculate but provide no data that “further descent of laryngeal structures occurs [after puberty]”. One longitudinal study involves 16 young adults with repeated cephalometric films taken across an interval of 32 years.¹⁸ The results show that the vertical oropharynx length increases by 4.7mm after 20 years of age. This result is confirmed by Malhotra et al., whose group examines pharyngeal changes with aging on non-obese and non-OSA subjects. They report that the length of the pharyngeal airway changes a mean of 4.2mm when they compare younger to older men and 8.0mm comparing younger to older women. They do not find an association between pharyngeal length and aging for the entire group to be statistically significant.¹⁹ However, when they are stratified by gender, a significant correlation is seen in women, but not in men. These findings are somewhat paradoxical if pharyngeal length is causative of OSA because men clearly have a greater tendency for OSA.

The above two studies suggest a need for additional cross-sectional and longitudinal data collection. The aim of our study is to examine the influence of aging and BMI on the oropharynx configuration in males and female Japanese patients. This study might generate new hypothesis on how aging and BMI affects the oropharynx in different ways in females than males, and that might help to understand the difference in obstructive sleep apnea's prevalence between genders. Our null hypotheses are: (#1) after normalizing by body's height (to account for height differences between males and females) there is no difference in oropharyngeal length between men and women; (#2) BMI, age and height are not correlated with oropharyngeal length; (#3) BMI and age are not correlated with oropharyngeal soft tissue volume after adjusting for patient's height.

2. Methods and Materials

Subjects

The subjects were 38 Japanese patients, 19 males and 19 females, who had spiral computed tomography (CT) taken to further examine their maxillofacial and cervical structures as part of their diagnostic assessment. These subjects were group matched for age and BMI. These patients were seeking treatment for one of several clinical problems including OSA (M=13;F=4), snoring (M=1;F=5), malocclusion (anterior open bite)(M=2;F=3), temporomandibular disorders (F=2), osteoarthritis (F=3), minor jaw deformity (M1;F1), enlarged oral torus (M=1), uncomfortable occlusion (F=1) and mandibular fracture (M=1) at

the Tsurumi university dental hospital. As indicated above a subset of 17 of these subjects had OSA problems and also had a polysomnogram (mean apnea hypoapnea index (AHI) was 23.49 ± 14.02). Six of the patients with loud snoring symptoms had polysomnograms to rule out OSA (mean apnea hypoapnea index (AHI) was 1.3 ± 1.28). The other patients did not have polysomnograms and based on clinical interviews, they did not exhibit hypersomnolence or loud snoring symptoms. The age and BMI for the subjects separated by gender are presented in table 1. The age of men ranged from 26 to 80 years. The BMI of males ranged from 19.1 to 29.4 kg/m². The age of females ranged from 24 to 84 years. The BMI of the women ranged from 17.3 to 30.5 kg/m². The patients gave written consent to participate in this study approved by the Ethics Committee at Tsurumi University dental hospital.

Device and Software—The spiral CT imaging (Radix Prima, Hitachi Medical Co., Tokyo, Japan) of the airway was performed with slice thickness of 1mm. From the CT data, the airway and soft tissues were extracted and measured using image analysis software (Amira 3.1, Mercury Computer Systems, San Diego, CA). Segmentation was performed semi-automatically based on Hounsfield units. The parameters used for the imaging were tube voltage = 120 kV; tube current = 75 mA; irradiation time = 1s; scan = volume scan; slice thickness = 1 mm; table speed = 1 mm/s.

Area of Interest—(Fig. 1) CT images were acquired with the subjects in supine position. The area of interest was the oropharyngeal airway defined as follows. The mid-sagittal slice was defined by using the incisive canal and the midline of upper central incisors as references. The lateral borders of the volume were defined by using 11 sagittal contiguous 1mm slices centered at the midline slice. The upper and lower borders were defined by the posterior nasal spine (PNS) and the top of the epiglottis in a mid-sagittal plane. The anterior border of the oropharynx volume was defined by a perpendicular line going through PNS and the posterior border was set by the posterior wall of the oropharynx. Within these borders we measured the total oropharynx length (TOL). Airway volume within the area of interest was calculated from the number of voxels that had a range from a minimum value (−1000HU) to −200HU (to exclude soft and hard tissues). Soft tissue volume within the area of interest was calculated from the number of voxels that were included in the range from −200 HU (to reject the air) to a patient-specific maximum value. The total airway and soft tissue volumes were next subdivided into upper and lower areas separated by a horizontal line located at the maxillary incisal edge. (Fig. 1A, Fig. 1B). These subdivided areas were labeled as the upper oropharynx airway length (UOL) and lower oropharynx airway length (LOL), upper and lower oropharyngeal soft tissue volumes (UST and LST) and the upper and lower oropharyngeal airway volumes (UAV, LAV). Differences in airway length between a young non-OSA female patient and an older OSA female patient are shown in Fig. 2.

Statistical analysis—We investigated the differences in mean age, height and the anatomical variables described above between males and females with the two-sample t-test. BMI, UST and LAV did not pass the formal normality test (Kolmogorov-Smirnov) so we used the non-parametric Mann-Whitney test. We investigated the linear relationships between variables with Spearman's test (due to the non-normality of BMI) and linear regression. The linear regression assumptions of linearity, homoscedasticity and normality of the residuals were not violated. Statistical analysis was carried out with SAS 9.1 (SAS Institute Inc. Cary, NC, USA) with $\alpha=0.05$.

3. Results

Descriptive statistics and p-values for the independent t-tests on age, patient's height, oropharynx lengths (TOL, UOL, LOL), oropharynx lengths normalized by body height (TOL/height, UOL/height, LOL/height), airway volumes (UAV) and soft tissue volumes (LST) are

listed in Table 1. Also Mann-Whitney test results comparing median BMI, LAV, and UST between males and females are listed there. This analysis revealed that patient's height, total oropharynx length (hard palate to tip of epiglottis), TOL/height, UOL/height, LOL, LOL/height, and the lower oropharynx volume measurements (soft tissue and airway) had statistically significant gender differences, with men consistently having longer total oropharyngeal lengths and larger volumes than women, except UOL/height which was larger in women. Importantly, when we normalized the total oropharynx length by body height (by dividing by patient's height), the men still had a longer total oropharyngeal and lower airway length than women.

In Table 2, we present the results of our examination of the extent to which height, gender and OSA status were good predictors of the variables for which we found statistically significant differences between men and women (Table 1): oropharynx lengths (TOL, LOL, TOL/height, UOL/height, LOL/height) and lower oropharyngeal airway and soft tissue volumes (LAV, LST). Gender adjusted by height and OSA status is a significant predictor of all oropharynx lengths (TOL, LOL, TOL/height, UOL/height, LOL/height); however the R-squares of the models are relatively low, between 18.2%–39.2%.

In Table 3, we present the results of our examination of the linear relationships between the oropharynx lengths (TOL, UOL, LOL) with height, BMI and age (Table 3). TOL is statistically significantly correlated with **height** after being adjusted for age, BMI and OSA status, but only in women. With regard to the relationship between **age** and TOL and LOL, we found a significant correlation after adjusting for height, BMI and OSA status only in males. In females, LOL and TOL are statistically significantly correlated with age (unadjusted), and height-adjusted age, but not after adjusting for BMI. TOL, UOL and LOL are not significantly correlated with **BMI** after adjusting for age, OSA status and height.

Table 4 contains the results for the tests of correlation between the TOL, UOL and LOL, BMI and age with UST and LST with and without adjustment for BMI, age, OSA and height (Table 4). In **men**, the UST **decreases** with increasing **age** ($R = -0.645$; $p = .003$) and decreases with increasing LOL ($R = -0.723$; $p = .002$); however, the LST **increases with age** ($R = 0.663$; $p = .002$). So, in males the length of the lower part of the airway and the volume of the lower soft tissues increases at the same time that the volume of the upper part decreases. On the other hand, the LST increases significantly with TOL ($R = 0.784$; $p = .0005$) in females only, after adjusting for BMI, age, OSA and height.

Results for the extent to which BMI, height, OSA and age were predictive of oropharynx lengths (TOL, UOL, LOL) and upper and lower soft tissue volumes (UST, LST) are presented in Table 5. **Age** is significantly predictive of TOL and LOL in both groups. LOL increases 0.49mm per year of age in males and 0.20mm in females with 64.2% ($p = .004$) and 40.3% ($p = .104$) of the variability of LOL explained by this model. In males, the UST decreases with age with $R^2 = 53.8\%$ ($p = .021$), and the LST increases with age with $R^2 = 46.3\%$ ($p = .055$). In females, we found a significant linear relationship between TOL and height ($p = .002$) and age ($p = .002$) with this model explaining 63.9% of the variability of TOL ($p = .004$).

4. Discussion

Our data allow us to partially reject our null hypothesis #1: “*after normalizing by body's height there is no difference in oropharyngeal **length** between men and women*”. Specifically, we found significant gender differences, with the men having a mean 8.1mm-longer airway (between hard palate and epiglottis) than women after adjusting for patient's height, and OSA ($p = .001$). (Table 2). Height and gender (statistically adjusted for OSA) explain 37.5% of the

variability of the total oropharynx length ($p=.001$). These data agree with the study by Malhotra et al.^{13,19}, which also found longer oropharyngeal length in men than in women.

Our data allow us to partially reject our null hypothesis #2: “*BMI, height and age are not correlated with oropharyngeal length (upper and lower oropharynx)*”. Using regression analysis we found that the TOL increased by 0.428mm per year of age in males ($p=.0012$), but only 0.153mm per year of age in females ($p=.032$), and both changes were found to be significant even after adjusting for height, OSA status and BMI (Table 5). We agree with the speculation by Pillar et al. (2000)²¹ that the longer oropharynx length in males (even after adjusting for height) is one of the OSA risk factors because a longer airway increases pharyngeal collapse potential. We added to their study the influences of BMI and height to the relationship between pharyngeal airway length and aging. We found a statistically significant correlation between pharyngeal airway length and age in men before and after adjusting for BMI, OSA status and height. However, the correlation between pharyngeal airway length and age was only significant after adjusting for patient’s height in our female subjects (Table 3). This adjustment could explain why our results differ from Malhotra et al. (2006), since they did not adjust for height.¹⁹

In our study we elected to look at the upper and lower portion of the airway separately because we speculated that the lower airway section was unsupported by any surrounding bony tissue region and would be the area where most of the airway stretching occurs. There were no significant changes in UOL with age, height or BMI in men or in women (Table 5). Not surprisingly, we found that age was a significant predictor of LOL which increases 0.49mm in males ($p=.0004$) and 0.20mm in females ($p=.047$) per 1 year of age increase, after adjusting for height, OSA status and BMI. Note that the change in LOL in males is more than twice as large as in females.

Our data allow us to partially reject null hypothesis #3: “*BMI and age are not correlated with oropharyngeal soft tissue volume (upper and lower oropharynx) after adjusting for patient’s height.*” From Table 4 we found that in men, the UST decreases with increasing age ($R=-0.645$; $p=.003$) and decreases with increasing lower oropharynx length ($R=-0.723$; $p=.002$). If the tongue and laryngeal mass stretches with time, this would explain this finding. Further studies may explore the possibility of this soft tissue laxity to be correlated to the increasing prevalence rate of OSA with age, particularly in males using a longitudinal examination of subjects.

We conclude that in Japanese male and female subjects with BMI ranging from 17 to 30 units, the supine static configuration of the length of the oropharynx airway increases with age in both groups (even after adjusting for height, OSA status and BMI) and is correlated with height only in women (after adjusting for age, BMI and OSA). Age is a significant predictor of LOL, which increases 0.49mm in males and 0.20mm in females per 1 year of age increase, after adjusting for height, OSA and BMI, however there are no significant changes in UOL. In **males** the upper oropharyngeal soft tissue volume **decreases** significantly with age increase ($p=.007$); however, the LST **increases** significantly with age increase ($p=.007$). In the **females**, there is no statistically significant relationship between the upper or lower oropharynx soft tissue and age. We speculate that as the airway lengthens it becomes more collapsible, but this concept must be examined with a dynamic assessment of the airway function. Examining a sample with more obese subjects or a different racial – ethnic group may also alter this relationship.

Sources of funding/Acknowledgments

Dr. Enciso and Dr. Nguyen were partially supported by NIDCR grant #5 K25 DE016391. No conflicts of interest.

Dr. Ogawa was partially supported by “High-Tech Research Center” Project for Private Universities and grant # 18390501: matching fund subsidy from MEXT (Ministry of Education, Culture, Sports, Science and Technology). No conflicts of interest.

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Fig. 1.

A. Sagittal midline CT image showing the anterior, superior and inferior limits of the investigation area.

B. Detailed figure of the upper airway region showing the lengths and volumes studied in this research.

A. 24 year-old Female (Non-OSA) **B. 71 year-old Female (OSA)**

Fig. 2.
Total airway length measured in mid-sagittal view: (A) 24 year-old non_OSA female compared to (B) 71 year-old OSA female.

Table 1

Comparison of each parameter in men and women (independent t-test except for non-parametric variables BMI, UST and LAV)

Variable	Men (n = 19) mean $\pm$ one s.d.	Women (n = 19) mean $\pm$ one s.d.	p value
Age (years)	56.6 $\pm$ 15.84	50.5 $\pm$ 17.20	.267
BMI (kg/m ²) *	22.8 $\pm$ 2.50	21.9 $\pm$ 3.68	.087
Height (cm)	167.8 $\pm$ 5.12	154.9 $\pm$ 6.10	<.0001
TOL [total oropharynx length] (mm) (hard palate to epiglottis)	52.6 $\pm$ 7.70	43.2 $\pm$ 4.55	<.0001
TOL/height (%)	0.30 $\pm$ 0.05	0.28 $\pm$ 0.03	.010
UOL [upper occlusal length] (mm) (from hard palate to line at maxillary incisor tip)	23.3 $\pm$ 3.48	24.6 $\pm$ 3.53	.274
UOL/Height (%)	0.14 $\pm$ 0.02	0.16 $\pm$ 0.02	.004
UAV [upper occlusal airway volume] (mm ³)	1317.1 $\pm$ 358.89	1301.6 $\pm$ 335.22	.892
UST [upper occlusal soft tissue volume] (mm ³) *	1489.8 $\pm$ 438.18	1672.7 $\pm$ 392.39	.264
LOL [lower occlusal length] (mm) (from line at maxillary incisor tip to epiglottis)	29.3 $\pm$ 8.35	18.6 $\pm$ 5.12	<.0001
LOL/Height (%)	0.18 $\pm$ 0.05	0.12 $\pm$ 0.03	.0004
LAV [lower occlusal airway volume] (mm ³) *	1227.4 $\pm$ 311.54	903.8 $\pm$ 357.98	.003
LST [lower occlusal soft tissue volume] (mm ³)	2447.1 $\pm$ 794.76	1636.8 $\pm$ 601.78	.001

* Non-parametric Mann-Whitney U-test

Table 2

Linear regression models to predict our dependent variables (total oropharynx length, upper and lower occlusal length/volume/soft tissue) by height (cm), gender (female=1, male=0) and OSA status (OSA=1, non-OSA=0). Fourth column shows the R-square of our model [dependent variable = Height Female OSA)] and the p-value of the ANOVA F-test.

Variable	Height slope (p value)	Female slope (p value)	OSA slope (p value)	R-square (p value)
TOL [total oropharynx length] (mm) (hard palate to epiglottis)	0.092 (p= .655)	-8.105 (p=.043)	0.402 (p=.876)	0.375 (p=.001)
TOL/Height (%)	N/A	-3.188 (p= .038)	0.791 (p=.532)	0.182 (p= .029)
UOL/Height (%)	N/A	2.076 (p= .012)	0.210 (p=.792)	0.190 (p= .025)
LOL [lower occlusal length] (mm) (from line at maxillary incisor tip to epiglottis)	-0.097 (p= .666)	-12.004 (p=.007)	-0.047 (p=.987)	0.392 (p=.001)
LOL/Height (%)	N/A	-5.264 (p= .003)	0.580 (p=.724)	0.303 (p= .002)
LAV [lower occlusal airway volume] (mm ³)	1.699 (p= .875)	-243.068 (p=.238)	123.757 (p=.362)	0.217 (p=.038)
LST [lower occlusal soft tissue volume] (mm ³)	12.268 (p=.588)	-519.498 (p=.229)	281.272 (p=.324)	0.281 (p=.010)

Table 3

Simple and partial correlations between total oropharynx length, upper occlusal length and lower occlusal length with height (unadjusted, BMI-adjusted, age-adjusted, and age-, BMI- and OSA-adjusted).

Dependent variable	Height (unadjusted) r score** (p value)	Height (Age adjusted) r score** (p value)	Height (BMI adjusted) r score** (p value)	Height (Age, BMI and OSA adjusted) r score** (p value)
<i>Males only (n=19)</i>				
TOL	-0.115 (p = .640)	0.249 (p = .319)	-0.074 (p = .771)	0.371 (p = .157)
UOL	0.216 (p = .374)	0.135 (p = .594)	0.232 (p = .355)	0.149 (p = .581)
LOL	-0.228 (p = .349)	0.186 (p = .460)	-0.198 (p = .430)	0.265 (p = .321)
<i>Females only (n=19)</i>				
TOL	0.380 (p = .109)	0.647 (p = .004)	0.428 (p = .076)	0.683 (p = .004)
UOL	0.231 (p = .342)	0.210 (p = .403)	0.212 (p = .397)	0.216 (p = .233)
LOL	0.172 (p = .482)	0.438 (p = .069)	0.233 (p = .353)	0.376 (p = .151)
Dependent variable	Age (unadjusted) r score** (p value)	Age (BMI adjusted) r score** (p value)	Age (Height adjusted) r score** (p value)	Age (BMI ,Height and OSA adjusted) r score** (p value)
<i>Males only (n=19)</i>				
TOL	0.652 (p = .003)	0.644 (p = .004)	0.673 (p = .002)	0.779 (p = .0004)
UOL	-0.225 (p = .355)	-0.230 (p = .358)	-0.148 (p = .558)	-0.152 (p = .574)
LOL	0.766 (p = .0001)	0.762 (p = .0002)	0.762 (p = .0002)	0.810 (p = .0001)
<i>Females only (n=19)</i>				
TOL	0.428 (p = .067)	0.349 (p = .156)	0.667 (p = .003)	0.443 (p = .086)
UOL	-0.098 (p = .689)	0.023 (p = .929)	-0.013 (p = .961)	-0.031 (p = .909)
LOL	0.485 (p = .035)	0.362 (p = .139)	0.603 (p = .008)	0.440 (p = .088)
Dependent variable	BMI(unadjusted) r score** (p value)	BMI (Age adjusted) r score** (p value)	BMI (Height adjusted) r score** (p value)	BMI (Age, Height and OSA adjusted) r score** (p value)
<i>Males only (n=14)</i>				
TOL	0.173 (p = .479)	0.118 (p = .640)	0.149 (p = .554)	0.193 (p = .474)
UOL	0.029 (p = .905)	0.060 (p = .812)	0.090 (p = .722)	0.095 (p = .725)
LOL	0.148 (p = .545)	0.077 (p = .761)	0.095 (p = .708)	0.119 (p = .660)
<i>Females only (n=14)</i>				
TOL	0.271 (p = .262)	0.058 (p = .819)	0.341 (p = .166)	-0.056 (p = .838)
UOL	-0.221 (p = .362)	-0.201 (p = .425)	-0.0202 (p = .421)	-0.259 (p = .334)
LOL	0.378 (p = .110)	0.164 (p = .514)	0.406 (p = .095)	0.130 (p = .630)

**
r score is the Spearman's correlation coefficient

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Table 4

Second column shows simple correlations between total oropharynx length, upper and lower occlusal length, BMI and age with upper occlusal soft tissue volume. Third column shows partial correlations adjusted for BMI, height, OSA and age. Fourth column shows simple correlations between total oropharynx length, upper and lower occlusal length, BMI and age with lower occlusal soft tissue volume. Fifth column shows partial correlations adjusted for BMI, height, OSA and age.

UST	UST (adjusted for LST BMI, Age, Height and OSA)		LST (adjusted for BMI, Age, Height and OSA)
Spearman's coefficient		Spearman's coefficient	
r score (p value)	Partial correlation r score (p value)	r score (p value)	Partial correlation r score (p value)
<i>Male and Female Pooled (n = 38)</i>			
TOL	-0.226(p =.172)		
UOL	0.621 (p< .0001)	0.810(p < .0001)	0.579 (p= .0003)
LOL	-0.486 (p =.002)	-0.370 (p =.002)	-0.325 (p =.061)
BMI	0.002 (p =.989)	0.880 (p < .0001)	0.746 (p <.0001)
Age	-0.300(p =.067)	0.427 (p =.008)	N.A.
	N.A.	0.531 (p =.0006)	N.A.
<i>Males only (n=19)</i>			
TOL	-0.516 (p =.024)	0.671(p =.002)	0.359(p =.190)
UOL	0.632 (p =.004)	-0.418 (p =.075)	-0.430 (p =.110)
LOL	-0.760 (p <.001)	0.833 (p <.0001)	0.678 (p =.006)
BMI	-0.061 (p =.803)	N.A.	N.A.
Age	-0.645 (p =.003)	0.279 (p =.247)	N.A.
	N.A.	0.663 (p =.002)	N.A.
<i>Females only (n=19)</i>			
TOL	0.401(p =.089)	0.809(p <.0001)	0.784 (p =.0005)
UOL	0.638 (p =.003)	-0.141 (p =.565)	-0.195 (p =.486)
LOL	-0.049 (p =.841)	0.826 (p< .0001)	0.752 (p=.001)
BMI	0.225 (p =.355)	0.398 (p =.091)	N.A.
Age	0.091 (p =.710)	0.364 (p =.125)	N.A.

Table 5

Linear regression models to predict total oropharynx length, and upper and lower occlusal length/soft tissue volume by change in height (cm), age (years) and unit of BMI (kg/m^2). Fifth column shows the R-square of our model [dependent variable = Height Age BMI] and the p-value of the ANOVA F-test.

Dependent variable	Height slope (p value)	Age slope (p value)	BMI slope (p value)	OSA status (p value)	R-square (p value)
<i>All subjects (n=38)</i>					
TOL (mm)	0.571 (p<.0001)	0.341 (p<.0001)	0.140 (p = .639)	-4.235 (p=.008)	0.614 (p<.0001)
UOL (mm)	0.007 (p = .928)	-0.053 (p = .288)	0.039 (p = .852)	0.053 (p = .950)	0.053 (p = .762)
LOL (mm)	0.565 (p<.0001)	0.393 (p<.0001)	0.101 (p = .768)	-4.333 (p=.102)	0.585 (p<.0001)
UST (mm ³)	-0.775 (p = .926)	-12.524 (p = .030)	19.594 (p=.401)	141.738 (p=.431)	0.149 (p = .242)
LST (mm ³)	47.458 (p = .0004)	31.756 (p=.0003)	22.034 (p=.518)	-252.609 (p=.329)	0.526 (p<.0001)
<i>Males only (n=19)</i>					
TOL (mm)	0.234 (p = .431)	0.428 (p = .0012)	0.237 (p = .679)	-8.616 (p=.020)	0.572 (p = .013)
UOL (mm)	0.187 (p = .321)	-0.057 (p = .408)	0.232 (p = .523)	0.568 (p = .787)	0.167 (p = .604)
LOL (mm)	-0.047 (p = .872)	0.485 (p = .0004)	0.006 (p = .992)	-9.185 (p=.013)	0.642 (p = .004)
UST (mm ³)	22.845 (p = .202)	-19.581 (p = .007)	33.738 (p = .326)	335.638 (p = .104)	0.538 (p = .021)
LST (mm ³)	17.841 (p = .601)	38.576 (p=.007)	29.364 (p=.658)	-353.379 (p=.365)	0.463 (p=.055)
<i>Females only (n=19)</i>					
TOL (mm)	0.598 (p = .002)	0.153 (p = .032)	-0.140 (p = .575)	3.790 (p=.247)	0.639 (p = .004)
UOL (mm)	0.250 (p = .189)	-0.050 (p = .522)	-0.160 (p = .859)	4.331 (p=.267)	0.148 (p = .663)
LOL (mm)	0.348 (p = .137)	0.204 (p = .047)	0.021 (p = .954)	-5.541 (p = .907)	0.403 (p = .104)
UST (mm ³)	30.790 (p = .147)	-3.000 (p = .730)	0.056 (p = .9986)	392.080 (p=.360)	0.153 (p = .648)
LST (mm ³)	47.408 (p = .090)	19.950 (p = .093)	22.232 (p = .603)	-87.765 (p=.873)	0.393 (p = .114)