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Does A Short, Thick Neck Predict Obstructive Sleep Apnea?: The Role of Physical Examination in OSA Screening

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Title

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Conflict of interest disclosures

None of the authors have any financial or other conflicts of interest to disclose.

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ABSTRACT

Purpose: The purpose of this study was to determine whether a short neck, alone or together with a thick neck, can predict obstructive sleep apnea (OSA).

Methods: The laryngeal heights of 169 new adult patients presenting to a sleep medicine physician were measured over a period of 5 months. Neck circumference, Mallampati score, and body-mass index (BMI) were also determined, together with medical history, smoking status, and serum bicarbonate. Lastly, patients' polysomnograms were obtained in order to ascertain the presence or absence of OSA as indicated by the apnea-hypopnea index, as well as other sleep study parameters.

Results: No association was found between laryngeal height and presence of OSA, bicarbonate concentration or oxygen saturation. Of interest, neck circumference was also not significantly associated with any of the aforementioned parameters, although there was a trend towards significance in its association with OSA ($p=0.055$). Still, a combined short laryngeal height and large neck circumference was associated with lower nadir SaO_2 ($p=0.018$). Of all clinical parameters we measured, only higher BMI, older age and male sex were positively associated with OSA ($p<0.05$).

Conclusion: This study challenges the popular notion that short necks predict OSA.

Key words: obstructive sleep apnea, laryngeal height, neck circumference

INTRODUCTION

When Supreme Court Justice Antonin Scalia died suddenly in his sleep on the night of February 12, 2016, it captured the nation's attention for many political and historical reasons. In addition, as one of 326,000 cases of out-of-hospital cardiac arrest occurring annually in the U.S., Justice Scalia's death serves as an important reminder of an increasingly prevalent, yet underdiagnosed, condition which may have been responsible for his demise: obstructive sleep apnea (OSA). Although it is not known with certainty that Justice Scalia had been diagnosed with OSA, the sheriff's report from his death noted that a continuous positive airway pressure (CPAP) machine, typically used to treat OSA, was found on the nightstand next to him, though unplugged and not turned on. Moreover, the former justice had the classic physical findings of OSA, and several physicians have theorized that it was the cause of his death[1].

The American Academy of Sleep Medicine estimates that 25 million Americans may have OSA, and that up to 90 percent of them are undiagnosed[2]. If OSA goes undiagnosed and therefore untreated, it can lead to devastating consequences including daytime sleepiness, mood disturbances, hypertension, arrhythmias, stroke, and even sudden cardiac death. Justice Scalia's recent passing is a reminder to a nation plagued by the obesity epidemic of the importance of early detection and screening for OSA.

A short, thick neck was classically described by Charles Dickens in the Pickwickian Papers and was the origin of the Pickwickian syndrome or obesity hypoventilation syndrome[3]. More than 90% of patients with this syndrome have OSA[4].

The laryngeal height is the distance between the top of the thyroid cartilage and the suprasternal notch. A laryngeal height less than 4 cm has been shown to predict both the presence of chronic obstructive pulmonary disease (COPD) and the severity of its post-operative pulmonary complications[5,6]. Although these data make a *short* neck an important and easily detectable predictor for the presence and severity of COPD, there is currently no data to suggest that a short neck might also predict the presence and/or severity of OSA. There is good data that a *thick* neck, defined as a neck circumference greater than 17 inches in men and 16 inches in women, is associated with OSA[7]. There is also data that neither the hyoid-mental not the thyroid-mental distance correlate with the severity of OSA[8]. However, a short neck has not yet been studied as a predictor of OSA. Still, conventional wisdom typically quotes short and thick necks as being predictive of the condition.

With this in mind we designed a study that could assess whether laryngeal height can indeed serve as an additional marker for OSA. We also looked for associations between other clinical parameters and sleep study results with the overall goal of identifying clinical factors that could be used to best identify patients at risk for OSA.

SUBJECTS AND METHODS

This was a cross-sectional observational study. The protocol was approved by the Institutional Review Board of the Division of Human Subjects Research Protection at Thomas Jefferson University (approval number 13D. 244). The study population comprised all new patients seen by one physician at the Jefferson Sleep Disorders Center in Philadelphia, Pennsylvania during a five month period. All patients over 18 years of age who presented to this physician for any previously undiagnosed sleep-related chief complaint were included in the study. On the date of each patient's first appointment at the Sleep Center, the following anthropometric measurements were taken: height, weight, neck circumference (in centimeters), laryngeal height (in centimeters), and modified Mallampati score[9]. Body-mass index (BMI) was calculated from the height and weight. Neck circumference was measured with a tape measure at the level of the cricothyroid membrane. Laryngeal height was measured with a tape measure from the top of the thyroid cartilage to the suprasternal notch. Modified Mallampati score was determined by asking upright patients to open their mouth without protruding their tongues and classifying the anatomy of the oropharynx according to the standard four-class system[10].

We recorded the presence or absence of the following medical conditions as reported by patients or documented in their medical records: hypertension, diabetes mellitus, hypothyroidism, coronary artery disease (CAD), COPD, and hypertriglyceridemia. Smoking status (having ever smoked cigarettes) was determined by patient self-report. If a patient's medical record had laboratory results for a serum bicarbonate level within the past one year, the most recent bicarbonate level was recorded.

On average, patients underwent overnight polysomnogram (PSG) one to two weeks after their initial appointment at the Sleep Center. Each patient had a full diagnostic PSG performed in a sleep laboratory using the Grass system, which included the following recordings: electroencephalography, chin and leg electromyography, electro-oculography, chest and abdominal inductance plethysmography, airflow using a nasal pressure transducer and a thermistor, oxygen saturation and heart-rate monitoring. A trained sleep technician staged each study using the updated 2007 American Academy of Sleep Medicine Manual for the scoring of sleep and associated events[11]. These were then verified by a board certified sleep physician. Apneas were defined as complete cessation of airflow greater than or equal to 10 seconds detected on the thermistor. Hypopneas were defined as reduction of greater than 30%, with an associated fall of greater than or equal to 4% in oxygen saturation on the nasal pressure transducer. Results reported from PSG included apnea-hypopnea index (AHI), baseline oxygen saturation (baseline SaO_2), and lowest nocturnal oxygen saturation (nadir SaO_2)

The three PSG parameters (AHI; baseline SaO_2; and nadir SaO_2) and the other dependent variable, bicarbonate[12], were analyzed via linear regression. The analyses for AHI were carried out after log transformation to account for its skewed distribution (and therefore, results for AHI are reported in terms of geometric means and geometric mean ratios, instead of the usual means and mean differences). For each of the four dependent variables, the final model included laryngeal height, and controlled for patient age, sex, smoking status, height, BMI, neck circumference, and Mallampati score. The hypothesis regarding the impact of short and thick necks was assessed by evaluating the interactions between neck circumference and laryngeal height. All statistical analyses were carried out in SAS 9.3 (SAS Institute Inc., Cary, NC).

RESULTS

Patient characteristics

The analyses were based on data from 169 adult patients. Table 1 summarizes the characteristics of these patients. Neck circumference ranged from 29 to 52 cm (mean = 38.1 cm). Laryngeal height ranged from 1.5 to 8 cm (mean = 4.7 cm). Most patients (91%) had Modified Mallampati scores 3 or 4. Table 2 summarizes the subjects' PSG results and bicarbonate levels. The AHI ranged from 0.1 to 156 (geometric mean = 6.5), CO2 ranged from 18 to 40 mmol/L (mean = 26), baseline SaO_2 ranged from 89% to 100% (mean = 97%), and nadir SaO_2 ranged from 29% to 99% (mean = 84%).

Independent association of laryngeal height and neck circumference with sleep study parameters

Figure 1 summarizes graphically the unadjusted association between the laryngeal height and each of the four dependent variables. None of these associations were significant (unadjusted p = 0.178 for AHI, 0.842 for bicarbonate, 0.539 for baseline oxygen saturation, and 0.200 for nadir oxygen saturation). Table 3 shows the final adjusted results for laryngeal height and neck circumference. Each successive 1 cm increment in laryngeal height was associated with a negligible decrease in the AHI score by about 3% (i.e., geometric mean ratio = 0.97, p = 0.689, Table 3). Even when the AHI score was analyzed as a dichotomous outcome (≥5 versus <5), the adjusted odds ratio for each 1 cm increment in laryngeal height was 0.97 (p = 0.878). An increment of 1 cm in laryngeal height was associated with a very small increase in bicarbonate, by an average of about 0.2 mmol/L (p = 0.489, Table 3). Finally, the average baseline and nadir oxygen saturation were practically unchanged with laryngeal height (baseline SaO_2 mean change per 1 cm increase in laryngeal height = 0.0%, p = 0.920; nadir SaO_2 mean increase per 1 cm increase in laryngeal height = 0.1%, p = 0.822, Table 3). Neck circumference was also not significantly associated with any of the four dependent variables, although the association between neck circumference and AHI approached significance ($p = 0.055$).

Joint association of laryngeal height and neck circumference with sleep study parameters

We then investigated the possibility that neck circumference and laryngeal height may have an effect only jointly, i.e., the "short and thick neck" hypothesis. Table 4 summarizes the four dependent variables by neck circumference (dichotomized as ≥40 vs. <40 cm) and laryngeal height (dichotomized as ≥4 vs. <4 cm). In these unadjusted analyses, short and thick necks were associated with worse (lower) nadir SaO_2, and to a lesser extent with worse (higher) AHI (interaction p-value = 0.018 and 0.242, respectively). In formal regression analyses that used neck circumference and laryngeal height as continuous variables and controlled for the other patient characteristics, none of the interactions were significant (interaction p-value = 0.584 for AHI, 0.251 for bicarbonate, 0.195 for baseline SaO_2, and 0.253 for nadir SaO_2).

Association between clinical data and sleep study parameters

Table 5 summarizes the significant predictors for each of the four dependent variables. BMI was significantly associated with all four parameters and age was associated with three. On average, the AHI score of women was about half that of men ($p = 0.013$), and bicarbonate was also lower among women by about 2.2 mmol/L ($p = 0.028$). Smoking was also associated with a 0.6% lower baseline SaO_2 ($p = 0.032$). When added to the main models, none of the medical conditions (hypertension, diabetes mellitus, hypothyroidism, CAD, COPD, and hypertriglyceridemia) was significantly associated with any of the dependent variables, except for COPD which was associated with a lower baseline oxygen saturation by about 1.1% (p = 0.033).

DISCUSSION

In this cross-sectional observational study, we found that neither laryngeal height nor neck circumference alone is significantly associated with AHI, baseline SaO_2, nadir SaO_2, or serum bicarbonate concentration, even though the association between neck circumference and AHI did approach statistical significance (p=.055) and a combined short and thick neck was indeed associated with lower nadir SaO_2 (p=.018). Of all the clinical parameters we measured, only higher BMI, older age, and male sex were positively associated with OSA (p<.05).

It has been shown in a prior prospective study that neck circumference adjusted for height was a better predictor of sleep apnea than BMI alone[8]. Conversely, we attempted to evaluate if a short laryngeal height either alone or together with a high neck circumference could be an even better predictor of sleep apnea. Our results revealed no association. Still, our study faced several limitations. First, we had no way to accurately measure the true laryngeal height externally. Hence the "laryngeal height" we used in our analysis was a surrogate value that might have not accurately reflected the *anatomic* laryngeal height. In addition, we undoubtedly encountered some inevitable degree of interobserver variation in anthropometric measurements. Moreover our sample size was modest: more specifically, we only had twelve patients with short and thick necks according to the dichotomous classification used in our study. Hence, it is possible that our sample size might have indeed been too small and under-powered to detect differences between patients with short and thick necks and those with tall and thin necks. Thus further studies with a larger sample size may be necessary. Yet for now we can conclude that the conventional wisdom that a short and thick neck predicts OSA seems to be erroneous, at least as applied to a short neck.

CONCLUSION

Our findings suggest that, contrary to popular belief, short necks do not predict OSA.

References

1. Cha AE. Did sleep apnea contribute to Justice Scalia's death? His unplugged breathing machine raises that question. *The Washington Post*. February 24, 2016.

2. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased Prevalence of Sleep-Disordered Breathing in Adults. *American Journal of Epidemiology*. 2013;177(9):1006-1014. doi:10.1093/aje/kws342.

3. Dickens, C. *The Posthumous Papers of the Pickwick Club*. London: Chapman & Hall, 1836. Print.

4. Mokhlesi B, Tulaimat A, Faibussowitsch I, Wang Y, Evans A. Obesity hypoventilation syndrome: prevalence and predictors in patients with obstructive sleep apnea. *Sleep Breath*. 2007;11,117-124.

5. Straus SE, McAlister FA, Sackett DL, Deeks JJ. The accuracy of patient history, wheezing, and laryngeal measurements in diagnosing obstructive airway disease. *JAMA*. 2000;283(14):1853-7.

6. McAlister FA, Khan NA, Straus SE, et al. Accuracy of the preoperative assessment in predicting pulmonary risk after nonthoracic surgery. *Am J Respir Crit Care Med*. 2003;167(5):741-4.

7. Davies RJO and Stradling JR. The relationship between neck circumference, radiographic pharyngeal anatomy, and the obstructive sleep apneoa syndrome. *Eur Respir J*. 1990(3):509-514.

8. Friedman M, Tanyeri H, La Rosa M, et al. Clinical predictors of obstructive sleep apnea. *Laryngoscope*. 1999;109(12):1901-7.

9. Nuckton TJ, Glidden DV, Browner WS and Claman DM. Physician examination: Mallampati score as an independent predictor of obstructive sleep apnea. *Sleep*. 2006;29(7):903-908.

10. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. *Anaesthesia*. 1987;42:487-90.

11. Berry RB, Budhiraja R, Gottlieb DJ, et al. Rules for scoring respiratory events in sleep: Update of the 2007 AASM manual for the scoring of sleep and associated events. *J Clin Sleep Med*. 2012;8(5):597-619.

12. Balachandran JS, Masa JF, Mokhlesi B. Obesity hypoventilation syndrome epidemiology and diagnosis. *Sleep Med Clin*. 2014;9(3):341-7.

Table 1. Summary of study subject characteristics (N = 169).

Age (years), mean ± sd	49	± 14
Age (years), n (%)		
20-29	13	(8)
30-39	35	(21)
40-49	41	(24)
50-59	40	(24)
60-69	28	(17)
70+	12	(7)
Sex, n (%)		
Male	67	(40)
Female	102	(60)
Smoking, n (%)	88	(52)
Hypertension, n (%)	86	(51)
Hypertriglyceridemia, n (%)	31	(18)
Diabetes, n (%)	32	(19)
CAD, n (%)	15	(9)
COPD, n (%)	15	(9)
Hypothyroidism, n (%)	20	(12)
Weight (kg), mean ± sd	101	± 28
Height (cm), mean ± sd	169	± 9
BMI (kg/m^2), mean ± sd	35.5	± 9.7
Obesity, n (%)		
Normal weight*	19	(11)
Overweight	33	(20)
Obese	117	(69)
Neck circumference (cm), mean ± sd	38.1	± 4.3
Laryngeal height (cm), mean ± sd	4.7	± 1.2
Mallampati score, n (%)		
1	6	(4)
2	8	(5)
3	43	(25)
4	112	(66)

sd: standard deviation.
(*) Includes 1 underweight patient (BMI 17.9 kg/m^2).

Table 2. Summary of sleep study parameters.

Apnea Hypopnea Index (AHI), geometric mean [iqr]	6.5	[15.4]
Apnea Hypopnea Index (AHI), n (%)		
<5 (no sleep apnea)	64	(38)
5-14.9 (mild)	41	(24)
15-29.9 (moderate)	39	(23)
30+ (severe)	25	(15)
Bicarbonate (CO2 mmol/L),* mean ± sd	26.0	± 3.1
Bicarbonate (CO2 mmol/L),* n (%)		
24-32 (normal)	99	(99)
>32 (abnormal)	1	(1)
Baseline SaO_2 (%),** mean ± sd	97.4	± 1.9
Baseline SaO_2 (%),** n (%)		
>96% (normal)	127	(78)
≤96% (abnormal)	35	(22)
Nadir SaO_2 (%), mean ± sd	83.6	± 9.3
Nadir SaO_2 (%), n (%)		
>90% (normal)	35	(21)
85-90% (mild)	49	(29)
75-85 (moderate)	64	(38)
<75 (severe)	21	(12)

iqr: interquartile range. sd: standard deviation.
(*) Measurements available only for 100 of the 169 patients.
(**) Measurements available only for 162 of the 169 patients.

Table 3. Main results for the association of laryngeal height and neck circumference with each of the four sleep study parameters.

	AHI	**Bicarbonate (mmol/L)**	**Baseline SaO_2 (%)**	**Nadir SaO_2 (%)**
Laryngeal height				
Unadjusted effect*	0.87	-0.05	0.1	0.8
Adjusted effect*	0.97	0.20	0.0	0.1
(95% CI)	(0.82, 1.14)	(-0.36, 0.76)	(-0.2, 0.2)	(-0.9, 1.2)
p-value	0.689	0.489	0.920	0.822
Neck circumference				
Unadjusted effect*	1.20	0.15	-0.2	-0.8
Adjusted effect*	1.07	-0.05	-0.1	-0.1
(95% CI)	(1.00, 1.16)	(-0.26, 0.16)	(-0.2, 0.0)	(-0.6, 0.3)
p-value	0.055	0.652	0.111	0.618

CI: confidence interval.
(*) Effect denotes the impact of an increment of 1 cm in laryngeal height or neck circumference, and is expressed as geometric mean ratio for AHI and as mean difference for the remaining parameters. The adjusted effects are from models that included both laryngeal height and neck circumference, as well as age, sex, smoking, height, BMI, and Mallampati score.

Table 4. Joint association of neck circumference and laryngeal height with each of the four sleep study parameters.

Neck circumference	Laryngeal height		AHI	Bicarbonate (mmol/L)	Baseline SaO_2 (%)	Nadir SaO_2 (%)
		N	*Geom Mean*	*Mean*	*Mean*	*Mean*
ALL	<4 cm	32	9.6	26.3	97.1	82.3
	≥4 cm	137	6.0	25.9	97.5	83.9
<40 cm	ALL	109	4.1	25.7	97.8	85.7
≥40 cm		60	15.1	26.4	96.8	79.8
<40 cm	<4 cm	20	4.8	25.8	97.6	87.0
<40 cm	≥4 cm	89	4.0	25.7	97.8	85.4
≥40 cm	<4 cm	12	30.4	27.1	96.3	74.4
≥40 cm	≥4 cm	48	12.7	26.3	96.9	81.2
p-value for interaction			0.242	0.665	0.574	0.018

Table 5. Association of other patient characteristics with each of the four sleep study parameters.

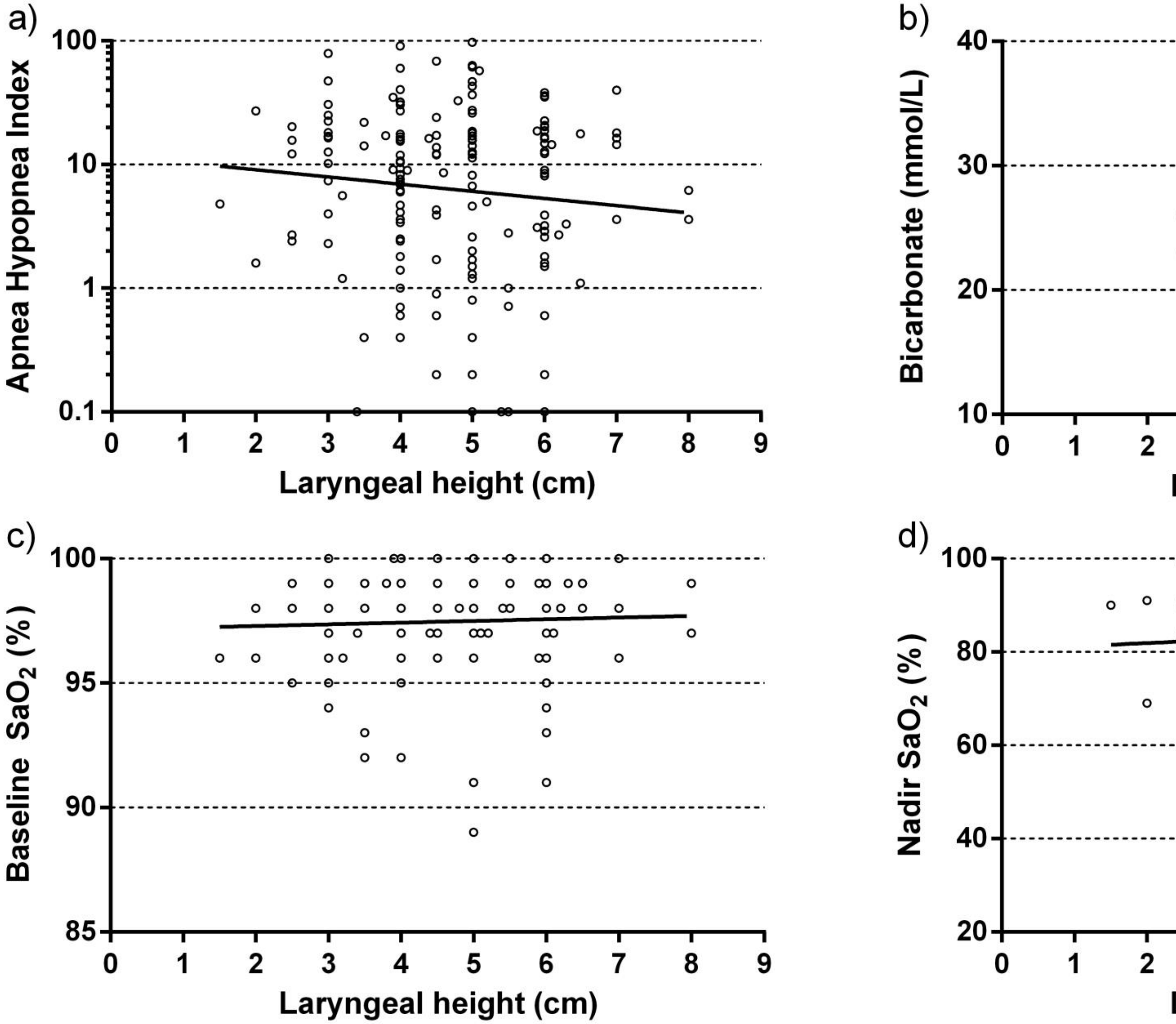
	AHI	Bicarbonate (mmol/L)	Baseline SaO_2 (%)	Nadir SaO_2 (%)
Age (per 10 years)				
Adjusted effect* (p-value)	**1.43** (0.001)	0.32 (0.173)	**-0.3** (0.004)	**-1.3** (0.006)
Sex (female vs. male)				
Adjusted effect* (p-value)	**0.45** (0.013)	**-2.17** (0.028)	0.3 (0.496)	2.5 (0.224)
Smoking (yes vs. no)				
Adjusted effect* (p-value)	1.24 (0.277)	0.37 (0.559)	**-0.6** (0.032)	-1.7 (0.180)
Height (per 10 cm)				
Adjusted effect* (p-value)	1.02 (0.917)	-0.09 (0.841)	-0.1 (0.715)	-0.5 (0.621)
BMI (per 10 kg/m^2)				
Adjusted effect* (p-value)	**1.86** (0.001)	**1.1** (0.011)	**-0.5** (0.017)	**-4.8** (0.001)
Mallampati score (per 1 point)				
Adjusted effect* (p-value)	0.94 (0.666)	-0.11 (0.835)	0.1 (0.795)	1.0 (0.232)

(*) Effect denotes the impact of each variable as shown and is expressed as geometric mean ratio for AHI and mean difference for the remaining parameters. The models also included laryngeal height and neck circumference (the effects of which are shown separately in Table 3).

Figure 1. Unadjusted association between laryngeal height and each of the four sleep study parameters.

[See separate JPEG file for image]

a) Linear regression between laryngeal height and AHI ($p=0.178$).
b) Linear regression between laryngeal height and serum bicarbonate ($p=0.842$).
c) Linear regression between laryngeal height and baseline oxygen saturation ($p=0.539$).
d) Linear regression between laryngeal height and nadir oxygen saturation ($p=0.200$).



a)
Apnea Hypopnea Index
100
10
1
0.1
0 1 2 3 4 5 6 7 8 9
Laryngeal height (cm)
b)
Bicarbonate (mmol/L)
40
30
20
10
0 1 2
c)
Baseline SaO2 (%)
100
95
90
85
0 1 2 3 4 5 6 7 8 9
Laryngeal height (cm)
d)
Nadir SaO2 (%)
100
80
60
40
20
0 1 2