Measurement of Upper Airway, Neck configurations and BMI as a Predictor of OSA Severity

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INTRODUCTION

At the present time, level 1 polysomnography is the gold standard in assessing severity of OSA. However, prompt access to a sleep laboratory is often difficult but necessary in some situation. For instance, pre-operative screening for high risk surgical patients and prediction of OSA severity are important so that appropriate selection of patients for more detailed sleep study can be arranged. Screening methods to estimate the presence of OSA include use of patient's self-reporting questionnaires (e.g. Epworth Scores), and the radiologic measurements of the upper airway (MRI, X-ray or digital imaging) have been documented (1-7). However, these methods have limited sensitivity and specificity, in particularly there is no available method to predict supine AHI, which is often an important measurement of OSA. Upper airway anatomy and BMI are the most important factors in determining severity of OSA(1-7). In this current study, various objective and subjective clinical measurements of the upper airway and neck configurations were analyzed and correlated with AHI. Using a statistical model, an attempt to create an index for simple yet sensitive and specific estimation of OSA severity, especially the severity of OSA in supine position was made.

METHODS

A retrospective, chart review and survey study were performed; analyzing the upper airway and neck parameters of all patients in comparison to the sleep parameters from level 1 polysomnography.

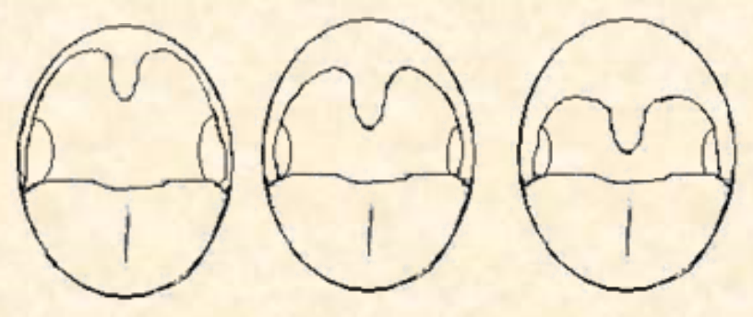
Subjects: Between the years 2013-2015, a total of 457 charts was chosen randomly and reviewed. Then, an additional 200 charts were chosen randomly for sensitivity and specificity analysis.

Polysomnography: Standard level 1 overnight polysomnography was collected on the subjects. All signals were collected and analyzed on a computerized polysomnography system (Sandman, Natus, Ottawa, Ontario, Canada). Sleep stages were scored in 30-s epochs using the AASM sleep scoring criteria. AHI was defined as the number of apneas and hypopneas per hour of sleep. Severity of sleep apnea was classified according to recommendations by the American Academy of Sleep Medicine.

Parameter Studied: There were total of nine measurements collected, includes five upper airway and three head and neck parameters and BMI.

Thickness and degree of palatal droop (PD) - subjective scores 0-3;

- Score 0: Normal degree
- Score 1: Mild degree of drooping
- Score 2: Moderate degree of drooping
- Score 3: Severe degree of drooping

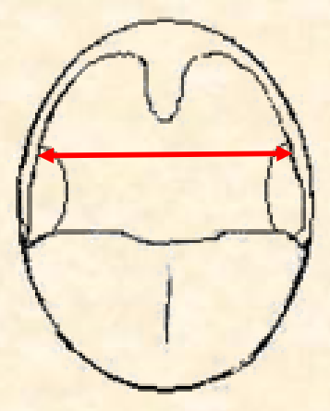


Tonsil size (T) – subjective scale using Friedman's Tonsillar Hypertrophy Grading Scale.

- Tonsil 0: Tonsils fit within tonsillar fossa
- Tonsil 1+: Tonsils <25% of space between pillars
- Tonsil 2+: Tonsils <50% of space between pillars
- Tonsil 3+: Tonsils <75% of space between pillars
- Tonsil 4+: Tonsils >75% of space between pillars

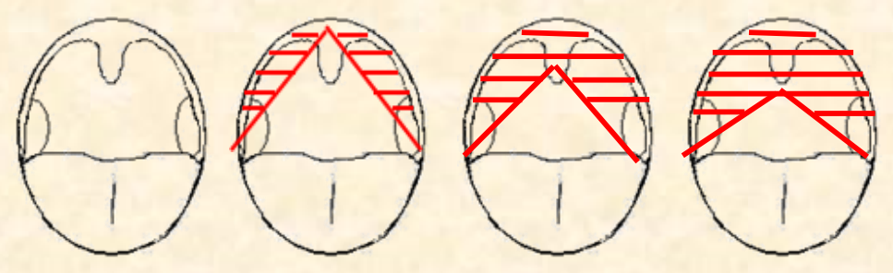
Palatal width (PW) - midpoint of the palatal arch, at the oropharynx (0-4),

- Scale 0: >= 35 mm
- Scale 1: ~ 30 mm
- Scale 2: ~ 25 mm
- Scale 3: ~20 mm
- Scale 4: <=15 mm



Presence and degree of posterior palatal webbing (Pweb) - subjective measurement of posterior palatal folds and webs (0-3);

- Score 0: Normal
- Score 1: Mild degree of narrowing
- Score 2: Moderate degree of narrowing
- Score 3: Severe degree of narrowing



Mallampati scores (M) – subjective scores 1-4;

Neck length (N) - from the angle of jaw to clavicle in cm;

Submental fat content (SF)- using skinfold calipers, in mm ;

Mandibular distance (Md)– in cm – distance from mandibular angle to anterior mentum

Body Mass Index (BMI)

Statistical analysis: A set of regression analysis was performed for each parameter for both average AHI and supine AHI. Furthermore, multiple regression was performed to analyze the statistic interaction between all parameters in comparison to average AHI and supine AHI. All data analyses were performed using the statistical package, IBM SPSS for Windows v.21. A p-value of <.05 was taken as significant.

RESULTS

AVERAGE AHI & MEASURED PARAMETERS

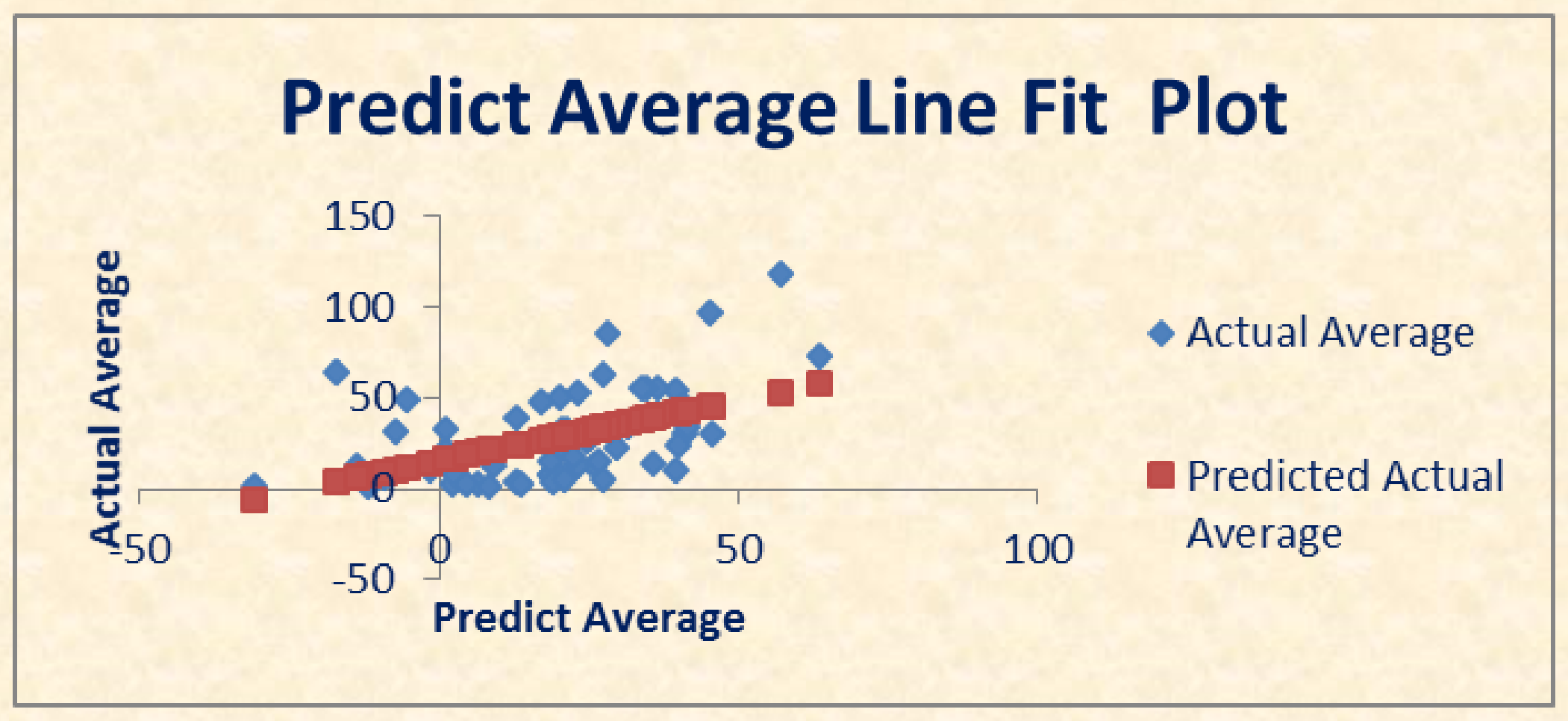
Significant correlations were observed between average AHI and several upper airway and neck configuration parameters measured (Tonsil size - T, Palatal Width- PW, Posterior Pillar Webbing - Pweb, Mallampati score -M, Submental fat– SF, Mandibular distance– Md, and BMI)

Multiple Regression Analysis:

	Coefficients	P-Value
Intercept	-52.395	0.000
Tonsil Size	2.829	0.014
Palatal Width	3.518	0.020
Posterior Pillars	8.996	0.000
Mallampati Score	8.080	0.000
Submental Fat	0.260	0.001
Mandible Distance	0.611	0.004
BMI	0.823	0.000

Using a combination of the measured parameters, an equation to estimate average AHI is established:

Estimated Average AHI= 2.829(T) + 3.518(PW) + 8.996(Pweb) + 8.080(M) + 0.260(SF) + 0.611(Md) + 0.823(BMI) -52.395



Sensitivity & Specificity Analysis:

Moderate OSA (n = 200)

	AHI>15	AHI<15
Positive	101	57
Negative	4	38
Sensitivity	**96.190**	
Specificity	**40**	

SUPINE AHI & MEASURED PARAMETERS

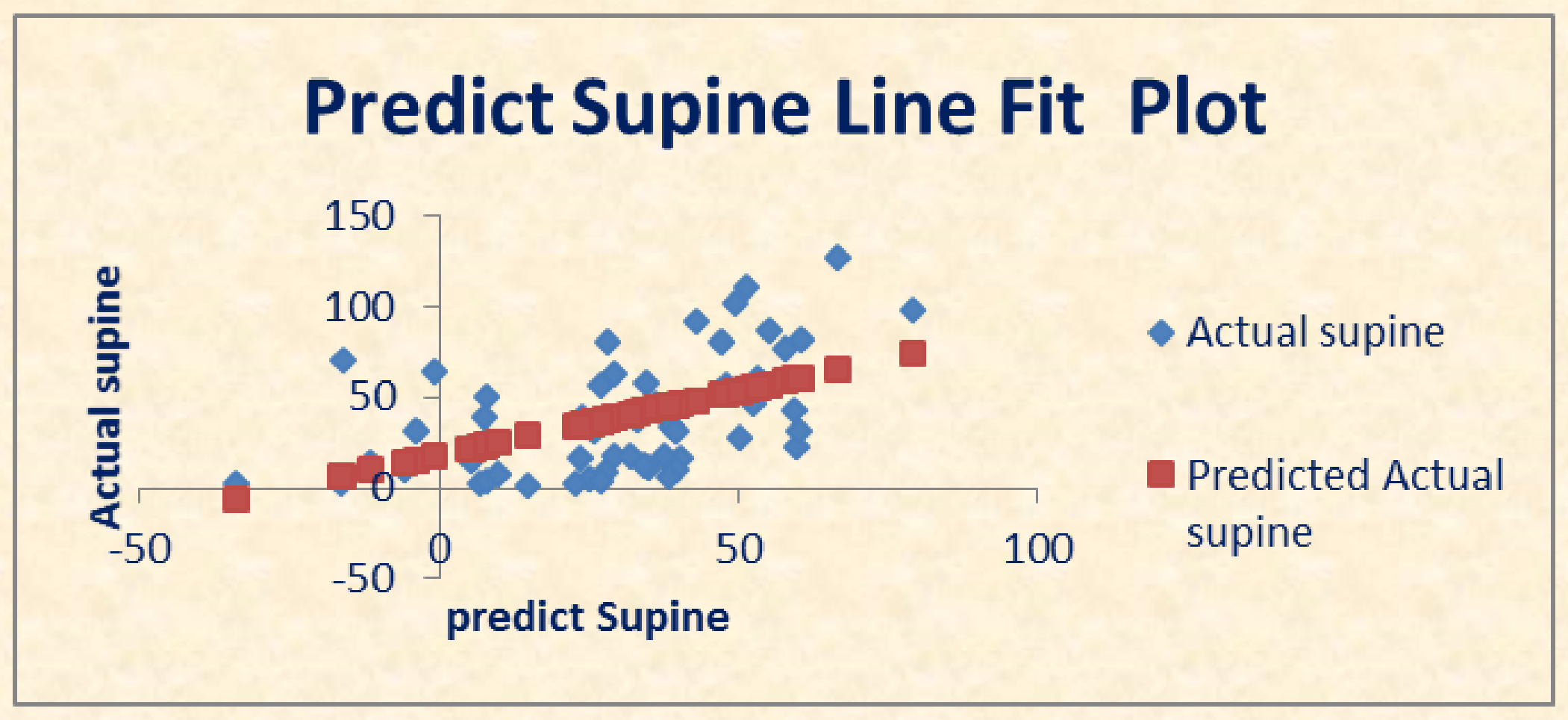
On the other hand, Posterior Pillars (Pweb), Mallampati score (M.), submental fat (SF.), Mandibular distance (Md) and BMI were found to be significantly correlated with supine AHI. Tonsil sizes and the width of the palatal did not significantly affect severity of OSA in supine sleep.

Multiple Regression Analysis:

	Coefficients	P-Value
Intercept	-60.909	0.000
Posterior Pillars	14.073	0.000
Mallampati Score	12.682	0.000
Submental Fat	0.323	0.001
Mandible Distance	0.652	0.017
BMI	1.110	0.000

Similarly, an equation to estimate supine AHI is established:

Estimated Supine AHI = 14.073 (Pweb) + 12.682 (M) + 0.323(SF.) + 0.652 (Md.) + 1.110 (BMI) -60.909



Sensitivity & Specificity Analysis:

Supine Moderate OSA (n = 200)

	AHI>15	AHI<15
Positive	130	52
Negative	2	16
Sensitivity	**98.484**	
Specificity	**23.529**	

CONCLUSION

The ability to predict and screen for the presence and severity of OSA is important so that more detailed sleep study and better planning to minimize complications can be initiated promptly. Screening methods such as Epworth Scores are limited by their low sensitivities and specificities. Furthermore, there is currently no method available to predict presence or severity of supine sleep apnea. Narrowing of the upper airway (nasopharynx and oropharynx airways) is known to be one of the important factors contributing to the severity of OSA. A simple and accurate clinical method to measure the upper airway so that the presence and severity of OSA, particularly supine position related apnea, can be estimated would be helpful. The results from this study confirm that several upper airway and neck configuration parameters correlate strongly with AHI and OSA severity. For instance, the configuration of the soft palate particularly the palatal width, presence of posterior pillars webbing, tonsil sizes, Mallampati score, submental fat content and mandible distance in combination with BMI significantly correlate with the average AHI. An equation based on these parameters can then be used to predict the degree of AHI with a sensitivity of 96.190% and specificity of 40% in predicting average AHI. Similarly, supine AHI can be estimated by measuring presence of posterior pillars webbing, Mallampati score, submental fat content, mandible distance and BMI and the sensitivity and specificity of predicting supine AHI were 98.484% and 23.52% respectively. These upper airway and neck parameters can be easily measured clinically without the need for special tools. Based on the average AHI, particularly supine AHI, estimated from the formula, a clinician can take appropriate further actions including proceeding to more detailed level 1 PSG study promptly.

REFERENCES

1. Moorthy, N., Reddy, P., Aruna, T. and Chander, D. (2014). Role of Magnetic Resonance Imaging Cephalometry in Obstructive Sleep Apnea. Indian Journal of Chest Disease Allied Science, 56, 157-159.
2. Albajalan, O., Samsudin, A. and Hassan, R. (2011). Craniofacial Morphology of Malay Patients with Obstructive Sleep Apnea. European Journal of Orthodontics, 33, 509 - 514
3. Gungor, A., Turkkahraman, H., Yilmaz, H. and Yariktas, M. (2013). Cephalometric Comparison of Obstructive Sleep Apnea patients and Healthy Controls. European Journal of Dentistry, 7, 48-54.
4. Banhiran, W., Wanichakorntrakul, P., Metheetrairut, C., Chiewvit, P. and Planuphap, W. (2013). Lateral Cephalometric Analysis and the risks of Moderate to Severe Obstructive Sleep-Disordered Breathing in Thai Patients. Sleep Breath, 17, 1249-1255.
5. Svaza, J., Skagers, A., Cakarne, D. and Jankovska, I. (2011). Upper Airway Sagittal Dimensions in Obstructive Sleep Apnea (OSA) Patients and Severity of Diseases. Stomatologija, Baltic Dental and Maxillofacial Journal, 13, 123-127.
6. Leitzen, K., Brietzke, S., and Lindsay, R. (2014). Correlation Between Nasal Anatomy and Objective Obstructive Sleep Apnea Severity. American Academy of Otolaryngology— Head and Neck Surgery, 150, 325-331.
7. Yucel, A., Unlu, M., Haktanir, A., Acar, M. and Fidan, F. (2005). Evaluation of Upper Airway Cross-sectional Area Changes in Different Degrees of Severity of Obstructive Sleep Apnea Syndrome: Cephalometric and Dynamic CT Study, 26, 2624-2629.

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