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Craniofacial Morphology of Croatian Patients with Obstructive Sleep Apnea

Neven Vidović[1], Senka Meštrović[2], Zoran Đogaš[3], Dino Buković[4], Ivan Brakus[5], Ratka Borić Brakus[6] and Ivan Kovačić[7]

[1] University of Split, School of Medicine, Study of Dental Medicine, Department of Orthodontics, Split, Croatia
[2] University of Zagreb, School of Dental Medicine, Department of Orthodontics, Zagreb, Croatia
[3] University of Split, School of Medicine, Department of Neuroscience, Split, Croatia
[4] University of Zagreb, School of Dental Medicine, Department of Prosthodontics, Zagreb, Croatia
[5] University of Split, School of Medicine, Study of Dental Medicine, Department of Oral Surgery, Split, Croatia
[6] University of Split, School of Medicine, Study of Dental Medicine, Department of Prosthodontics, Split, Croatia
[7] University of Split, School of Medicine, Study of Dental Medicine, Department of Prosthodontics, Split, Croatia

A B S T R A C T

Currently, there is no information available regarding craniofacial morphology of Croatian patients with obstructive sleep apnea (OSA). The aim of the study was to determine the craniofacial characteristics of patients with OSA and to assess the association of cephalometric and anthropometric variables related to craniofacial morphology with the apnea hypopnea index (AHI). Anthropometric measurements and upright lateral cephalometric radiographs were obtained from 20 male patients with OSA and 20 male controls. The 20 OSA patients were classified into two groups on the basis of body mass index (BMI) as obese and non-obese. Twenty three variables were identified and calculated for each cephalometric radiograph. OSA was defined as AHI ≥ 5/hour. The OSA patients showed greater body mass index (BMI), neck circumference (NC) and cranial index (CI) and lower facial index (FI) compared to the controls (p<0.01). The patients with OSA showed significant cephalometric features as opposed to the controls: smaller linear distance between gonion and menton and anterior cranial base, greater linear distance from the hyoid bone to the mandibular plane, and from the posterior nasal spine to the tip of the soft palate. Furthermore, they showed reduced upper airway width at two levels: the nasopharynx, and the region of posterior airway space, smaller linear distance from the hyoid bone to the posterior wall of the nasopharynx and greater upper airway length. They also displayed significantly increased craniocervical angulation, larger angle between supramentale, menton and hyoid bone and larger angle between posterior nasal spine, supramentale and hyoid bone. The obese OSA patients showed greater neck circumference (NC) compared with the non--obese OSA. The obese OSA patients showed significant cephalometric features compared with the non-obese OSA patients: larger craniocervical angles larger angle between the third cervical vertebra, the centre of sella turcica and the posterior nasal spine, furthermore, greater linear distance between the hyoid bone and the third cervical vertebra and smaller linear distance from the hyoid bone to the posterior wall of the nasopharynx. In our study, AHI was significantly correlated with cephalometric measurements S-Go, S-H, H-C3 and S-PNS-C3.

***Key words**: cephalometry, sleep apnea, obstructive, anthropometry*

Introduction

Obstructive Sleep Apnea (OSA) is associated with the excessive drowsiness during the day or with at least two of the following symptoms: sudden awakening with a sensation of suffocation, insufficiently refreshing sleep, tiredness during the day and problems in the cognitive sphere. Apnea can be defined as an interruption of breathing during sleep, with persistence of thoracic and/or abdominal movements associated with the decrease in oxygen tension and a consequent arterial hemoglobin oxygen desaturation[1]. Clinic-based studies have shown that the ratio of male to female patients referred for clinical evaluation ranges from 5 to 8:1[2]. Epidemiologic studies

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have confirmed a higher prevalence of obstructive sleep apnea in men but report a lower male-to-female ratio in the range 2 to 3:1[3–6]. Repetitive occlusion of the upper airway during sleep is correlated with the increased morbidity and mortality from cardiovascular complications in adults[7–9]. Ethnicity may have an impact on the prevalence of OSA and differences in associations of OSA with obesity and craniofacial measures among races have been suggested[10–13]. Obesity was considered as the major risk factor in Caucasian populations while craniofacial factors were more significant than obesity and soft tissue factors in Asians[14]. The pathophysiology of OSA involves factors that relate to the anatomic dimensions of the upper airway, upper airway resistance, and upper airway muscle activity during sleep[15]. Cephalometric studies have identified skeletal and soft tissue abnormalities in sleep apnea patients. When compared with normal controls, these patients have short anterior cranial bases, elongated soft palates, large tongues, retrognathic maxillas and mandibles, severe overjets, long anterior facial heights, inferiorly positioned hyoid bones and narrow posterior airway spaces[16–21]. Skeletal craniofacial abnormalities seem to be more clearly associated with OSA in non-obese patients whereas the obese OSA patients had more abnormalities in the upper airway soft tissue morphology, head posture and position of the hyoid bone[22–25].

The aim of the study was to determine the craniofacial characteristics of patients with OSA and to assess the association of cephalometric and anthropometric variables related to the craniofacial morphology with the apnea hypopnea index (AHI).

TABLE 1
VALUES OF CRANIOFACIAL TYPES

Cranial index		Facial index	
Dolichocephalia	71.0–75.9	Euriprosopia	79.0–83.9
Mesocephalia	76.0–80.9	Esoprosopia	84.0–87.9
Brachycephalia	81.0–85.4	Leptoprosopia	88.0–92.9

Materials and Methods

Subjects

The subjects in the present study consisted of 20 Croatian male patients who attended the Department of Neuroscience Medicine Sleep Laboratory at the Split University Hospital Centre, in Split, for investigation of OSA. The control group comprised 20 non-obstructed male patients with no history of snoring, excessive daytime sleepiness, upper airways problems, or health-related complaints. The Ethics Committee of the School of Dental Medicine at the University of Zagreb, approved the study. Written and informed consents were taken for all subjects.

Anthropometric measurements and upright lateral cephalometric radiographs were obtained on 20 male patients with OSA and 20 controls. The 20 OSA patients were classified into two groups on the basis of body mass index (BMI) as obese (BMI ≥ 28 kg/m^2) and non-obese (BMI < 28 kg/m^2). Consequently, the OSA patients were examined and compared with a control group of 20 healthy males. All patients underwent a history and physical examination with measurements of anthropometric parameters and craniofacial structure including height (m) and weight (kg), enabling the calculation of body mass index – BMI (kg/m^2) and neck circumference (cm). OSA was defined as an apnoea-hypopnoea index (AHI) ≥ 5/hour on a full overnight polysomnography.

Anthropometric Measurements

Measurements of basic craniofacial parameters were taken directly on the patients by cephalometer GPM Instruments, Zurich, Switzerland, and defined by cephalometric points according to Martin and Saler [26]: G (glabela), OP (opisthocranion), EU (eurion), ZY (zigion), Gn (gnation).

The subjects were asked to sit on a chair in a relaxed condition with their heads in anatomical position. On the

TABLE 2
DEFINITIONS OF LINEAR MEASUREMENTS AND ANGLE MEASUREMENTS

Measurements	Definitions
SNA (°)	angle formed between the SN line to A
SNB (°)	angle formed between the SN line to B
ANB (°)	angle formed between the AN and NB lines
S-N (mm)	linear distance between S and N
ANS-PNS (mm)	linear distance between ANS and PNS
MP (mm)	linear distance between Me and Go
S-Go (mm)	linear distance between S and Go
N-Me (mm)	linear distance between N and Me
PV-A (mm)	linear distance between PV and A
OPT-NSL (°)	angle between the odontoid process tangent (OPT) and the NSL line
CVT-NSL (°)	angle between the cervical vertebrae tangent (CVT) and the NSL line
B-Me-H (°)	angle between B, Me and H
MP-H (mm)	perpendicular linear distance from H to MP
S-H (mm)	linear distance between S and H
H-C3 (mm)	linear distance between H and C3
H-Ppw (mm)	linear distance between H and Ppw
PNS-PPW (mm)	linear distance between PNS and PPW
C3-S-PNS (°)	angle between C3, S and PNS
PNS-B-H (°)	angle between PNS, B and H
S-PNS-C3 (°)	angle between S, PNS and C3
PAS (mm)	linear distance between Tb and Ppw, both determined by an extension of a line from point B through Go
UAL (mm)	linear distance between the PNS and H
PNS-P (mm)	linear distance between PNS and soft palate tip

TABLE 3
DEFINITIONS OF CEPHALOMETRIC LANDMARKS AND REFERENCE LINES

S (sella)	the centre of sella turcica (Broadbent, 1975.)
N (nasion)	the most anterior point at the frontonasal suture (Broadbent, 1975.)
ANS (anterior nasal spine)	the most anterior point of the nasal spine (Sassouni, 1971.)
PNS (posterior nasal spine)	the most posterior point of the nasal spine (Sassouni, 1974.)
Or (orbitale)	the deepest point on the infra-orbital margin (Björk, 1945.)
Po (porion)	the top of the ear rod's shadows, the external auditory meati (Moyers, 1973.)
PV (porion vertical)	the line from Po perpendicular to the FH line
A (ss, subspinale)	the point at the deepest midline concavity on the maxilla between the anterior nasal spine and prosthion (Downs, 1948.)
B (sm, supramentale)	the point at the deepest midline concavity on the mandibular symphysis between infradentale and pogonion (Björk, 1947.)
Go (gonion)	the constructed point of intersection of the ramus plane and the mandibular plane (Ricketts, 1989.)
Me (menton)	the most inferior midline point on the mandibular symphysis (Graber, 1975.)
P	the lowest point of the soft palate
Tb	the base of the tongue
Ppw	the posterior wall of the nasopharynx
PPW	the point on the posterior pharyngeal wall identified by an extension of the palatal plane (ANS-PNS)(Mazaheri et al., 1977.)
C2 ip	the most inferior and posterior point on the body of the 2^{th} cervical vertebra
C2 sp	the most superior and posterior point on the body of the 2^{th} cervical vertebra
C4 ip	the most inferior and posterior point on the body of the 4^{th} cervical vertebra
C3	the most anterior and inferior point on the body of the 3rd cervical vertebra
H	the most antero-superior point on the body of the hyoid bone (Tallgren and Solow, 1987)
NS (nasion-sella line)	the anterior cranial base – line connecting S and N (Björk, 1947)
FH (Frankfort horizontal line)	a line through Or and Po
NL (nasal line)	a line through ANS and PNS (Björk, 1947)
MP (mandibular plane)	a plane constructed from Me through Go (Björk, 1947)
OPT (odontoid process tangent)	a line across the most superior and posterior point and the most inferior and posterior point of the axis (Björk, 1960)
CVT (cervical vertebra tangent)	a line across the most superior and posterior point of the axis and the most inferior and posterior point of the 4th cervical vertebra (Björk, 1960)
PAS (posterior airway space)	linear distance between a point on the base of the tongue (tb) and another point on the posterior pharyngeal wall (ppwb), both determined by an extension of a line from point B through Go (Riley et al., 1983);
PNS-PPW	linear distance between the point PNS and the intersection point between the palatal plane and the posterior wall of the nasopharynx (PPW) (Mazaheri et al., 1977)
C3-H	linear distance between C3 and H (Bibby and Preston, 1981)
H-Ppw	horizontal position of the hyoid -linear distance between point H and point Ppw (Haralabakis et al. 1993)
UAL	linear distance between the PNS and H

basis of basic measurement data, head and face indexes were calculated according to the formulae: Cranial index (CI) = Eu – Eu x 100 / G – Op, Facial index (FI) = N – Gn x 100 / Zy – Zy. The values of the particular craniofacial types are shown in Table 1.

Cephalometric analysis

All cephalograms were taken by the same x-ray technician with Orthoceph OC200DT, Instrumentarium Dental, Tuusula, Finland with a tube voltage of 85 kV and a tube current of 13 mA at 16 s. The patients were seated upright with a natural head posture in the intercuspal position and they were instructed not to swallow during the cephalometric procedure. Radiographs were taken with the patients exhaling slowly from a deep breath. One of the authors traced all the cephalometric radiographs with no prior knowledge of the polysomnographic results. Twenty-three variables including 15 linear distances and 8 angles are shown in Table 2 and Figure 1. The reference points and lines used in the analysis are shown in Table 3. The reliability of the measure-

TABLE 4
DIFFERENCES BETWEEN DEMOGRAPHIC AND ANTHROPOMETRIC DATA OF THE OBSTRUCTIVE SLEEP APNEA PATIENTS AND CONTROLS

	OSA patients (n=20)				Controls (n=20)				p value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Age (years)	53.85	12.95	35.00	80.00	37.25	14.38	24.00	72.00	0.000**
BMI(kg/m^2)	29.24	3.74	22.21	37.04	25.11	1.03	23.66	27.04	0.000**
AHI	34.92	19.46	16.00	89.90	n/a	n/a	n/a	n/a	n/a
NC	45.02	3.76	39.00	52.00	39.45	2.41	36.00	44.00	0.000**
CI	82.10	5.65	70.00	90.00	76.82	2.89	72.72	82.50	0.001**
FI	82.87	5.82	71.87	96.66	90.31	4.97	81.25	96.66	0.000**

**p<0.01, OSA – obstructive sleep apnea, BMI – body mass index, AHI – apnea – hypopnea index, n/a – not applicable, NC – neck circumference, CI – cranial index, FI – facial index

TABLE 5
DIFFERENCES BETWEEN DEMOGRAPHIC DATA OF THE NON-OBESE AND OBESE OBSTRUCTIVE SLEEP APNEA PATIENTS

	Non-obese OSA patients (n=10)				Obese OSA patients (n=10)				p value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Age (years)	56.55	12.86	41.00	78.00	51.63	13.20	35.00	80.00	0.331NS
BMI(kg/m^2)	26.27	1.99	22.21	27.77	31.68	2.99	28.08	37.04	0.000**
AHI	27.43	6.51	20.00	38.00	41.05	24.37	16.00	89.90	0.503NS
NC	42.18	2.61	39.00	47.00	47.30	2.86	42.00	52.00	0.002**

**p<0.01, *p<0.05, NS – not significant, p>0.05, OSA – obstructive sleep apnea, BMI – body mass index, AHI – apnea – hypopnea index, NC – neck circumference

ments was tested. A total of 15 cephalometric radiographs were traced twice, with a month between the tracings in order to avoid memorization of the anatomical structures. No statistically significant difference was found among measurements for each of the measured variable (p>0.05). The intraclass correlation coefficient (ICC) varied between 0.96 and 0.981, depending on the variable. Therefore, it was assumed that the measurements were reliable and the same observer completed all the measurements. All of the cephalometric tracings were analyzed with a software (Ax. Ceph, Audax, Ljubljana, Slovenia).

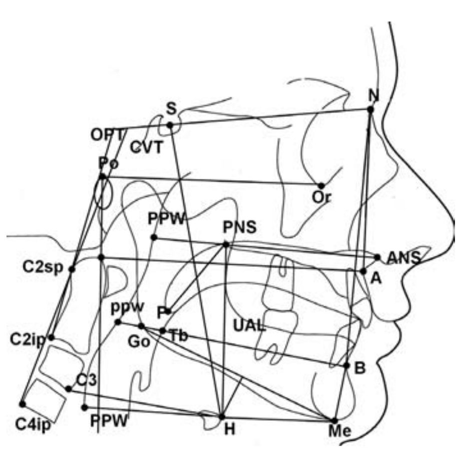

Fig. 1 Cephalometric landmarks, reference lines and linear and angle variables.

Polysomnography

OSA was diagnosed using the overnight polysomnographic studies. Polysomnography (PSG) was performed over the duration of one night on subjects with OSA. The PSG included electroencephalogram (EEG,C3/A2,C4/A1,O2/A1), submental electromyogram (EMG), anterior tibialis EMG, electrocardiogram, oronasal airflow (expired CO2) and arterial oxygen saturation with pulse oximetry. OSA was defined as an apnoea-hypopnoea index (AHI)≥ 5/hour on a full overnight polysomnography.

Statistical analysis

Statistical procedures were performed on the recorded data using the SPSS statistical package (version 15, SPSS, Chicago, IL, USA). One-sample Kolmogorov-Smirnov test was used to check the normality of the distribution. Although the distribution of cephalometric variables obtained in this study was normal, the Mann-Whitney U-test was used to determine if significant craniofacial differences existed between the OSA patients and the controls, and the non-obese and the obese OSA patients, as the sample of patients in this study was rather small. Spearman's rank correlation coefficient (r_s) was used to detect associations between AHI and cra-

TABLE 6
DIFFERENCES IN CEPHALOMETRIC VARIABLES BETWEEN OBSTRUCTIVE SLEEP APNEA PATIENTS AND CONTROL SUBJECTS

Variables	OSA, n=20		Controls, n=20		p value
	X±SD	Median (range)	X±SD	Median (range)	
SNA	82.39±6.59	82.57 (69.92–95.17)	81.97±4.00	81.70 (74.70–95.17)	0.478 NS
SNB	79.09±5.07	78.94 (71.60–90.80)	78.81±3.91	79.00 (72.10–90.80)	0.862 NS
ANB	3.29±3.60	3.33 (–3.44–12.31)	3.16±1.39	3.60 (0.50–4.90)	0.883 NS
S–N	68.68±4.92	69.25 (54.08–78.72)	72.83±2.85	73.40 (66.22–76.30)	0.000**
ANS–PNS	54.01±5.00	53.57 (42.26–67.26)	53.58±2.88	53.05 (49.50–58.40)	0.758 NS
MP	72.23±7.70	73.37 (56.00–83.60)	77.09±3.86	77.25 (71.90–83.90)	0.049*
S–Go	84.75±6.91	85.77 (69.15–101.00)	80.40±8.14	82.60 (67.60–91.00)	0.257 NS
N–Me	121.39±8.74	124.16 (92.53–130.88)	120.14±7.9	117.85 (110.60–132.50)	0.461 NS
PV–A	96.40±11.54	94.45 (78.10–131.26)	93.48±3.20	94.44 (86.50–97.30)	0.640 NS
OPT–NSL	104.42±8.09	104.77 (89.58–115.54)	93.45±9.59	94.20 (79.70–109.01)	0.001**
CVT–NSL	109.01±8.01	108.58 (96.72–123.74)	100.70±12.27	99.60 (83.30–117.10)	0.056 NS
B–Me–H	102.14±7.25	102.36 (85.50–116.46)	96.68±7.31	97.92 (83.90–106.90)	0.038*
MP–H	19.84±5.57	21.18 (8.80–29.17)	15.46±5.69	16.30 (8.50–27.12)	0.040*
S–H	113.19±10.36	115.00 (83.44–129.76)	112.0±15.9	111.30 (104.20–121.00)	0.063 NS
H–C3	36.59±4.16	37.32 (25.97–43.67)	35.06±2.64	35.15 (31.30–39.20)	0.149 NS
H–Ppw	31.40±4.04	31.83 (24.00–37.78)	35.78±2.49	36.10 (30.90–39.20)	0.000**
PNS–PPW	24.34±5.36	24.72 (9.78–38.28)	27.49±5.10	28.50 (9.78–31.90)	0.001**
C3-S-PNS	37.09±6.50	37.72 (19.06–47.57)	34.23±5.75	35.20 (26.80–44.80)	0.102 NS
PNS-B-H	72.71±6.43	73.80 (61.81–84.33)	67.42±8.04	69.55 (52.80–80.00)	0.007**
S-PNS-C3	118.14±4.43	117.11 (107.77–125.66)	119.11±7.76	119.75 (102.20–128.30)	0.277 NS
PAS	8.68±3.90	8.34 (3.41–16.11)	14.23±4.39	14.45 (7.66–21.80)	0.000**
UAL	70.70±7.94	72.11 (49.39–86.39)	66.92±3.94	66.30 (62.30–74.20)	0.030*
PNS-P	42.46±3.95	42.99 (34.47–49.96)	37.11±2.67	36.50 (32.20–43.85)	0.000**

**p<0.01, *p<0.05, NS – not significant, p>0.05

niofacial variables of the OSA patients. The level of significance was set at 95% probability ($p<0.05$).

Results

The demographic and anthropometric data of the OSA patients and the controls are shown in Table 4. The data are shown as mean and standard deviation. In our study the OSA patients showed a greater mean BMI score, neck circumference (NC) and cranial index (CI) and a lower facial index (FI) compared with the control group, which was statistically significant ($p<0.01$). According to the size of the mean value of the variable CI, which amounted to 76.82 in control subjects, it can be concluded that mesocephalia was predominant, compared to the mean value of the variable CI=82.10 in OSA patients, where brachycephalia prevailed. When relative frequencies in control subjects are analyzed, mesocephalia (55.0%) and dolichocephalia (35.0%) were predominant, and brachycephalia (10%) was the least frequent. When relative frequencies in OSA patients are analyzed, brachycephalia (75.0%) and dolichocephalia (15.0%) were predominant and mesocephalia (10%) was the least frequent. According to the size of the mean value of the variable FI, which amounted to 90.31 in control subjects, it can be concluded that leptoprosopia was predominant, compared to the mean value of the variable FI=82.87 in OSA patients, where euriprosopia prevailed. When relative frequencies in control subjects are analyzed, leptoprosopia (50.0%) and esoprosopia (50.0%) were predominant. When relative frequencies in OSA patients are analyzed, euriprosopia (70.0%) was predominant and esoprosopia (15.0%) and leptoprosopia (15%) were the least frequent.

The demographic data of the non-obese and the obese OSA patients are shown in Table 5. The data are shown as mean and standard deviation. In the present study, the obese OSA patients showed 5.12 mm greater mean neck circumference (NC) compared with the non-obese OSA patients, which was statistically significant ($p<0.05$).

The comparison of the results of cephalometric analysis in OSA patients and control subjects are shown in Table 6. The data are shown as mean, standard deviation, median and range.

In the present study, the OSA patients showed significant cephalometric features compared with the controls:

TABLE 7
CORRELATION BETWEEN APNEA HYPOPNEA INDEX AND CEPHALOMETRIC VARIABLES OF OBSTRUCTIVE SLEEP APNEA PATIENTS

Cephalometric variables	Spearman's Correlation (r_s)	p value
SNA	–0.072	0.762 NS
SNB	–0.120	0.613 NS
ANB	–0.150	0.527 NS
S-N	0.155	0.515 NS
ANS-PNS	0.316	0.175 NS
MP	0.059	0.806 NS
S-Go	0.492	0.028*
N-Me	0.420	0.066 NS
PV-A	0.039	0.870 NS
OPT-NSL	0.149	0.531 NS
CVT-NSL	0.156	0.510 NS
B-Me-H	0.071	0.767 NS
MP-H	0.164	0.490 NS
S-H	0.544	0.013*
H-C3	0.454	0.044*
H-Ppw	0.346	0.135 NS
PNS-PPW	0.391	0.088 NS
C3-S-PNS	0.352	0.128 NS
PNS-B-H	0.370	0.108 NS
S-PNS-C3	–0.466	0.038*
PAS	0.271	0.248 NS
UAL	0.335	0.148 NS
PNS-P	0.176	0.458 NS

*$p<0.05$, NS – not significant- $p>0.05$.

smaller median linear distance between gonion and menton (MP, $p<0.05$) and the anterior cranial base (S-N, $p<0.01$), greater median linear distance from the hyoid bone to the mandibular plane (MP-H, $p<0.05$) and from the posterior nasal spine to the tip of the soft palate (PNS-P), reduced median upper airway width at two levels: the nasopharynx (PNS-PPW, $p<0.01$), and the region of posterior airway space (PAS, $p<0.01$), furthermore, smaller median linear distance from the hyoid bone to the posterior wall of the nasopharynx (H-Ppw, $p<0.01$) and greater median upper airway length (UAL, $p<0.05$). They also displayed significantly increased median craniocervical angulation (OPT-NSL, $p<0.01$), a larger median angle between supramentale, menton and hyoid bone (B-Me-H, $p<0.05$) and a larger angle between the posterior nasal spine, supramentale and hyoid bone (PNS-B-H $p<0.01$).

No significant differences were found for other craniofacial variables measured, but the median linear distance between the centre of sella turcica and the hyoid bone (S-H, $p=0.063$) and the angle between the cervical vertebrae tangent (CVT) and the NSL line (CVT-NSL, $p=0.056$) almost reached statistical significance.

Our groups were not matched for body mass index (BMI, $p<0.01$). The BMI was not, however, correlated with any of the cephalometric variables, except for the linear distance from the hyoid bone to the mandibular plane (MP-H, $p<0.01$), so the differences in cephalometric measurements observed between the groups are unlikely to have been influenced by this variable.

The correlation between the AHI and cephalometric variables of OSA patients are shown in Table 7. A significant correlation was found with the posterior facial height (S-Go, $p<0.05$), the linear distance between the centre of sella turcica and the hyoid bone (S-H, $p<0.05$), the linear distance between the hyoid bone and the third cervical vertebra (H-C3, $p<0.05$) and the angle between the centre of sella turcica, the posterior nasal spine and the third cervical vertebra (S-PNS-C3, $p<0.05$).

The comparison of the results of cephalometric analysis in non-obese and obese OSA patients are shown in Table 8. The data are shown as mean, standard deviation, median and range. The obese OSA patients showed significant cephalometric features compared with the non-obese OSA patients: larger median craniocervical angles (NSL-CVT, NSL-OPT, $p<0.05$), and larger median angle between the third cervical vertebra, the centre of sella turcica and the posterior nasal spine (C3-S-PNS $p<0.01$), furthermore, greater median linear distance between the hyoid bone and the third cervical vertebra (H-C3, $p<0.05$) and smaller linear distance from the hyoid bone to the posterior wall of the nasopharynx (H-Ppw, $p<0.01$).

Discussion and Conclusion

It is really difficult to obtain a large sample of OSA patients in the Sleep Laboratory at the Split University Hospital Centre, who are diagnosed by the same clinician and who have cephalograms taken on the same equipment by the same x-ray technician. The present sample was obtained over a 10-month period and represents a consecutive selection of patients seen at the Sleep Laboratory who gave permission to be included in the study.

Davies et al.[27] and Katz et al.[28] reported that NC and BMI are the only physical examination characteristics that are consistently predictive of OSA. Differences in the size and the shape of the cranium and cranial base actually form the anatomic basis for subsequent variations in facial and upper airway morphology. Brachycephalic head forms are wider in the biparietal dimension and shorter in the anterior-posterior (occipital-frontal) dimension (CI>81.0). This head form is associated with a cranial base that is wider and shorter. Because the face is built on the cranial base, brachycephalic persons usually have wider and shorter (euryprosopic) facial forms. Dolichocephalic subjects exhibit a narrower biparietal width and relatively longer anterior-posterior length (CI<75.9), resulting in a cranial base that is also narrower and longer and a long-thin (leptoprosopic) facial form[29].

TABLE 8
DIFFERENCES IN CEPHALOMETRIC VARIABLES BETWEEN NON-OBESE AND OBESE OBSTRUCTIVE SLEEP APNEA PATIENTS

Variables	Non-obese OSA, n=10		Obese OSA, n=10		p value
	X±SD	Median (range)	X±SD	Median (range)	
SNA	84.24±4.81	84.72 (77.00–92.00)	80.00±7.65	80.74 (69.92–95.17)	0.295 NS
SNB	79.27±3.51	79.56 (74.93–86.48)	78.95±6.24	76.61 (71.60–90.80)	0.503 NS
ANB	4.97±3.47	3.96 (0.15–12.31)	1.92±3.22	2.04 (–3.44–7.35)	0.112 NS
S-N	69.42±6.68	69.50 (54.08–78.72)	68.08±3.08	68.12 (63.66–73.39)	0.261 NS
ANS-PNS	54.73±6.93	53.13 (42.26–67.26)	53.42±2.88	54.01 (48.79–57.23)	0.766 NS
MP	72.57±7.72	74.22 (56.00–81.01)	71.96±8.05	71.71 (58.57–83.60)	0.656 NS
S-Go	83.14±7.90	86.00 (69.15–91.96)	86.06±6.06	85.55 (79.26–101.00)	0.710 NS
N-Me	120.28±11.34	124.33 (92.53–130.54)	122.31±6.33	124.00 (110.18–130.88)	0.824 NS
PV-A	96.71±10.86	99.30 (78.10–111.25)	96.15±12.60	94.43 (82.93–131.26)	0.603 NS
OPT-NSL	100.05±7.52	100.32 (89.58–112.85)	108.00±6.92	110.23 (96.07–115.54)	0.031*
CVT-NSL	105.54±6.60	105.27 (96.72–115.84)	111.85±8.21	113.31 (97.53–123.74)	0.046*
B-Me-H	101.57±4.34	102.15 (95.41–108.00)	102.61±9.18	103.51 (85.50–116.46)	0.656 NS
MP-H	18.12±5.87	20.19 (8.80–27.15)	21.24±5.16	22.85 (13.71–29.17)	0.201 NS
S-H	113.50±12.90	114.62 (83.44–129.76)	112.94±8.40	115.39 (97.73–122.13)	0.941 NS
H-C3	34.29±4.59	34.59 (25.97–41.87)	38.48±2.70	37.46 (34.29–43.67)	0.020*
H-Ppw	28.21±3.13	27.33 (24.00–32.73)	34.01±2.57	34.45 (29.95–37.78)	0.001**
PNS-PPW	24.30±3.13	23.95 (20.35–28.31)	24.37±6.83	25.49 (9.78–38.28)	0.916 NS
C3-S-PNS	33.31±7.25	36.75 (19.06–39.85)	40.18±3.85	40.78 (33.024–7.57)	0.007**
PNS-B-H	72.23±4.90	72.41 (65.69–80.44)	73.10±7.68	75.62 (61.81–84.33)	0.710 NS
S-PNS-C3	119.78±2.96	119.75 (116.11–123.98)	116.80±5.09	115.91 (107.77–125.66)	0.056 NS
PAS	7.14±4.03	5.74 (3.41–14.95)	9.93±3.48	9.45 (4.69–16.11)	0.056 NS
UAL	68.91±10.01	67.34 (49.39–86.39)	72.16±5.85	72.74 (63.44–81.09)	0.456 NS
PNS-P	43.55±4.06	43.04(36.93–49.96)	41.58±3.82	42.95 (34.97–46.12)	0.412 NS

OSA – obstructive sleep apnea, $**p<0.01$, $*p<0.05$, NS – not significant – $p>0.05$

In the present study the median cranial index was increased and the median facial index decreased in subjects with OSA, which was statistically significant ($p<0.01$). Cakirer et al.[30] concluded that brachycephaly is associated with an increased AHI in whites.

Tangugsorn et al.[31], Lee et al.[11] and Sakakibara et al.[17] found a significant reduction in the anterior cranial base length (S–H) in OSA patients. Flexion or extension of the head has been postulated by Hellsing[32] to influence the dimension of the oropharyngeal airway. Craniocervical angulation of OSA patients in the standing position was significantly greater in OSA subjects than in controls in the studies of Solow et al.[33], Tangugsorn et al.[31] and Li et al.[34]. The hyoid bone position has been found to be more inferior than normal in relation to the mandibular plane in OSA subjects in the studies of Hui et al.[35], Albajalan et al.[36] and Johal et al.[37]. The results of this study are consistent with the results of those studies. Sforza et al.[38] consider that obesity, through the depositing of fat around the neck, could be the cause of the inferior position of the hyoid bone. The view regarding an inferiorly positioned hyoid bone and an extended head position suggests that, rather than predisposing factors, these are physiological adaptations to lift away the base of the tongue and the soft palate from the posterior pharyngeal wall in order to alleviate the obstructive condition[39,40]. Susarla et al.[41] reported that UAL ≥ 72 mm for males were significantly associated with the presence of OSA. In the present study, the OSA patients showed significantly greater median upper airway length compared with the controls, ($p<0.05$).

Sakakibara et al.[17] concluded that in obese patients, the upper airway soft tissue enlargement may play a more important role in the development of obstructive sleep apnea, whereas in non-obese patients, the bony structure discrepancies may be the dominant contributing factors for obstructive sleep apnea.

In the study of Chang and Shiao[42] the measurements of the hyoid bone to the mandibular plane and the posterior nasal spine to the velum tip, were positively related to the AHI. Aihara et al.[43] found a significant correlation between the AHI and the distance from the hyoid bone to the mandibular plane. Hou et al.[44] found that lower posterior facial height, mandibular body length, craniocervical extension and sella-hyoid distance were the significant predictive variables for AHI. In our study AHI was significantly correlated with cephalometric measurements S-Go ($p<0.05$), S-H ($p<0.05$), H-C3 ($p<0.05$), and S-PNS-C3 ($p<0.05$).

In the present study, we have introduced three new skeletal variables, angles C3-S-PNS, PNS-B-H and S-PNS-C3. The C3-S-PNS variable is set in relation to the horizontal position of the most anterior and the most inferior point on the body of the 3rd cervical vertebra and posterior nasal spine. The PNS-B-H variable is set in relation to the mandibular and hyoid bone vertical position. The change of the angle S-PNS-C3 depends on the horizontal position of the point PNS. The OSA patients showed significantly increased angle PNS-B-H compared with the controls. The obese OSA patients showed a larger angle C3-S-PNS compared with the non-obese OSA patients.

We can conclude that OSA patients and control subjects have differences in craniofacial morphology.

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N. Vidović

University of Split, School of Medicine, Study of Dental Medicine, Šoltanska 2, 21000 Split, Croatia
e-mail: neven.vidovic2@st.t-com.hr

KRANIOFACIJALNA OBILJEŽJA HRVATSKIH PACIJENATA S OPSTRUKTIVNOM APNEJOM U SPAVANJU

SAŽETAK

Trenutačno ne postoje informacije o kraniofacijalnoj morfologiji hrvatskih pacijenata s opstruktivnom apnejom u spavanju (OAS). Istraživanje je imalo za cilj rentgenkefalometrijskom i antropometrijskom analizom utvrditi kraniofacijalna obilježja pacijenata s opstruktivnom apnejom u spavanju i njihovu povezanost s apnea hypopnea indeksom

(AHI). Kod 20 muških OAS pacijenata i 20 kontrolnih muških ispitanika uzete su antropometrijske mjere i analizirane 23 varijable na latero-lateralnom rentgenkefalogramu. Prema indeksu tjelesne mase (BMI) 20 OAS pacijenata podijeljeno je na dvije grupe, pretile i nepretile. OAS je definirana kad je AHI ≥ 5/h. U usporedbi OAS pacijenata i kontrolnih ispitanika uočena je povišena vrijednost BMI, opsega vrata (OV) i indeksa glave (IG), a smanjena vrijednost indeksa lica (IL) kod OAS pacijenata. OAS pacijenti su pokazali statistički značajne razlike u rentgenkefalometrijskim varijablama prema kontrolnim ispitanicima: smanjenu dužinu mandibularne ravni i prednje kranijalne baze, povećanu udaljenost jezične kosti od mandibularne ravni, povećanu duljinu mekog nepca, smanjenu širinu gornjeg dišnog puta na dvije razine: u nazofarinksu i području stražnjeg dišnog puta, smanjenu udaljenost jezične kosti od stražnjeg zida nazofarinksa, povećanu duljinu gornjeg dišnog puta, povećanu kraniocervikalnu angulaciju, povećan kut između točaka supramentale, menton i jezične kosti, povećan kut između točaka spina nasalis posterior, supramentale i jezične kosti. Pretili OAS pacijenti su pokazali povećani OV u usporedbi s nepretilim OAS pacijentima i statistički značajne razlike u rentgenkefalometrijskim varijablama prema nepretilim OAS pacijentima: povećane kraniocervikalne kuteve, povećan kut između trećeg vratnog kralješka, centra selle turcice i spine nasalis posterior, povećanu udaljenost između jezične kosti i trećeg vratnog kralješka, smanjenu udaljenost između jezične kosti i stražnjeg zida nazofarinksa. U ovoj studiji utvrđena je statistički značajna korelacija između AHI i rentgenkefalometrijskih varijabli: S-Go, S-H, H-C3 i S-PNS-C3.