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Correlation between craniofacial parameters and obstructive sleep apnea syndrome in Iranian population

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Objectives As craniofacial and anthropometric parameters seem to affect this disease and these parameters differ between ethnicities, this study was aimed to assess these correlations in Iranian population.
Methods This cross-sectional study was done on 73 patients who were referred to Baharloo hospital for overnight polysomnography in order to approve OSAS. Meanwhile, their craniofacial and anthropometric indices including weight, height, neck circumference, waist circumference, hip circumference, head length (HL), head width, total face height, upper face height, and face width were measured after obtaining informed consent. Body mass index, cephalic index (CI), total facial index, and upper facial index were calculated based on measured parameters. Apnea–Hypopnea index (AHI) was extracted from polysomnography results. Then correlations between AHI and other parameters in total, males, and females were analyzed by SPSS software and 0.05 was the significance level.
Results This study showed that mean CI was correlated with AHI in males (p=0.024) and mean HL was correlated with AHI in females (p=0.008). The dominant head form was dolichocephalic in males and hyper-brachycephalic in females. The dominant face form was hyper-leptoprosopic in either genders.
Conclusion Cephalic index in males and head length in females correlate with OSAS in Iranian population.
Keywords Craniofacial, sleep apnea syndrome, Iranian

Introduction

Obstructive sleep apnea syndrome (OSAS) is a respiratory disorder characterized by multiple episodes of upper airway obstruction, either complete or partial, during sleep which can lead to apnea or hypopnea and finally causes arousal or hypoxia. Apnea is defined as complete obstruction of airway for at least 10 s and hypopnea is defined as one of the following conditions:

1. 30% or more reduction in basal airflow plus at least 3% reduction in oxygen saturation;
2. 30% or more reduction in basal airflow plus evidence of arousal in electroencephalogram (EEG).[1–3].

OSAS can manifest by loud snoring, daytime sleepiness, morning headaches, unrefreshing sleep, fatigue, and inspection of apnea by others. OSAS has so many complications which can be serious such as cardiovascular and cerebrovascular events and car accidents.[1–4] Some risk factors for OSAS have been identified such as old age, obesity, smoking, alcohol consumption, male gender, menopause, race, craniofacial anomalies, and nasal obstruction.[1,2]

Reported prevalence of OSAS differs between studies that can be due to different age and race groups, other health conditions, and different techniques and interpretations of polysomnography. The global prevalence was 17–27% in males and 3–28% in females. Prevalence was reported 44% in Iran which is higher than other Asian countries. It can be hypothesized that craniofacial properties in Asian populations predispose them to this disease because evidence shows more OSAS in Asians despite lower prevalence of obesity as an important risk factor for OSAS.[1,2,5]

Based on the multifactorial origin of OSAS, the pathophysiology of this disease is not fully understood.[6] Its pathophysiology has been studied by some physiologic and anatomic methods which showed abnormal upper airway structure.[7,8] Anatomic and anthropometric studies of the craniofacial skeleton and upper airway soft tissues can help in diagnosis and predicting this disorder, meanwhile attention should be paid to the role of age, gender, and obesity.[6,9] Craniofacial morphologies and anomalies can cause upper airway collapse during sleep.[10] Aging leads to soft tissue changes in head and face, hence it is beneficial to study craniofacial and upper airway structures in various age groups and ethnicities.[4,8] There are two types of craniofacial anomalies: first is skeletal anomalies (micrognathia, retrognathia), and second is soft tissue anomalies (macroglossia, large soft palate and adenoid). One pathophysiological theory for OSAS is enlarged peri-pharyngeal soft tissues disproportionate to skeleton which is fixed.[11] It was shown that cephalic and facial indices differ between individuals and ethnicities, which highlights the importance of anthropometric studies.[12] Previous studies indicated that decreased length of maxilla and mandible, inferiorly positioned hyoid bone, increased facial height, decreased total facial index, retrognathia, micrognathia, macroglossia, larger soft palate, and increased cephalic index were related to OSAS.[7,11,13,14] Furthermore, other anthropometric properties such as body mass index (BMI), waist circumference, hip circumference, and neck circumference may affect OSAS incidence.[15]

Despite advancements in imaging and other diagnostic techniques, diagnosing OSAS is still challenging. Overnight polysomnography is the most accurate approval test for OSAS. This test includes electroencephalogram (EEG), electrocardiogram (ECG), electrooculogram (EOG), chin electromyogram (EMG), and measuring airflow, oxygen saturation, and heart rate.[6] Health care expenses can be reduced by early diagnosis and treatment of OSAS.[16] Scientists have introduced some economical predicting models for diagnosing OSAS in last decade, which included regression analysis of demographic, clinical, and anthropometric variables.[14] Finding more economical methods to prevent and predict OSAS can lower health care expenses. This study was aimed to assess correlations between craniofacial variables and OSAS in Baharloo sleep disorders clinic, Iran.

Materials and methods

In this cross-sectional study, 73 patients in Baharloo sleep disorders clinic were assessed. Ethical code was obtained from Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1396.4116). Cases were selected by easy sampling method. Inclusion criteria were as following: Being Iranian, OSAS symptoms or referral due to that, and STOP-BANG score of 3 or more. Exclusion criteria were as following: craniofacial anomalies and craniofacial surgeries. Demographic information including age and gender were obtained from approved identification cards. Anthropometric measurements (height, weight, neck circumference, waist circumference, hip circumference) were made by scale and tape measure. Craniofacial measurements (head length, head width, face height, face width, upper face height) were made by anthropometric caliper, while patient seated, head in Frankfort plane and mouth closed. Neck circumference was measured in the level of cricothyroid membrane. Waist circumference was measured halfway between costal margin and iliac crest. Hip circumference was the largest circumference of hip in the level of greater trochanters of femur. Weight and height were measured by manual scale in kilograms and meters, respectively. BMI was calculated as weight divided by squared height. Head length (HL) was obtained by measuring the distance between glabella and inion. Head width (HW) was obtained by measuring maximum biparietal diameter. Cephalic index (CI) was calculated as HW multiplied by 100 divided by HL. Total face height (TFH) was measured while one end of the caliper placed on nasion and the other on gnathion. Measuring bizygomatic distance showed face width (FW). Total facial index (TFI) was calculated as TFH multiplied by 100 divided by FW. Upper face height (UFH) was obtained by measuring the distance between nasion and prosthion. Upper facial index (UFI) was calculated exactly like TFI except for UFH replacing TFH. Head form was detected based on CI as shown in Table 1, and face form was detected based on TFI and UFI as shown in (Table 2 and Table 3).

Table 1. **Head forms based on cephalic index**

Head form	Cephalic index
Dolichocephalic	74.9≥
Mesocephalic	75-79.9
Brachycephalic	80-84.9
Hyper-brachycephalic	85≤

Table 2. **Face forms based on total facial index**

Face form	Total facial index
Hyper-euryprosopic	79.9≥
Euryprosopic	80-84.9
Mesoprosopic	85-89.9
Leptoprosopic	90-94.9
Hyper-leptoprosopic	95≤

Table 3. **Face forms based on upper facial index**

Face form	Upper facial index
Hyper-eurene	44.9≥
Eurene	45-49.9
Mesene	50-54.9
Leptene	55-59.9
Hyper-leptene	60≤

Full standard overnight polysomnography class one was used as gold-standard diagnostic test for OSAS. Patients underwent overnight polysomnography for STOP-BANG score of 3 or more or serious symptoms of OSAS. STOP-BANG is an acronym for snoring, tiredness, observed apnea, high blood pressure, BMI > 35, age > 50, NC > 40, and male gender. Apnea–hypopnea index (AHI) was extracted from the polysomnography result. Patients were classified to four groups based on AHI:

1. Normal (AHI < 5)
2. Mild OSAS (5 ≤ AHI < 15)
3. Moderate OSAS (15 ≤ AHI < 30)
4. Severe OSAS (AHI ≥ 30).

The day after overnight polysomnography, patients underwent craniofacial and anthropometric measurements after obtaining oral and written informed consent. SPSS version 16 was used for statistical analysis of data. Significance level was 0.05.

Results

Seventy-three patients with symptoms suggesting OSAS participated in this study, including 47 males (64.4%) and 26 females (35.6%). Based on AHI, there were 10 patients with mild or no OSAS (13.7%), 19 with moderate OSAS (26%), and 44 with severe OSAS (60.3%). Mean, standard deviation and correlation with AHI of all studied variables are shown in Table 4, in total population and two gender groups.

Despite significant difference between two gender groups in HL ($p < 0.0001$), CI ($p < 0.01$), TFH ($p < 0.0001$), UFH ($p < 0.003$), and FW ($p < 0.0001$), there was no significant difference in HW, TFI, and UFI between them. Frequency of head form was studied in total and two gender groups. The most frequent head form was dolichocephaly in males and hyper-brachycephaly in females (Table 5).

Face form was obtained based on TFI in different genders. Most patients were hyper-leptoprosopic (Table 6).

Table 4. **Correlation between craniofacial and anthropometric variables and AHI, in total population and two gender groups**

	Male			Female			Total		
	Mean ± SD	*r*	*p* value	Mean ± SD	*r*	*p* value	Mean ± SD	*r*	*p* value
Age	47±12	0.186	0.21	55±12	0.184	0.369	50±12	0.088	0.459
BMI	31.52±5.84	0.441	0.002	32.21±6.56	0.307	0.128	31.77±6.07	0.363	0.002
NC	43.89±3.46	0.368	0.012	37.56±3.56	0.07	0.734	41.74±4.51	0.355	0.002
WC	109.58±11.97	0.424	0.005	108.41±13.66	0.255	0.252	109.18±12.47	0.362	0.003
HC	113.56±11.95	0.398	0.008	116±11.69	0.144	0.523	114.38±11.83	0.28	0.024
HL	19.75±0.94	-0.127	0.394	18.85±1.08	-0.511	0.008	19.43±1.07	-0.137	0.249
HW	15.46±1.43	0.254	0.085	15.56±1.16	-0.313	0.119	15.5±1.33	0.075	0.527
FH	13.06±1.11	-0.063	0.672	11.75±0.92	0.014	0.946	12.6±1.22	0.097	0.415
UFH	6.94±1.03	-0.121	0.416	6.24±0.66	0.104	0.612	6.69±0.97	0.028	0.815
FW	12.43±0.71	0.148	0.322	11.7±0.64	0.118	0.566	12.17±0.77	0.114	0.339
CI	78.38±7.01	0.329	0.024	82.63±5.57	-0.321	0.109	79.89±6.81	0.171	0.148
TFI	105.45±10.71	-0.141	0.344	100.74±9.95	0.195	0.34	103.77±10.62	0.022	0.85
UFI	56.13±10	-0.155	0.3	53.52±6.51	0.237	0.245	55.2±8.96	-0.019	0.876

SD: Standard deviation, BMI: Body mass index, NC: Neck circumference, WC: Waist circumference, HC: Hip circumference, HL: Head length, HW: Head width, FH: Face height, UFH: Upper face height, FW: Face width, CI: Cephalic index, TFI: Total facial index, UFI: Upper facial index

Table 5. **Frequency of different head forms in total, males, and females**

Head form	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Dolichocephalic	16	34	2	7.7	18	24.7
Mesocephalic	12	25.5	6	23.1	18	24.7
Brachycephalic	13	27.7	8	30.8	21	28.8
Hyper-brachycephalic	6	12.8	10	38.5	16	21.9

Table 6. **Frequency of different face forms in total, males, and females**

Face form	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Hyper-euryprosopic	1	2.1	1	3.8	2	2.7
Euryprosopic	1	2.1	1	3.8	2	2.7
Mesoprosopic	2	4.3	1	3.8	3	4.1
Leptoprosopic	2	4.3	4	15.4	6	8.2
Hyper-leptoprosopic	41	87.2	19	73.1	60	82.2

Mean AHI in total and two gender groups is shown in Table 7. There was a significant difference between to genders regarding mean AHI ($p = 0.032$).

As shown in Table 4, there was a correlation between CI and AHI in males ($p = 0.0.024$). Also, HL and AHI were correlated in females ($p < 0.008$).

Table 7. **Mean AHI in total, males, and females**

Gender	Mean	SD	Median	Minimum	Maximum
Male	52.24	31.30	50.3	0.7	123.5
Female	35.85	29.42	25.05	3.2	109.8
Total	46.4	31.45	40.8	0.7	123.5

Discussion

In this study, mean HL was 19.75 ± 0.94 and 18.85 ± 1.08 in males and females, respectively. Hassanzadeh and colleagues conducted a study in 2013 on natives of Qazvin in Iran and Dera Ghazi Khan (DG khan) in Pakistan. They reported that mean HL was 18.3 ± 0.82 and 18.55 ± 0.7 in males of Qazvin and DG khan, respectively. Also, HL was 17.97 ± 0.58 and 17.74 ± 0.99 in females of Qazvin and DG khan, respectively. Madadi and colleagues did a study on medical students of Tehran University of Medical Sciences (TUMS) in 2018. They reported 18.84 ± 1.12 and 17.48 ± 0.94 as mean HL in males and females, respectively. These results show that HL in our study is greater than normal Iranian population.[17,18] On the other hand, Pouya and colleagues showed in 2017 that HL in both genders was less than what we showed in our study.[19] Perri and his colleagues reported in 2015 that mean HL in white Australians suffering from OSAS was 19.66 ± 6.9 in males and 18.82 ± 7 in females. Although these means are close to our results, Perri showed that mean HL in people with OSAS was lower than normal population in either genders. This difference can reflect regional and ethnical characteristics and necessitates more studies to be done. Present study showed a correlation between HL and OSAS in females, while Perri did not report any correlations between cranial variables and OSAS in either genders.[20]

Mean HW was 15.46 ± 1.43 and 15.56 ± 1.16 in males and females, respectively in current study. Although no significant difference was found between two genders regarding HW, mean HW was greater in females. Mean HW in male patients was more than the same variable in Madadi's and Pouya's studies, but it was less than what Hassanzadeh reported for Qazvin and DG khan males.[17–19] Mean HW was more than what Perri reported in 2015 and it is of interest that Perri reported greater HW in males than females, which opposes our results.[20]

Mean CI was calculated as 78.38 ± 7.01 in males which is less than CI in Qazvin, DG khan, and TUMS males, but is concordant with what Pouya and colleagues reported. Mean CI in females was 82.63 ± 5.57 which is less than the same index calculated by Madadi and Hassanzadeh and more than what Pouya reported.[17–19]

The dominant head form in this study was dolichocephaly in males and hyper-brachycephaly in females. Hassanzadeh and colleagues showed in 2013 that hyper-brachycephaly and brachycephaly were the first two common cephalic types in natives of Qazvin. Madadi and colleagues reported in 2018 that brachycephaly and hyper-brachycephaly were the most common cephalic types in males and females, respectively. Heidari and colleagues showed in 2006 that mesocephaly and brachycephaly were the most common cephalic types in Sistani and Baluchi women, respectively. Pouya and colleagues claimed in 2017 that mesocephaly was the dominant cephalic type in both genders. Current study shows that males suffering from OSAS more commonly have dolichocephalic head and there is a correlation between AHI and CI, however most women were hyper-brachycephalic that corresponds to normal Qazvin and TUMS females.[17–19,21] Although there was no significant correlation between AHI and CI in females, HL and AHI correlated significantly in this gender group, which can support this hypothesis that dolichocephalization is more common in OSAS patients. In other words, the more the HL, the more the chance of developing OSAS. However, this is not congruent with what Cakirer and colleagues showed in 2001. They showed that patients with AHI of 15 or more tend to have greater CI compared to normal population. This result was true for both blacks and whites.[22]

Results regarding TFH, UFH, FW, TFI, and UFI are shown in Tables 8 and 9 in comparison with what Azizi, Dodangeh, and Navaei reported.[13,23,24]

The dominant face form in males and females was hyper-leptoprosopic in current study, which is congruent with what Azizi and colleagues showed in 2014 regarding natives of Qazvin.[13] Dodangeh and colleagues showed the same result for males of TUMS, however they also showed that mesoprosopic face was the dominant face form in females that does not support our results.[24] Heidari and Madadi showed that euryprosopic face was the major face form in females. Madadi reported mesoprosopic face as the major face form in males. Therefore, these two studies do not support our results regarding the face form.[21,25] This difference may be due to the studied populations, which was OSAS patients in current study, while normal population in two other studies.

This study showed that dolichocephalization and narrower face, which is anthropometrically congruent with dolichocephaly, affect OSAS. However, recent studies claimed that skull tends to be more brachycephalic in whites, whom OSAS

Table 8. **Face height, face width, and total facial index compared in three studies**

Author, Year, Area	Face height			Face width			Total Facial index		
	Total	Males	Females	Total	Males	Females	Total	Males	Females
Azizi 2014 Qazvin		12.83 ±1.03	11.98 ±0.93		12.49 ±0.61	12.4 ±0.55		102.88 ±10.28	96.69 ±7.67
Azizi 2014 DG Khan		11.83 ±0.72	11.15 ±0.78		13.11 ±0.86	12.71 ±0.91		90.55 ±7.6	87.87 ±5.8
Dodangheh 2018 Iran	11.155 ±0.982	11.918 ±0.583	10.392 ±0.65	11.68 ±0.71	11.79 ±0.62	11.56 ±0.78	95.75 ±8.80	101.26 ±6.05	90.24 ±7.60
Navaei 2018 Iran	11 ±0.12	11.1 ±0.1	10 ±0.1	11 ±0.11	11.2 ±0.1	12 ±0.2			
Present study	12.6 ±1.22	13.06 ±1.11	11.75 ±0.92	12.17 ±0.77	12.43 ±0.71	11.7 ±0.64	103.77 ±10.62	105.45 ±10.71	100.74 ±9.95

Table 9. **Upper face height, face width, and Upper facial index compared in three studies**

Author, Year, Area	Upper facial Height			Face Width			Upper facial Index		
	Total	Males	Females	Total	Males	Females	Total	Males	Females
Azizi 2014 Qazvin		7.94 ±0.5	7.5 ±0.92		12.49 ±0.61	12.4 ±0.55		63.75 ±5.45	61.08 ±9.03
Azizi 2014 Dg khan		7.33 ±0.48	7.09 ±0.71		13.11 ±0.86	12.71 ±0.91		56.04 ±4.22	55.92 ±5.37
Dodangheh 2018 Iran	7.05 ±0.55	7.33 ±0.38	6.77 ±0.56	11.68 ±0.71	11.79 ±0.62	11.56 ±0.78	60.55 ±5.58	62.31 ±4.25	58.80 ±6.2
Navaei 2018 Tums	7.05 ±0.2	7.1 ±0.2	6 ±0.2	11 ±0.11	11.2 ±0.1	12 ±0.2			
Present study	6.69 ±0.97	6.94 ±1.03	6.24 ±0.66	12.17 ±0.77	12.43 ±0.71	11.7 ±0.64	55.2 ±8.96	56.13 ±10	53.52 ±6.51

is more common in. Cakirer and colleagues reported in 2001 that OSAS and FI were correlated in whites. They showed that FI was lower in OSAS group compared to control group (84.5 ± 6.1 *vs* 87.4 ± 8).[22] Vidovic and colleagues claimed in 2013 that OSAS patients tend to have greater CI and lesser FI compared to normal population. In their study which was done on Croatians, OSAS was correlated with brachycephaly and euryprosopic face that opposes our results.[26] There was no control group in the current study and the studied population was not ethnically and sexually homogenous. Therefore, due to the controversies, further studies on bigger and more uniform samples with matched controls should be done.

Conclusion

To sum up, this study showed that dolichocephaly, longer head, and hyper-leptoprosopic face, which are anthropometrically congruent, affect OSAS incidence.

References

1. Sarokhani M, Goli M, Salarvand S, Gheshlagh RG. The prevalence of sleep apnea in Iran: A systematic review and meta-analysis Mandana. Tanaffos. 2019;18(1):1–10.
2. Gharibeh T, Mehra R. Obstructive sleep apnea syndrome: Natural history, diagnosis, and emerging treatment options. Nat Sci Sleep. 2010;2:233–55.
3. Park JG, Ramar K, Olson EJ. Updates on definition, consequences, and management of obstructive sleep apnea concise review for clinicians. Mayo Clin Proc. 2011;86(6):549–55.
4. Ryu HH, Kim CH, Cheon SM, Bae WY, Kim SH, Koo SK, et al. The usefulness of cephalometric measurement as a diagnostic tool for obstructive sleep apnea syndrome: A retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;119(1):20–31.
5. Lam B, Ip MSM, Tench E, Ryan CF. Craniofacial profile in Asian and white subjects with obstructive sleep apnoea. Thorax. 2005;60(6):504–10.
6. Neelapu BC, Kharbanda OP, Sardana HK, Balachandran R, Sardana V, Kapoor P, et al. Craniofacial and upper airway morphology in adult obstructive sleep apnea patients: A systematic review and meta-analysis of cephalometric studies. Sleep Med Rev. 2017;31:79–90.
7. Silva VG, Pinheiro LAM, Silveira PL da, Duarte ASM, Faria AC, Carvalho EGB de, et al. Correlation between cephalometric data and severity of sleep apnea. Braz J Otorhinolaryngol. 2014;80(3):191–5.
8. Gungor AY, Turkkahraman H, Yilmaz HH, Yariktas M. Cephalometric comparison of obstructive sleep apnea patients and healthy controls. Eur J Dent. 2013;7(1):48–54.
9. Barrera JE, Pau CY, Forest V-I, Holbrook AB, Popelka GR. Anatomic measures of upper airway structures in obstructive sleep apnea. World J Otorhinolaryngol - Head Neck Surg. 2017;3(2):85–91.
10. Takai Y, Yamashiro Y, Satoh D, Isobe K, Sakamoto S, Homma S. Cephalometric assessment of craniofacial morphology in Japanese male patients with obstructive sleep apnea-hypopnea syndrome. Sleep Biol Rhythms. 2012;10(3):162–8.
11. Perri RA, Kairaitis K, Cistulli P, Wheatley JR, Amis TC. Surface cephalometric and anthropometric variables in OSA patients: Statistical models for the OSA phenotype. Sleep Breath. 2014;18(1):39–52.
12. Zolbin MM, Hassanzadeh G, Mokhtari T, Arabkheradmand A, Hassanzadeh S. Anthropometric studies of nasal parameters of Qazvin Residents, Iran. MOJ Anat Physiol. 2015;1(1).
13. Azizi M, Hassanzadeh G, Barbarestani M, Sadr M, Dehbashipour A, Alaghbandha N, et al. Comparative anthropometric analysis of facial dimensions and types in Qazvin, Iran and DeraGhazi Khan, Pakistan. Anat Sci J. 2014;11(3):119–26.
14. Kim ST, Park KH, Shin SH, Kim JE, Pae CU, Ko KP, et al. Formula for predicting OSA and the Apnea–Hypopnea Index in Koreans with suspected OSA using clinical, anthropometric, and cephalometric variables. Sleep Breath. 2017;21(4):885–92.
15. Borges P de TM, da Silva BB, Moita Neto JM, Borges NE de S, Li LM. Cephalometric and anthropometric data of obstructive apnea in different age groups. Braz J Otorhinolaryngol. 2015;81(1):79–84.
16. De Tarso M Borges P, Ferreira Filho ES, De Araujo TME, Moita Neto JM, De Sa Borges NE, Melo Neto B, et al. Correlation of cephalometric and anthropometric measures with obstructive sleep apnea severity. Int Arch Otorhinolaryngol. 2013;17(3):321–8.
17. Hassanzadeh G, Sadr M, Alaghbandha N, Dehbashipour A, Abbas MA HZO. Anthropometric characteristics of craniums in residents of Qazvin, Iran and Dera Ghazi Khan, Pakistan: A comparative study. Anat Sci J. 2013;10:43–9.
18. Madadi S, Khanehzad M, Tahmasebi F, Gordon K, Hassanzadeh G. Correlation of horizontal cephalic index and cranial parameters in Iranian medical students. Acta Med Iran. 2018;56(9):577–84.
19. Pouya F, Eftekhar-Vaghefi SH, Salehinejad P. Anthropometric analysis of cephalofacial dimensions in Kerman, Iran. Acta Med Iran. 2017;55(4):241–8.
20. Perri RA, Kairaitis K, Wheatley JR, Amis TC. Anthropometric and craniofacial sexual dimorphism in obstructive sleep apnea patients: Is there male-female phenotypical convergence? J Sleep Res. 2015;24(1):82–91.
21. Heidari Z, Sagheb HRM, Mugahi MHN. Morphological evaluation of head and face in 18-25 years old women in southeast of Iran. J Med Sci. 2006;6(3):400–4.
22. Cakirer B, Hans MG, Graham G, Aylor J, Tishler P V., Redline S. The relationship between craniofacial morphology and obstructive sleep apnea in whites and in African-Americans. Am J Respir Crit Care Med. 2001;163(4):947–50.
23. Navaei F, Ghaffari N, Mojaverrostami S, Dodongeh M, Nemati M. Stature estimation from facial measurements in medical students of Tehran university of Medical Sciences : an Iranian population. Iraq Med J. 2018;2(3):68–71.

24. Dodangheh M, Mokhtari T, Mojaverrostami S, Nemati M, Zarbakhsh S, Arabkheradmand A, et al. Anthropometric study of the facial index in the population of medical students in Tehran University of Medical Sciences. GMJ Med. 2018;V(June):51–7.
25. Madadi S, Tahmasebi F, Khanehzad M, Kazemzadeh S, Hassanzadeh G. Estimation of stature from facial indices among Iranian medical students. J Contemp Med Sci. 2019;5(2).
26. Vidovic N, Mectrovic S, Dogas Z, Bukovic D, Brakus I, Brakus RB, et al. Craniofacial morphology of Croatian patients with obstructive sleep apnea. Coll Antropol. 2013;37(1):271–9.